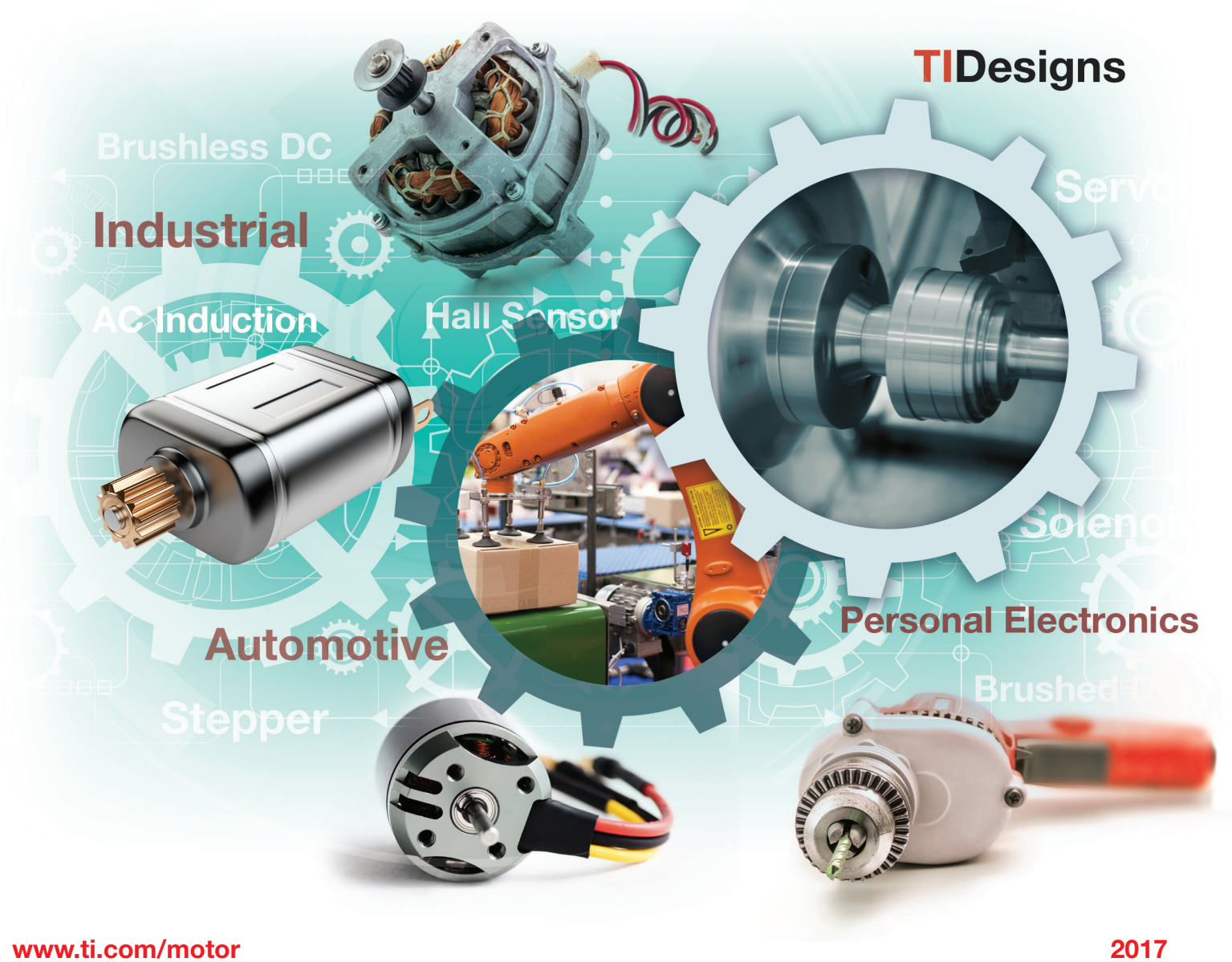
Motor Drive and Control Solutions

Texas Instruments



www.ti.com/motor

2017

Motor drive and control solutions
Introduction

Introduction

Texas Instruments (TI) is a global market leader that provides complete motor drive and control solutions along with broad analog and microcontroller (MCU) 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 for industrial, consumer and automotive applications 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

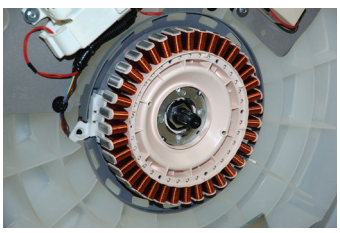
Power stage – IGBTs or MOSFETS

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

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

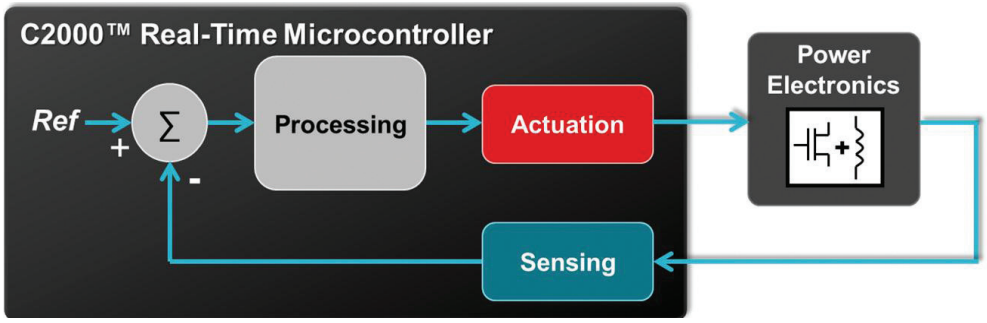
Learn more at:
www.ti.com/motor



Microcontrollers for motor control
C2000™ real-time MCUs

MCUs built for real-time control

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



C2000 MCU 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 (30 ns) 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 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 MCU 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 (1 ku)	**From: $8.95 (1 ku)**	**From: $9.40 (1 ku)**	**From: $4.45 (1 ku)**

Microcontrollers for motor control

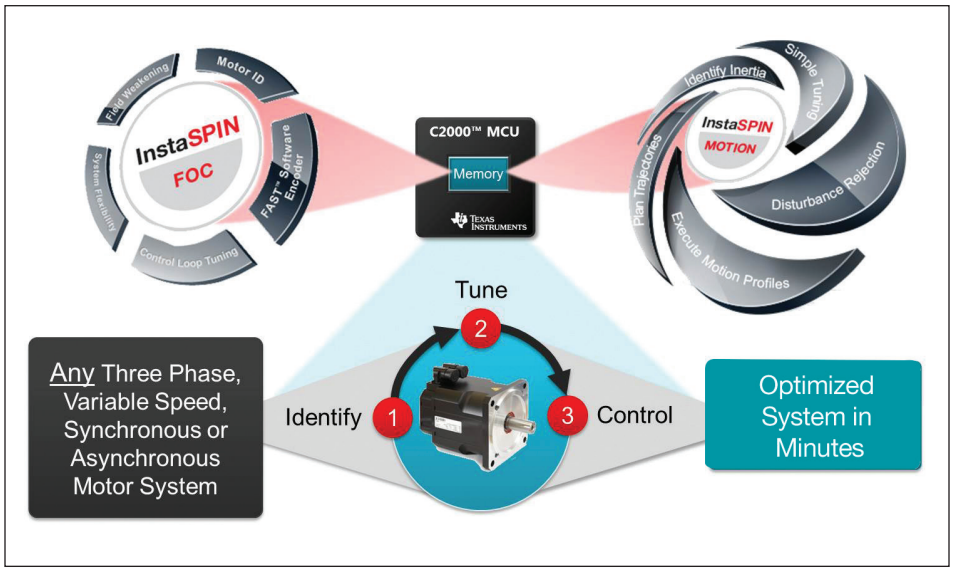
C2000™ real-time MCU software solutions

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.



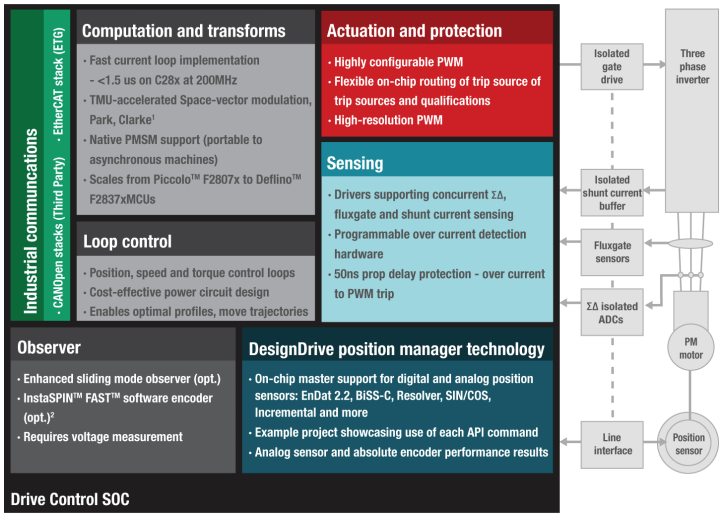
To learn more about InstaSPIN, visit **www.ti.com/InstaSPIN**

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.

DesignDRIVE platform: The place to create many designs for industrial drives

C2000 provides optimized macro-based libraries for rapid deployment of motion control systems as well as specific solutions for servo and AC inverter drives based on those libraries with DesignDRIVE. This software block-based approach makes building your system easy and intuitive.



Jumpstart industrial drives and servo control evaluation and development with:

- Examples of vector control of motors, incorporating torque, speed and position
- Multiple current sense topologies
- Analog and digital position sensor interfaces
- Flexible real-time connectivity
- Series of platform releases

To learn more about DesignDRIVE and motor control solutions for C2000 MCUs, visit www.ti.com/**DesignDRIVEApplications**, www.ti.com/**tool/DesignDRIVE** and www.ti.com/**C2000**.

Microcontrollers for motor control

TM4C ARM® Cortex®-M core based high-performance MCUs

Texas Instruments is the industry leader in bringing 32-bit capabilities along with the full benefits of ARM® Cortex®-M-based MCUs 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, integrated Ethernet PHY+MAC, wireless connectivity option via TI Designs 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 MCU features deterministic performance and IP especially designed for simultaneous advanced motion control and real-time connectivity. These MCUs 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 up to 4 MSPS 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

- ARM Cortex-M4F core
- 32 to 1 MB of flash
- Up to 120 MHz CPU clock speed
- 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
- 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

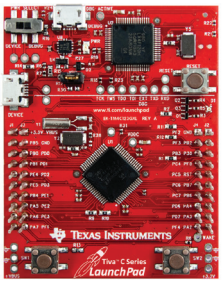
For more information on TM4C MCUs for motor-control applications, visit **www.ti.com/TM4C**

Microcontrollers for control

TM4C ARM® Cortex®-M core based high-performance MCUs

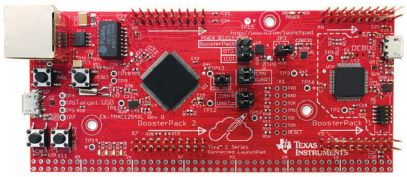
Evaluation kit

The TM4C123G LaunchPad™ evaluation kit is a low-cost evaluation platform for ARM® Cortex®-M4F-based MCUs from Texas Instruments. The price is only US $12.99. The design of the TM4C123G LaunchPad highlights the TM4C123GH6PM MCU with a USB 2.0 device interface and hibernation module.

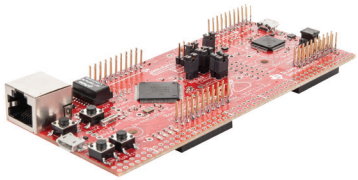


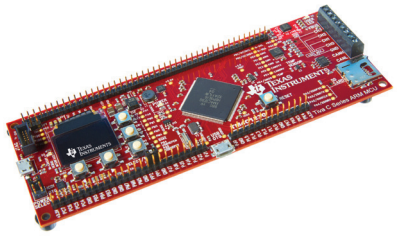
The EK-TM4C123GXL also features programmable user buttons and an RGB LED for custom applications. The stackable headers of the TM4C123G LaunchPad BoosterPack™ XL Interface make it easy and simple to expand the functionality of the TM4C123G LaunchPad when interfacing to other peripherals with Texas Instruments' BoosterPacks.

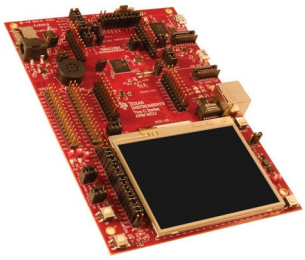
The TM4C1294 Connected LaunchPad evaluation kit is a low-cost development platform for ARM Cortex-M4F-based MCUs. The price is only US $19.99. The Connected LaunchPad design highlights the TM4C1294NCPDT MCU with its on-chip 10/100 Ethernet MAC and PHY, USB 2.0, hibernation module, motion control pulse-width modulation and a multitude of simultaneous serial connectivity.



The TM4C129E Crypto Connected LaunchPad evaluation kit is a low-cost platform for ARM Cortex-M4-based MCUs. The price is US $24.99. The kit design highlights the TM4C129ENCPDT MCU with on-chip crypto acceleration hardware, 10/100 Ethernet MAC + PHY, USB 2.0, hibernation module, motion control pulse-width modulation and a multitude of simultaneous serial connectivity.







Development kits

The TM4C Series TM4C123G ARM Cortex M4F-based MCU development kit is a compact and versatile evaluation platform for the TM4C123G ARM Cortex-M4-based 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 TM4C123GH6PGE MCU 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 TM4C129x Connected LaunchPad evaluation kit is a versatile and feature-rich engineering platform that highlights the 120 Hz TM4C129XNCZAD ARM Cortex-M4 based microcontroller, including an integrated 10/100 Ethernet MAC + PHY as well as many other key features such as color LCD, USB 2.0 port, etc.

The kit also includes an in-circuit debug interface (ICDI) and extensive software offerings that provide libraries for key functions, source code examples and important utilities to allow professional engineers to build and debug C code-based solutions quickly and efficiently in one of the several supported integrated development environments (IDEs), including Keil™, Mentor™ Embedded, IAR Systems® and Code Composer Studio™.

Microcontrollers for motor control

Hercules™ TMS570 32-bit ARM® Cortex®-R4 safety MCUs

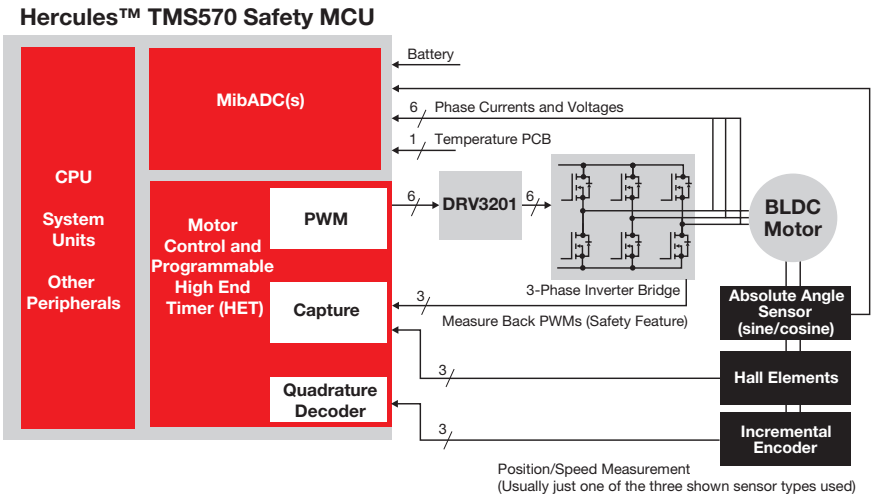
Hercules MCUs help enable safe motor control

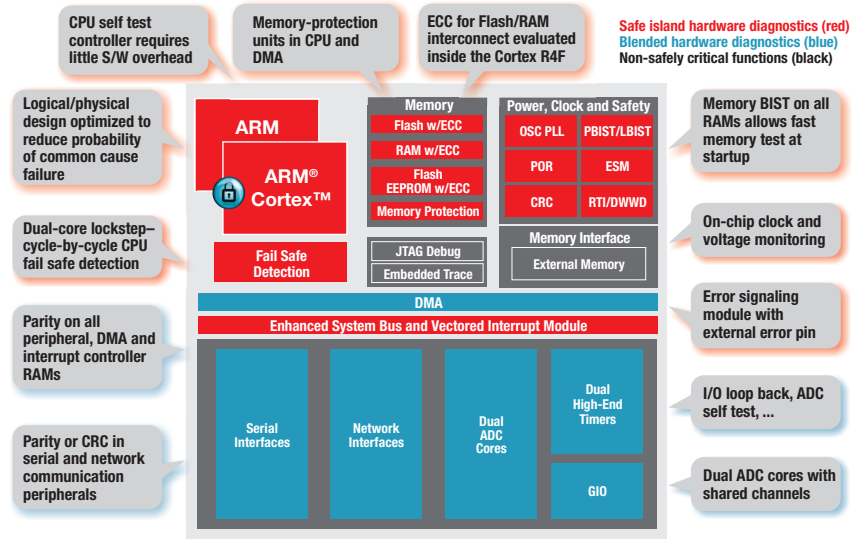
The Hercules™ MCU family makes it easier for customers to build motor-control applications that meet specific safety standards. Devices are available today with up to 330 MHz of floating-point performance and integrated safety features that provide a high level of diagnostic coverage.

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

The high-performance 32-bit ARM Cortex-R based Hercules MCU family is developed according to the ISO26262 ASIL-D and IEC 61508 SIL3 safety standards and, additionally many products are certified.

The 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.





Key features

ARM Cortex-R4 CPUs in lockstep

- Up to 330 MHz with floating-point support

Memory

- Flash: 128 KB to 4 MB with ECC protection
- RAM: 32 KB to 512 KB with ECC protection

Peripheral highlights

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

Packages

- 100 QFP, 144 QFP, 337 nFBGA

Applications

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

Motor control benefits

Motor control timers

- Effective support of many motor control concepts
- PWM generation – symmetric, asymmetric, deadband
- Single- or multiple-shunt systems quadrature decoder
- Timers 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

Learn more at:
www.ti.com/hercules

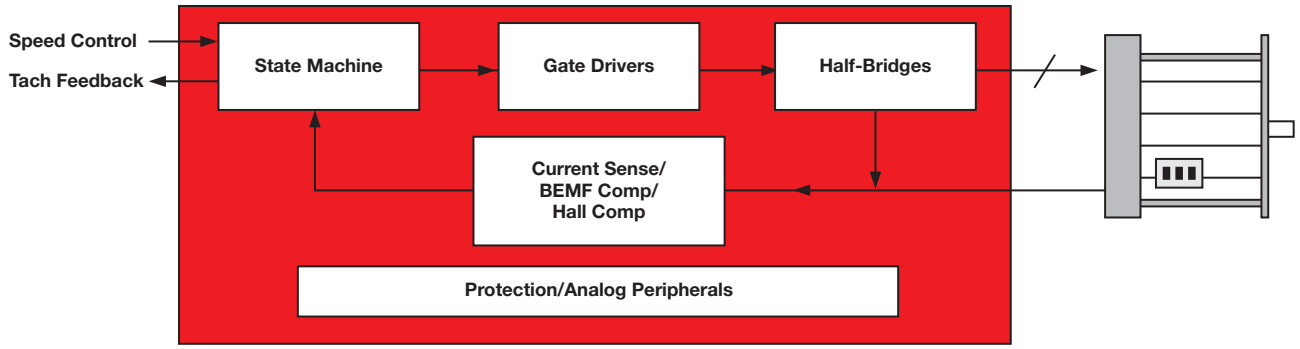
DRV10x integrated BLDC motor controllers
Featured integrated BLDC motor controllers

The DRV10x family of motor controllers offers fully integrated BLDC motor control solutions, enabling faster motor control design with high performance and quality. From traditional trapezoidal to true sinusoidal, from Hall sensored to sensorless, the on-chip state-machine based motor control algorithms are code-free but configurable through either integrated registers or external passive components, minimizing design efforts without losing the flexibility to tune for different motors. These motor control cores aim to provide the highest possible efficiency and lowest possible acoustic noise, optimizing the BLDC motor performance.

As TI aims to keep evolving and stay the industry leader in the motor driver market, the DRV10x family is expanding with TI's first fully integrated automotive qualified BLDC motor controller, the DRV10983-Q1**. The DRV10x are fully integrated solutions with control, gate drive, power stage, analog peripherals and protection, making them ideal for applications including white goods, small appliances, motor modules and many others where compact system architecture is the key concern.

The TI advantage:

- Code-free tuning, quick time-to-market
- High efficiency, high performance and low noise
- Highly integrated, efficient system cost
- Fully protected, dependable operation for industrial and automotive applications



Featured integrated BLDC motor controllers

Device	Description	Supply voltage (V)	Max I_{OUT} (A)	Communication type	Price*
DRV10983-Q1	Automotive, up to 45V 3-phase BLDC controller	4.5 to 45	3	Sensorless, true sinusoidal	TBD
DRV10964	5-V, 3-Phase Sinusoidal Sensorless BLDC Motor Driver	2.1 to 5.5	0.5	Sensorless, true sinusoidal	0.54
DRV10963	5V, 3-phase BLDC motor controller	2.1 to 5.5	0.5	Sensorless, true sinusoidal	0.49
DRV10970	12V, 3-phase BLDC motor controller	5 to 18	2	Hall-sensored, true sinusoidal	1.18
DRV10975	12V, 3-phase BLDC motor controller	6.5 to 18	2	Sensorless, true sinusoidal	1.55
DRV10983	8V to 28 V 3-phase BLDC motor controller	8 to 28	3	Sensorless, true sinusoidal	1.95
DRV10866	5V, 3-phase BLDC motor controller	1.65 to 5.5	0.68	Sensorless, enhanced trapezoidal	0.39
DRV11873	12V, 3-phase BLDC motor controller	5 to 16	2	Sensorless, enhanced trapezoidal	0.79

**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**.*

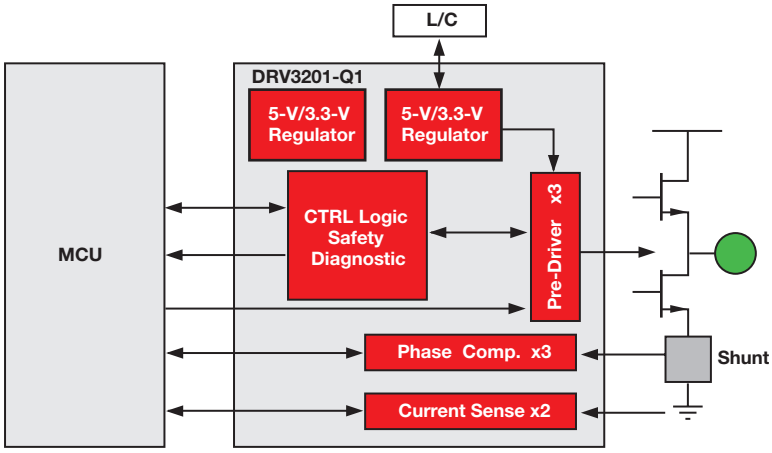
DRV32xx motor drivers
Motor drivers for functional safety applications

The industry's first automotive motor driver family meeting the functional safety requirements of ISO 26262

- Devices help customers design applications to meet the functional safety requirements of ISO 26262: the DRV3201-Q1 can help TI customers design critical- safety applications, such as electric power steering and electric braking systems, to meet ASIL-D requirements, and the DRV3203-Q1 and DRV3204-Q1 can help customers design safety applications, such as oil pump and water pump, to meet ASIL-B requirements.
- Design simplicity for start-stop and cold-crank applications: with an integrated boost regulator, the DRV3201-Q1 eliminates the need for a large capacitor to hold battery voltage. With an integrated low dropout (LDO) linear regulator and an external FET, the DRV3203-Q1 and DRV3204-Q1 also eliminate the need for a large capacitor or external boost regulator. This integration simplifies design and speeds up development time.
- Optimized component count and board space for cost- and space-sensitive applications: the DRV3202-Q1 integrates a voltage regulator and CAN interface to reduce component count and minimize system cost and board space.

Key features

- Three-phase pre-FET drivers
- Programmable 140 mA to 1 A gatecurrent drive
- Gate driver with low-supply voltage operation, with integrated boost converter
- Two modes of gate drivers:
  - Direct mode (6x inputs)
  - PWM mode to 20 kHz, 100% duty operation (3x inputs)
- High-accuracy current-sense amplifiers (two channel)
- Real-time phase comparator (three channel)
- Shoot-through protection
- Pre-FET driver short-circuit protection
- AEC-Q100 grade 1 (–40°C to 125°C)
- Operating supply voltage: 4.75 V to 30 V
- 3.3 V to 5 V MCU interface
- –7 V to 40 V tolerance for all FET driver pins
- Logic functional down to 3 V
- Package: 64-pin HTQFP PowerPad™



Functional block diagram

DRV32xx product overview

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

Device	Gate driver stage	Current sense amplifiers	Short protecting	Watchdog	Phase comparators	Voltage monitoring	Others	Maximum supply voltage	Maximum operating temp. range (°C)	Package
DRV3201-Q1	140 mA to 1 A programmable current sources	2 ch, low side	VDS	No	3	VB	ASIL-D system target	40	Ta = 125	64-pin HTQFP PowerPad
DRV3202-Q1	1 A gate driver switches	1 ch, high side	High-side overcurrent, phase comparator	Pulse, WD input	3	VB, VCC5	5 V CAN, LDO MCU	40	Ta = 125	80-pin HTQFP PowerPad
DRV3203-Q1	1 A gate driver switches	1 ch, high side	High-side overcurrent, phase comparator	Pulse, WD input	3	VB, VCC3	3.3 V MCU LDO	40	Ta = 125 Ta = 150 option	48-pin HTQFP PowerPad
DRV3204-Q1	1 A gate driver switches	1 ch, high side	High-side overcurrent, phase comparator	Pulse, WD input	3	VB, VCC5	5 V MCU LDO	40	Ta = 125 Ta = 150 option	48-pin HTQFP PowerPad
DRV3205-Q1	140 mA to 1 A programmable current sources	3 ch, low side	VDS, shunt overcurrent	Q & A	None	VB, VDDIO, ADCREF monitored for UV and OV	ASIL-D system target	40	Ta = 125	48-pin HTQFP PowerPad
DRV3210-Q1	1 A gate driver switches	1 ch, high side	High-side overcurrent, phase comparator	Pulse, WD input	3	VB, VCC5	5 V low-power MCU LDO	40	Ta = 125	48-pin HTQFP PowerPad
DRV3211-Q1	1 A gate driver switches	1 ch, high side	High-side overcurrent, phase comparator	Pulse, WD input	3	VB, VCC5	5 V MCU LDO	40	Ta = 125	80-pin HTQFP PowerPad

**Suggested resale price in U.S. dollars in quantities of 1,000. Monitored for UV/OV.*

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

DRV8x integrated motor drivers
Introducution

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.

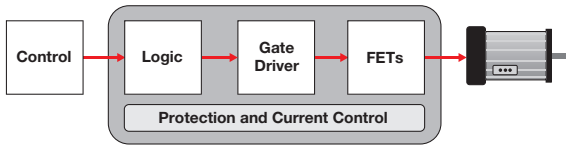
The right part for each application

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 motor drivers and FET gate drivers that support voltage ranges from 1.8 V to 60 V and load currents as high as 100 A. 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.

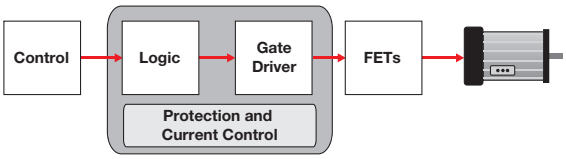
Integrated motor drivers include the gate driver and MOSFETs in a single package, optimizing board space and time-to-market for the designer. These solutions offer high levels of integrated, multi-layer protection schemes for the entire drive stage.

Gate drivers can more easily scale to meet different motor current requirements. By using a gate driver solution, designers can keep their overall system architecture the same and change the MOSFETs without changing the complete drive stage design. This ensures efficient, optimal performance for each motor while still providing protection and integrated intelligence to the design.

Integrated motor driver



Gate driver with external FETs



TI's featured DRV8x motor drivers (see page 15 for full selection table) www.ti.com/motordrivers

Device	Motor Type	Description	Supply voltage (V)	I_{OUT} cont. (A)	I_{OUT} peak (A)	Price*
DRV8870	Brushed-DC	3.6 A brushed DC driver with current regulation	6.5 to 45	2	3.6	1.28
DRV8871	Brushed-DC	3.6 A brushed DC driver with integrated current sensing (eliminates need for external current sensing resistor for current regulation)	6.5 to 45	2	3.6	1.41
DRV8701	Brushed-DC	12 V to 24 V brushed DC gate driver with integrated current shunt amplifier, 3.3 V or 5 V LDO and adjustable gate drive settings	5.9 to 45	Ext FETs	Ext FETs	0.92
DRV8884	Stepper	1.5 A stepper driver with on-chip microstepping and integrated current sensing for current regulation (16 microsteps)	8 to 37	1	1	1.30
DRV8885	Stepper	1.5 A stepper driver with on-chip microstepping and integrated current sensing for current regulation (16 microsteps)	8 to 37	1	1.5	1.49
DRV8880	Stepper	2.0 A stpper driver with on-chip microstepping and AutoTune™ for automatic adaptive current decay (16 microsteps)	6.5 to 45	1.4	2	1.92
DRV8305	Brushless-DC	3-phase FET gate driver with three integrated current-sense amplifiers	4.4 to 45	Ext FETs	Ext FETs	2.30

**Suggested resale price in U.S. dollars in quantities of 1,000. † Available in Q1 versions.*

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

DRV8x integrated motor drivers

DRV8880

2 A stepper motor driver with 1/16 microstepping indexer and AutoTune™ (STEP/DIR ctrl)

Key features

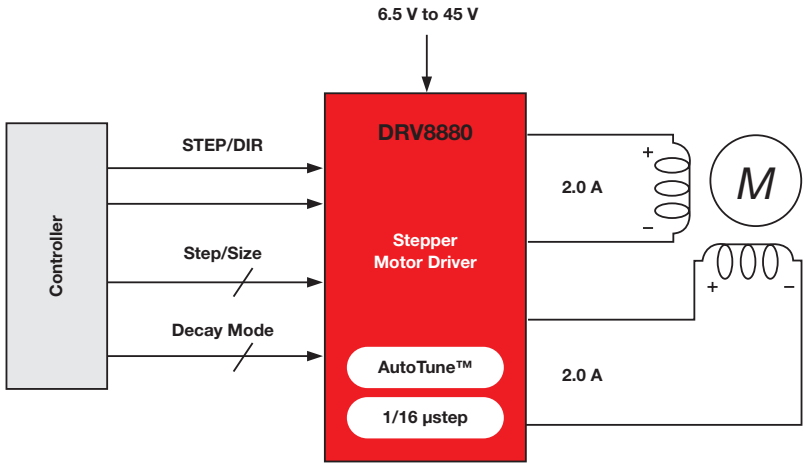
- Microstepping stepper motor driver
  - STEP/DIR interface
  - Up to 1/16 microstepping indexer
  - Non-circular and standard 1/2 step modes
- 6.5 V to 45 V operating supply voltage range
- Multiple decay modes to support any motor
  - AutoTune™
  - Mixed decay
  - Slow decay
  - Fast decay
- Adaptive blanking time for smooth stepping
- Configurable off-time PWM chopping
  - 10 , 20 , or 30 µs off-time
- 3.3 V, 10 mA LDO regulator
- Low-current sleep mode (28 µA)
- Small package and footprint
  - 28 HTSSOP (PowerPAD™)
  - 28 WQFN (PowerPAD™)

Benefits

- Wide supply range supports industry standard supplies and high output current delivers maximum performance
- Accurate and smooth operation without support from the system controller
- Smoother, quieter microstepping motion profiles; flexible configuration options
- AutoTune™ eliminates manual motor tuning and dynamically adjusts settings to result in the lowest ripple for the motor
- Advanced on-chip protection reduces design complexity and enables higher system reliability

Applications

- Automatic teller and money handling machines
- Video security cameras
- Multifunction printers and document scanners
- 3D printers
- Office automation machines
- Factory automation and robots



1/16 Microstepper

DRV8x integrated motor drivers

DRV8305

3-Phase brushless gate driver with three shunt amplifiers and voltage regulator

Key features

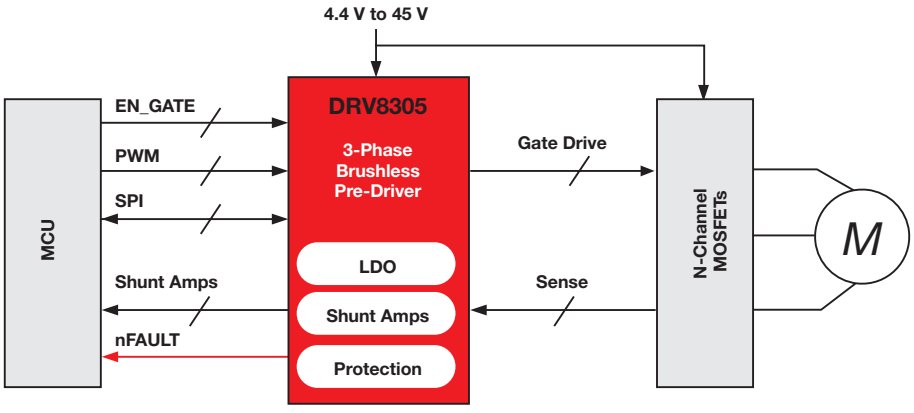
- 4.4 V to 45 V operating voltage
- 1.25 A/1 A peak gate driver currents
- Programmable, independent HS/LS slew rate/slope control
- Charge pump gate driver for 100% duty cycle
- Three integrated current shunt amplifiers
- Integrated 50 mA LDO (3.3 V/5 V option)
- Control of 3 PWM or 6 PWM inputs up to 200 kHz
- Built-in commutation tables for using 1 PWM
- Programmable dead time
- MOSFET shoot through prevention
- Programmable VDS protection of MOSFETs
- Reverse battery protection support
- Supports both 3.3 V/5 V digital interface
- SPI interface
- Thermally enhanced 48-pin QFP (9 mm x 9 mm)

Benefits

- Wide supply range supports industry standard +12 V, +24 V rails
- Three current shunt amplifiers with programmable gain and output bias scaling for bi-directional current sensing
- Supports start-stop/crank
- Accurate slew rate/slope settings (factory trimmed) 10 mA to 1 A for repeatable EMC/switching loss control
- Advanced on-chip protection reduces design complexity and enables higher system reliability
- Eliminates up to 10 active/passive components
- Detailed fault reporting access support

Applications

- Three-phase BLDC and PMSM motors
- CPAP and pumps
- Robotics and RC toys
- Power tools
- Industrial automation



DRV8x integrated motor drivers
DRV8871/DRV8701

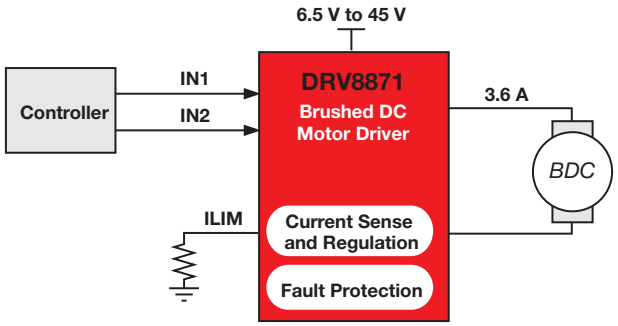
DRV8871

3.5 A brushed DC driver with integrated FETs for 12 V and 24 V motors

Key features
- H-bridge motor driver
  - Drives one DC motor, one winding of a stepper motor or other loads
- Wide 6.5 V to 45 V operating voltage
- 565 mΩ typical RDS_{ON} (HS + LS)
- 3.6 A peak current drive
- PWM control interface
- Current regulation without a sense resistor
- Low-power sleep mode
- Small package and footprint
  - 8-pin HSOP with PowerPAD
  - 4.9 mm x 6.0 mm

Benefits
- Wide supply range supports 12 V and 24 V industry standard supplies and high peak supports large startup and stall current
- Reduced component count and reduced system cost
- Scalable family of low pin count and small package size drivers
- Easy to drive and stop with a single-pin control interface
- Higher system reliability and reduced design complexity with integrated current regulation (DRV8870 and DRV8871) and fault detect (DRV8872) features

Applications
- Printers
- Appliances
- Industrial equipment
- Other mechatronic applications



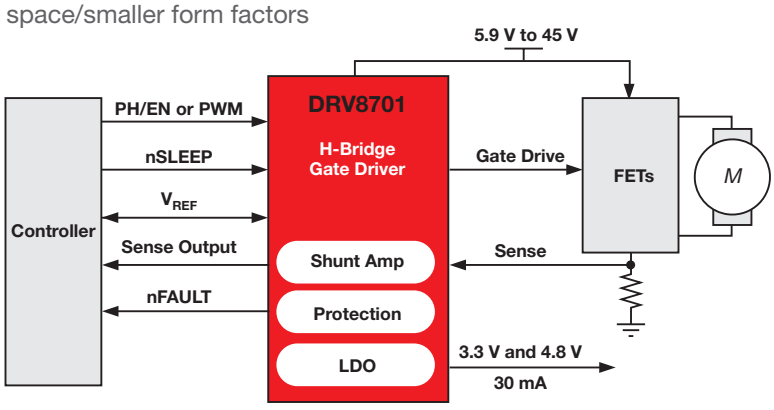
DRV8701

12 V to 24 V bidirectional full bridge brushed DC motor gate driver

Key features
- 5.9 V to 45 V operating supply voltage range
- Two control interface options
  - PH/EN (DRV8701E)
  - PWM (DRV8701P)
- Adjustable gate drive (5 levels)
  - 6 mA to 150 mA source current
  - 12.5 mA to 300 mA sink current
- Supports 1.8 V, 3.3 V, and 5 V logic inputs
- Current shunt amplifier (20 V/V)
- Integrated PWM current regulation limits motor inrush current
- Low-power sleep mode (9 µA)
- Two LDO voltage regulators to power external components
  - 4.8 V, 30-mA LDO regulator
  - 3.3 V, 30-mA LDO regulator
- Small 4.0 x 4.0 x 0.9 mm 24-pin VQFN package with PowerPAD™

Benefits
- Wide supply range supports industry standard supplies; N-channel FETs on high-side save system cost; tune gate driver performance to application needs
- Limit in-rush start up and stall currents
- Sleep mode minimizes power consumption
- Integrated LDOs (x2) and integrated current sense amplifier reduces board space/smaller form factors
- Advanced on-chip protection and diagnosis reduces design
- Complexity and enables higher system reliability

Applications
- Industrial brushed-DC motors
- Robotics
- Home automation
- Industrial pumps and valves
- Power tools
- Handheld vacuum cleaners



Stepper motor drivers

www.ti.com/motordrivers

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 with 8813)	8 to 45	1.1	1.6	Phase/enable	No	1.45
DRV8813	2.5 A stepper driver (P2P with 8812)	8 to 45	1.75	2.5	Phase/enable	No	1.75
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	1.45
DRV8829	5 A stepper driver (need 2x per motor)	8 to 45	3.5	5	Phase/enable	No	1.75
DRV8842	5 A stepper driver (need 2x per motor)	8 to 45	3.5	5	PWM	Yes (2x)	1.75
DRV8843	2.5 A stepper driver	8 to 45	1.75	2.5	PWM	No	1.75
DRV8881E	2.0 A stepper driver with parallel capability for brushed DC motors	6.5 to 45	1.4	2.0	Phase/enable	No	1.60
DRV8881P	2.0 A stepper driver with parallel capability for brushed DC motors	6.5 to 45	1.4	2.0	PWM	No	1.60
Stepper drivers with on-chip microstepping indexer							
DRV8811	1.9 A stepper driver (8 microsteps) (P2P with 8818)	8 to 38	1.4	1.9	Indexer	No	1.45
DRV8818	2.5 A stepper driver (8 microsteps) (P2P with 8811)	8 to 35	1.75	2.5	Indexer	No	1.85
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 with 8825)	8 to 45	1.1	1.6	Indexer	No	1.50
DRV8825	2.5 A stepper driver (32 microsteps) (P2P with 8824)	8 to 45	1.75	2.5	Indexer	No	1.90
DRV8846	1.4 A stepper driver with on-chip microstepping and AutoTune™ for automatic adaptive current decay (32 microsteps)	4 to 18	1	1.4	Indexer	No	1.40
DRV8880	2.0 A stepper driver with on-chip microstepping and AutoTune™ for automatic adaptive current decay (16 microsteps)	6.5 to 45	1.4	2.0	Indexer	No	1.92
DRV8885	1.5 A stepper driver with on-chip microstepping and integrated current sensing for current regulation (16 microsteps) (P2P with 8884)	8 to 37	1	1.5	Indexer	No	1.49
DRV8884	1.5A stepper driver with on-chip microstepping and integrated current sensing for current regulation (16 microsteps) (P2P with 8885)	8 to 37	1	1	Indexer	No	1.30
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 with indexer	8 to 60	1.4	2	Indexer	No	1.40
DRV8806	2 A unipolar stepper driver with open load detect	8 to 40	1.4	2	Serial	Yes (4x)	1.50
DRV8860	Dual 330 mA Unipolar stepper driver	8 to 38	0.33	0.33	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
DRV8833C	1 A stepper driver	2.7 to 10.8	0.7	1	PWM	No	0.85
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 with 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
DRV8846	1.4 A stepper driver with on-chip microstepping and AutoTune™ for automatic adaptive current decay (32 microsteps)	4 to 18	1	1.4	Indexer	No	1.40
DRV8848	2 A stepper driver	4 to 18	1	2	PWM	No	1.30
Stepper FET gate driver							
DRV8711	Stepper FET gate 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.† Available in Q1 versions.*

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

Selection guides for analog motor solutions

Brushed DC motor drivers

Brushed DC motor drivers

www.ti.com/motordrivers

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
DRV8801A†	Automotive qualified 2.8 A brushed DC driver with current-sense pin and wettable flank package	6.5 to 36	1.5	2.8	Phase/enable	No	1.60
DRV8816	2.8 A brushed DC driver with independent half bridge control	8 to 38	1.5	2.8	PWM/enable	Yes (2x)	1.50
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	PWM	Yes (2x)	2.25
DRV8844	5 A brushed DC driver with split supply support (±30 V)	8 to 60	3.5	5	PWM	Yes (4x)	2.50
LMD18200	3 A, 55 V H-bridge for DC motors	12 to 55	3	6	PWM	No	8.10
LMD18201	3 A, 55 V H-bridge for DC motors	12 to 55	3	6	PWM	No	7.70
LMD18245	3 A, 55 V H-bridge for DC motors	12 to 55	3	6	4 bit digital	No	9.15
DRV8701	12 V to 24-V brushed DC gate driver with integrated current shunt amplifier, 3.3-V or 5-V LDO, and adjustable gate drive settings	5.9 to 45	Ext FETs	Ext FETs	PWM or phase/enable	No	0.92
DRV8870	3.6 A brushed DC driver with current regulation	6.5 to 45	2	3.6	PWM	No	1.28
DRV8871	3.6 A brushed DC driver with integrated current sensing (eliminates need for external current sensing resistor for current regulation)	6.5 to 45	2	3.6	PWM	No	1.41
DRV8872	3.6 A brushed DC driver with fault condition reporting	6.5 to 45	2	3.6	PWM	No	1.28
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
DRV8704	Dual brushed DC gate-driver for external FETs	8 to 52	Ext FETs	Ext FETs	PWM, or SPI	No	2.75
DRV8802†	Dual 1.6 A brushed DC driver (P2P with 8814)	8 to 45	1.1	1.6	Phase/enable	No	1.65
DRV8814	Dual 2.5 A brushed DC driver (P2P with 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 with split supply support (±30 V)	8 to 60	1.75	2.5	PWM	Yes (4x)	2.50
DRV8848	Dual 2 A or single 4 A brushed DC motor driver	4 to 18	1 or 2	2 or 4	PWM	No	1.30
DRV8881E	Dual 2.5 A or single 5 A brushed DC driver	6.5 to 45	1.4 or 2.8	2.5 or 5	Phase/enable	No	1.60
DRV8881P	Dual 2.5 A or single 5 A brushed DC driver	6.5 to 45	1.4 or 2.8	2.5 or 5	PWM	No	1.60
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	1.5 or 3	2 or 4	PWM	No	0.95
DRV8833C	Dual 1 A or single 2 A brushed DC driver	2.7 to 10.8	0.7 or 1.4	1 or 2	PWM	No	0.80
DRV8835	Dual 1.5 A or single 3 A brushed DC driver with dual supplies	2.0 to 11	1.5 or 3	1.5 or 3	PWM or phase/enable	No	0.70
DRV8836	Dual 1.5 A or single 3 A brushed DC driver	2.0 to 7	1.5 or 3	1.5 or 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
DRV8838	1.8 A brushed DC driver with dual supplies	1.8 to 11	1.8	1.8	Phase/enable	No	0.45
DRV8839	Dual 1.8 A uni-direction or single 1.8 A bi-direction brushed DC driver	1.8 to 11	1.8	1.8	PWM	Yes (2x)	0.50
DRV8848	Dual 2 A or single 4 A brushed DC driver	4 to 18	1 or 2	2 or 4	PWM	No	1.30
DRV8850	8 A low-voltage brushed DC driver	2 to 5.5	5	8	PMW	Yes (2x)	0.52

**Suggested resale price in U.S. dollars in quantities of 1,000. See www.ti.com/hirel for HiRel options. † Available in Q1 versions.*

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

Selection guides for analog motor solutions
Brushless DC motor drivers

Brushless DC motor drivers

www.ti.com/**motordrivers**

Device	Description	Supply voltage (V)	I_{OUT} cont. (A)	I_{OUT} peak (A)	Control interface	Drives solenoids	Price*
3-phase drivers and gate drivers							
DRV8301	3-phase FET gate 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	3-phase FET gate 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	3-phase FET gate driver with dual current-sense amps (SPI config)	6 to 60	Ext FETs	Ext FETs	PWM	No	1.95
DRV8305	3-phase FET gate driver with three integrated current-sense amplifiers	4.4 to 45	Ext FETs	Ext FETs	PWM	No	2.30
DRV8305-Q1	Automotive qualified 3-phase FET gate driver with three integrated current-sense amplifiers (Grade 1 and Grade 0 options)	4.4 to 45	Ext FETs	Ext FETs	PWM	No	2.80
DRV8307	3-phase sinusoidal or trapezoidal controller + gate driver with digital speed loop	8.5 to 32	Ext FETs	Ext FETs	PWM	No	1.20
DRV8308	3-phase trapezoidal controller + gate driver	8.5 to 32	Ext FETs	Ext FETs	CLK, PWM or SPI	No	1.20
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 (new **6 mm x 6 mm** QFN package option available)	8 to 60	1.75	2.5	PWM	Yes (3x)	2.25
DRV8332	13 A high-performance 3-phase driver (see **www.ti.com/hirel** for HiRel options)	0 to 52	8	13	PWM	Yes (3x)	4.70

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

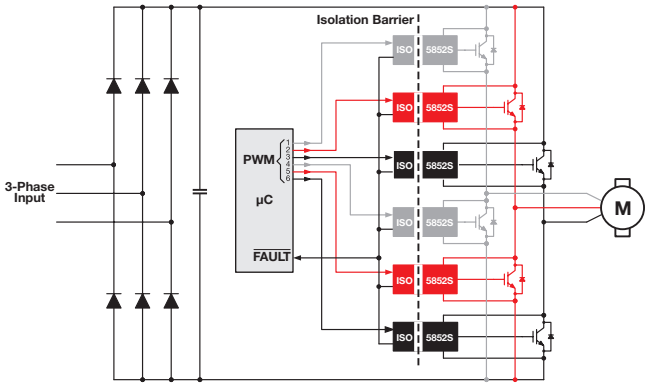
*New products are listed in **bold red**.*

Gate drivers
ISO585x, ISO545x and UCC21520 families of isolated gate drivers

ISO585x and ISO545x

TI's ISO585x and ISO545x products are isolated gate drivers for IGBTs with DC bus voltages up to 2121 V.

The input CMOS 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

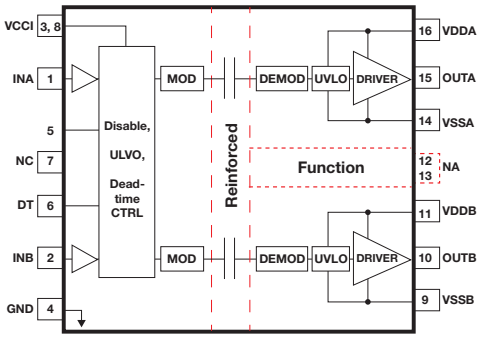
- 100 kV/µs minimum common-mode transient immunity (CMTI)
- Split outputs to provide 2.5 A peak source and A peak sink currents
- Short propagation delay: 76 ns (typ), 110 ns (max)

UCC21520

TI's new UCC21520 is the first in a new family of gate drivers in TI's isolation portfolio. The UCC21520 is the industry's fastest 5.7 kV RMS isolated dual channel gate driver and can be used as a low-side, high-side, high-side/low-side or half-bridge driver. With the ability to configure the device for multiple applications, along with its integrated components, advanced protection features and optimized switching performance, the UCC21520 delivers faster time-to-market for high-frequency, switched-mode power electronic applications involved in high-power and high-voltage conversion.

Key features

- 6 A/4 A sink/source current capability
- 25 ns (typ) propagation delay
- 100 V/ns minimum CMTI
- 3 ~ 18 V wide input range / 6.5 ~ 30 V wide output voltage range



Isolated gate drivers

Device	Description	Isolation rating (kVrms)	Working voltage (kVrms)	Input V_{CC} (min) (V)	Input V_{CC} (max) (V)	Output V_{CC} (min) (V)	Output V_{CC} (max) (V)	Propagation delay (max) (ns)	Operating temperature range (°C)	Pin/package	Price*
ISO5451	Reinforced isolated IGBT gate driver with high CMTI and Miller clamp	5.7	1.0	2.25	5.5	15	30	110	–40 to 125	16/SOIC	2.15
ISO5452	Isolated IGBT gate driver with high CMTI, split outputs and safety features	5.7	1.0	2.25	5.5	15	30	110	–40 to 125	16/SOIC	2.25
ISO5851	Reinforced isolated IGBT gate driver with high CMTI and Miller clamp	5.7	1.5	2.25	5.5	15	30	110	–40 to 125	16/SOIC	4.50
ISO5852S	Reinforced isolated IGBT gate driver with high CMTI, split outputs and safety features	5.7	1.5	2.25	5.5	15	30	110	–40 to 125	16/SOIC	4.60
UCC21520	Reinforced isolated dual-channel universal gate driver	5.7	1.5	3	18	6.5	30	25	-40 to 125	16/SOIC	2.88

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

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

Gate drivers

Low-side and half bridge gate drivers for motor control

In motor control, power transistors form the “bridge” connecting the control to the motor. A controller switches the power transistors, typically MOSFETs and IGBTs, in a sequential manner to obtain the desired speed, direction and position of the motor shaft. Since the high power transistors cannot be driven directly by the controller, gate drivers take the commutation signals from the controller and efficiently drive the transistors.

TI offers a wide variety of gate drivers for different motor types and drive configurations, such as DC brush, DC brushless, stepper and AC induction. The portfolio consists of low-side drivers with up to 35 V operation and ½ bridge drivers for up to 600 V power busses. The drivers have a mix of features including different drive strengths, inverting or non-inverting inputs, split ON/OFF outputs, high drive voltage for split gate drive configurations and dead-time programming. Designed for harsh environments, the drivers are tolerant of negative input and switch-node voltages.

MOSFET and IGBT gate drivers

Device	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 V_{DD} 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	4 A/8 A 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	4 A/4 A single-channel high-speed low-side gate driver with 5 V 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, 5 A, 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
UCC27517A	Single-channel 4 A high-speed, low-side gate driver with inverting or non-inverting configuration with 5 V 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 4 A 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 5 A 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 2.5 A/5 A, 35 V max V_{DD} FET and IGBT gate driver with split output and with 5 V 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 7 A 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	120 V boot, 3 A/4 A 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
UCC27714	High-speed, 4 A, 600 V high-side low-side gate driver	Dual, non-inverting	4	8	18	15	15	90	TTL/CMOS	–40 to 125	14/SOIC	1.75
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	100 V boot, 1 A 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
LM5109B	High voltage 1 A peak half bridge gate driver	Dual, independent	1	7.5	14	15	15	25	TTL	–40 to 125	8/SOIC, 8/WSON	0.50
LM5101B	3 A high voltage high-side and low-side gate driver	Dual, independent	3	7.5	14	10	10	25	TTL	–40 to 125	8/SO PowerPAD, 8/SOIC, 8/WSON	1.16
LM5105	100 V half bridge gate driver with programmable dead-time	Dual, single	2	7.5	14	10	10	35	TTL	–40 to 125	10/WSON	0.90

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

NexFET power MOSFET
Single N-channel and dual 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)	RDS_{ON} @ V_{GS} = 10 V (mΩ)	Q_G (nC)	Q_{GD} typ (nC)	Q_{GS} (nC)	Configuration	Package	Operating temp. range (°C)
CSD18501Q5A	40	20	1.8	161	2.5	42	5.9	8.1	Single	SON5x6	–55 to 150
CSD18502KCS	40	20	1.8	212	2.4	52	8.4	10.3	Single	TO-220	–55 to 175
CSD18502Q5B	40	20	1.8	204	1.8	52	8.4	10.3	Single	SON5x6	–55 to 150
CSD18503KCS	40	20	1.9	142	3.6	30	4.6	7.7	Single	TO-220	–55 to 175
CSD18503Q5A	40	20	1.8	121	3.4	26	4.3	4.5	Single	SON5x6	–55 to 150
CSD18504KCS	40	20	1.9	89	5.5	19	3.5	4.4	Single	TO-220	–55 to 175
CSD18504Q5A	40	20	1.8	75	5.3	16	2.4	3.2	Single	SON5x6	–55 to 150
CSD18509Q5B	40	20	1.9	299	1	150	17	29	Single	SON5x6	–55 to 150
CSD18531Q5A	60	20	1.8	134	3.5	36	5.9	6.9	Single	SON5x6	–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	SON5x6	–55 to 150
CSD18532Q5B	60	20	1.8	172	2.5	44	7.9	10	Single	SON5x6	–55 to 150
CSD18533KCS	60	20	1.9	118	5	28	3.9	9.4	Single	TO-220	–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	73	7.6	19	3.1	4.8	Single	TO-220	–55 to 150
CSD18534Q5A	60	20	1.9	69	7.8	17	3.5	3.2	Single	SON5x6	–55 to 150
CSD18535KCS	60	20	1.6	279	1.6	63	10.4	15.7	Single	TO-220	–55 to 175
CSD18536KCS	60	20	1.3	349	1.3	83	14	18	Single	TO-220	–55 to 175
CSD18537NKCS	60	20	3	56	11	14	2.3	5.2	Single	TO-220	–55 to 175
CSD18537NQ5A	60	20	3	54	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	–55 to 150
CSD18563Q5A	60	20	2	91	5.7	15	2.9	3.3	Single	SON5x6	–55 to 150
CSD19501KCS	80	20	2.6	129	5.5	38	5.8	12.4	Single	TO-220	–55 to 175
CSD19502Q5B	80	20	2.7	157	3.4	48	8.6	14	Single	SON5x6	–55 to 150
CSD19503KCS	80	20	2.8	94	7.6	28	5.4	9.8	Single	TO-220	–55 to 175
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	110	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	SON5x6	–55 to 150
CSD19532Q5B	100	20	2.6	140	4	48	8.7	13	Single	SON5x6	–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
CSD19534KCS	100	20	2.7	54	13.7	16.4	3.2	5.1	Single	TO-220	–55 to 175
CSD19535KCS	100	20	2.7	187	3.1	78	13	25	Single	TO-220	–55 to 175
CSD19536KCS	100	20	2.5	259	2.3	118	17	37	Single	TO-220	–55 to 175
CSD19535KTT	100	20	2.7	197	2.8	75	11	24	Single	D2PAK	–55 to 175
CSD19536KTT	100	20	2.5	272	2.5	118	17	37	Single	D2PAK	–55 to 175
CSD19537Q3	100	20	3	53	12.1	16	2.9	5.5	Single	SON3x3	–55 to 150

Dual N-channel

Device	V_{DS} (V)	V_{GS} (V)	$V_{GS(TH)}$ typ (V)	I_D max @ T_C= 25°C (A)	RDS_{ON} @ V_{GS} = 10 V (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

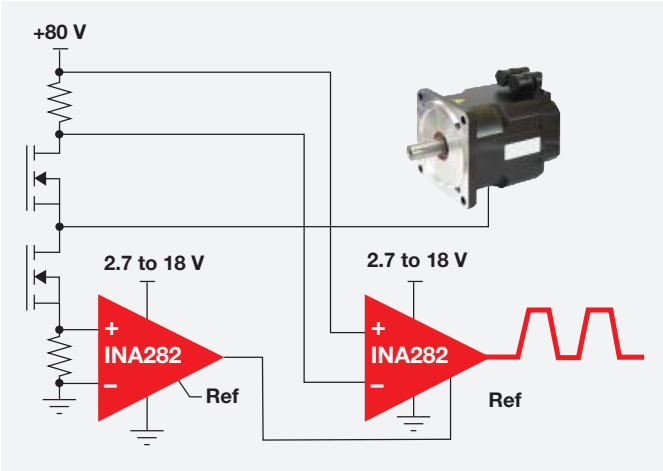
*New products are listed in **bold red**.*

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

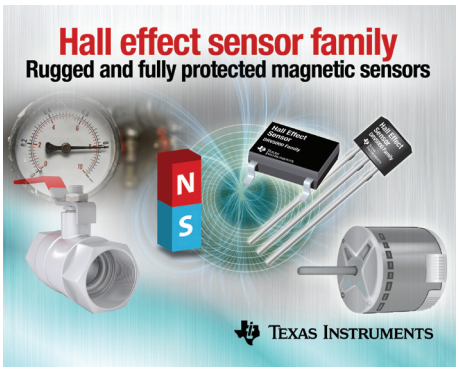
Device	CMR (V)	Offset	Offset drift µV/°C	Bidirectional
INA138/INA139	2.7 to 36	1 mV	1	No
INA149	–275 to 275	1.1 mV	3	Yes
INA168/INA169	2.7 to 60	1 mV	1	No
INA170	2.7 to 60	1 mV	1	Yes
INA193-INA198	–16 to 80	2 mV	2.5	No
INA282	–14 to 80	70 µV	0.5	Yes
LMP8601	–22 to 60	1 mV	10	Yes
LMP8603	–22 to 60	1 mV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

Signal chain solutions
DRV5000 Hall effect sensors

DRV5000 Hall effect sensors

Texas Instruments is investing in magnetic Hall effect sensors for future sensing needs and continues to build upon a robust and growing sensor portfolio. This offering of switches and latches includes sensors of various magnetic sensitivities for system flexibility. These sensors are used in applications from home appliances all the way to the harshest automotive powertrain systems where the reliability of the sensor is important to the safety and performance of the automobile. These Hall effect sensors are tested in production at 165 degrees Celsius, operate at the widest voltage range in industry, come in AEC-Q100 variants and integrate protection features for reverse supply (down to -22 V) and overvoltage conditions (up to 40 V).

Along with TI's existing portfolio of Hall effect sensors, this year the DRV5032 will be released and will be the world's lowest power Hall effect sensor for battery powered and IoT sensing applications. As part of this development, TI is also building a low-sensitivity Hall effect switch for tamper detection in systems like smart utility meters, a 30 kHz Hall effect latch in a tiny 1.1x1.4 mm SON package, as well as an ultra-low power latch with a pin-selectable sample rate, just to name a few. More details can be found below in the tables provided.



Why are they used?

- Solid-state devices include signal conditioning and protection logic
- Magnetic sensing is a highly repeatable operation (no mechanical wear or tear)
- Contact is not required for operation
- Hall effect sensors are immune to dust, dirt, air, RF noise
- Hall effect sensors are invariable over a wide temp range
- The devices are pin-to-pin compatible and low cost (only 3 pins)

TI's DRV5000 Hall effect sensors support a variety of applications

Some examples include:

- 3-phase BLDC motors
- Index counting
- Position, speed, acceleration
- Presence detection
- Proximity sensing
- Open/close detection

Key benefits of a TI integrated Hall effect sensor solution

- Large voltage operating range (2.5 V to 38 V)
- Supports high-voltage load dump (up to 40 V)
- Devices feature a power-on "ready" pulse at start-up
- Fast power-on time (35 µsec)
- Fast switching time (less than 15 µsec)
- Reverse supply protection (up to –22 V)
- Overcurrent protection

Low voltage Hall effect switches and latches

Device	Description	Sensitivity identifier	Maximum operating point (mT)	Minimum release point (mT)	Typical hysteresis (mT)	Available temperature range		Additional Special Feature	Packages	Price*
						Automotive grade 1 -40 to 125°C	Industrial -40 to 125°C			
DRV5011	Industrial latch	AD	4.8	-4.8	6.2		✔	World's first 30 kHz bandwidth latch, ultra tiny 1.1x1.4 mm SON package	SOT-23, SON	0.30
DRV5011-Q1	AEC-Q100 qualified automotive Hall effect latch	AD	4.8	-4.8	6.2	✔		Automotive latch for encoding DC motors for automotive applications such as window lifters, sunroofs, seat positioners, seatbelt positioners, and other motors in automobiles	SOT-23	0.35
DRV5021-Q1	Automotive unipolar switch, AEC-Q100 qualified	C	14	4	2	✔		–	SOT-23	0.35
		D	32	10	4	✔		–	SOT-23	0.35
		DI	-32	-10	4	✔		Automotive Hall effect switch that responds to magnetic north poles	SOT-23	0.35

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

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

For more information visit **www.ti.com/DRV5000**

Signal chain solutions
DRV5000 Hall effect sensors

Digital output Hall effect switches, latches and linear output devices

Device	Description	Sensitivity identifier	Maximum operating point (mT)	Minimum release point (mT)	Typical hysteresis (mT)	Available temperature range: Automotive grade 0 -40 to 150°C	Available temperature range: Automotive grade 1 -40 to 125°C	Available temperature range: Industrial -40 to 125°C	Additional Special Features	Packages	Price*
DRV5013	Industrial latch	FA	3.2	-3.2	2.6			✔	TI's highest sensitivity latch	SOT-23	0.26
		AD	5	-5	5.4			✔	–	SOT-23, TO-92	0.26
		AG	9	-9	12			✔	–	SOT-23, TO-92	0.26
		BC	18	-18	24			✔	–	SOT-23, TO-92	0.26
DRV5013-Q1	Automotive latch, AEC-Q100 qualified	FA	3	3	2.6	✔			TI's highest sensitivity AEC-Q100 qualified latch	SOT-23	0.29
		AD	5	-5	5.4	✔	✔		–	SOT-23, TO-92	0.29
		AG	9	-9	12	✔	✔		–	SOT-23, TO-92	0.29
		BC	18	-18	24	✔	✔		–	SOT-23, TO-92	0.29
DRV5023	Industrial unipolar switch	FA	6.8	0.5	1.5			✔	TI's highest sensitivity unipolar switch	SOT-23	0.26
		AJ	12	1	3.7			✔	–	SOT-23, TO-92	0.26
		BI	24	3	8.5			✔	–	SOT-23, TO-92	0.26
DRV5023-Q1	Automotive unipolar switch, AEC-Q100 qualified	FA	6.8	0.5	1.5	✔			TI's highest sensitivity AEC-Q100 qualified unipolar switch	SOT-23	0.29
		FI	6.8	0.5	1.5	✔			Identical to DRV5023FA-Q1 but has an inverted output (switches high in presence of a south pole). It can be used in conjunction with the DRV5023FA for redundancy in automotive applications	SOT-23	0.29
		AJ	12	1	3.7	✔	✔		–	SOT-23, TO-92	0.29
		BI	24	3	8.5	✔	✔		–	SOT-23, TO-92	0.29
DRV5033	Industrial omnipolar switch	FA	±6.8	±0.5	1.5			✔	TI's highest sensitivity omnipolar switch	SOT-23	0.26
		AJ	±12	±1	3.4			✔	–	SOT-23, TO-92	0.26
DRV5033-Q1	Automotive omnipolar switch, AEC-Q100 qualified	FA	±6.8	±0.5	1.5	✔			TI's highest sensitivity AEC-Q100 qualified omnipolar switch	SOT-23	0.29
		AJ	±12	±1	3.4	✔	✔		–	SOT-23, TO-92	0.29
DRV5053	Industrial analog bipolar output	See datasheet	N/A	N/A	N/A			✔	–	SOT-23, TO-92	0.31
DRV5053-Q1	Automotive analog bipolar output, AEC-Q100 qualified	See datasheet	N/A	N/A	N/A	✔	✔		–	SOT-23, TO-92	0.34

Micropower Hall effect switches and latches (1.65 to 5.5 V)

Device	Description	Sensitivity identifier	Maximum operating point (mT)	Minimum release point (mT)	Typical hysteresis (mT)	Available temperature range: Automotive grade 2 -40 to 125°C	Available temperature range: Industrial -40 to 125°C	Bandwidth	Typical Current at 1.8V	Additional Special Features	Packages	Price*
DRV5012	Industrial latch	AE	4.8	-4.8	6.2		✔	20 Hz / 2.5 kHz	1 / 76 µA	Pin-selectable sample rate for reducing power	SON	0.40
DRV5032	Industrial switch	FA	±4.8	±0.6	1.5		✔	20 Hz	1 µA	–	SOT-23, SON	0.30
		FB	±4.8	±0.6	1.5		✔	5 Hz	0.4 µA	World's lowest power Hall effect switch (0.4 µA)	SOT-23	0.40
		FC	±4.8	±0.6	1.5		✔	20 Hz	1 µA	–	SOT-23	0.30
		AJ	±11	±3.1	1.5		✔	20 Hz	1 µA	–	SOT-23, SON	0.30
		FD	±4.8	±0.6	1.5		✔	20 Hz	1 µA	TI's Hall effect sensor for case-closure detection of personal electronic devices such as tablets, cell phones and laptop computers	SON	0.30
		ZE	±70	±25	4		✔	20 Hz	1 µA	Low sensitivity Hall effect switch for environmental magnetic immunity and for detecting large magnetic fields in applications such as tamper detection in smart utility meters	SOT-23	0.30
DRV5032-Q1	Automotive unipolar switch	AK	11	3.1	1.5	✔		320 Hz	10 µA	TI's Hall effect sensor for automotive system wake-up and brake light activation	SOT-23	0.35

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.***

Signal chain solutions
Precision magnetic fluxgate sensors

DRV425x integrated fluxgate magnetic sensors

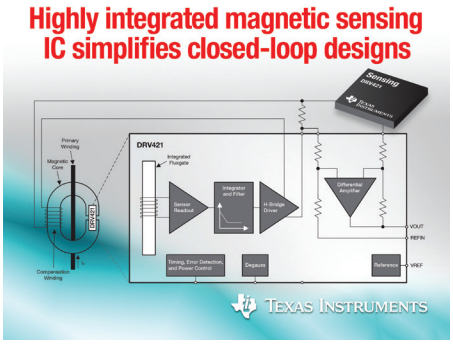
Integrated magnetic sensors have a broad range of applications, such as position sensing, compasses and isolated current sensing of DC and AC currents. Although Hall plates are widely used, they tend to be limited in terms of their offset, noise, gain stability and achievable linearity. Fluxgate magnetic sensors offer higher performance, but until recently they were limited to discrete and at times bulky solutions.

TI's DRV42x family offers the industry's first integrated fluxgate magnetic sensor based current sensing solutions including diagnostic features like overrange and error flag.

The DRV421 targets the high-accuracy, high-bandwidth closed-loop current sensing solutions. The device provides high sensitivity, superior offset performance and small footprint. It exceeds the performance of discrete sensors, simplifies the assembly process and allows the use of concentrator core materials with improved high frequency properties. The DRV421's integrated sensor enables superior performance, best-in-class linearity and accuracy. It also reduces coil coupling, emissions and increases dynamic range.

The DRV425 targets open-loop current measurement methods and magnetic field measurement. Differentiated by its 4 decades of dynamic range, low -offset, low-noise, superior gain accuracy and stability, the DRV425 can be used for gradient field detection and isolated bus bar current measurement. The sensor sensitivity is set via a single gain resistor.

All the parts come with diagnostic functions like overrange detection and error flags for added safety. They also provide best-in-class linearity, along with very high precision and accuracy.



Integrated fluxgate magnetic sensors

Device	Description	Vs (min) (V)	Vs (max) (V)	System bandwidth (KHz)	Sensor offset (±) (µT) (typ)	Sensor drift (±) (nT/°C) (typ)	Gain error (max) (±) (ppm/°C)	Gain drift (typ) (±) (ppm/°C)	Diagnostic functions	Operating temp. range (°C)	Package	Price*
DRV421	3.0 V to 5.5 V Integrated magnetic fluxgate sensor	3.0	5.5	200	2	5	0.3	1	Overrange, error flags	–40 to 125	4 x 4 mm thin QFN20	2.50
DRV425	3.0 V to 5.5 V Fully integrated precision magnetic field sensor and readout	3.0	5.5	47	2	5	0.3	1	Overrange, error flags	–40 to 125	4 x 4 mm thin QFN20	2.90

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

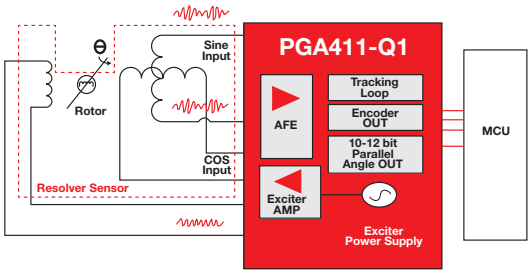
*New products are listed in **bold red**.*

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

Signal chain solutions
Resolver sensor signal conditioning

PGA411-Q1 resolver-to-digital converter with integrated power supply & exciter amplifier

Resolver sensors are rotary position sensors that are used for a wide range of motor drive applications to read and report the angle and velocity information of a moving motor shaft. The construction of this sensor is much like that of a mini transformer, with three windings of coil, allowing resolver sensors to do very well in end equipments that are in harsh environments such as: vibrations, extreme temperatures and particle contamination. A robust sensor like a resolver needs a sensor signal conditioning IC that is just as robust and brings integration, safety and precision along with it.



TI's PGA411-Q1 device is the industry's first resolver sensor signal conditioner with the resolver-to-digital functionality integrated into the same package as the exciter amplifier and power supply needed to run the resolver sensor allowing the signal chain required for exciting and reading from the resolver sensor to be reduced from more than ten components to just the PGA411-Q1 and a microcontroller. Due to the PGA411-Q1's integration, motor drive systems using a resolver are now able to achieve an overall reduction of board space and BOM cost.

In addition to the integration, the PGA411-Q1 also brings a comprehensive set of diagnostics features enabling the motor drive control to be designed for functional safety applications. Developed according to the requirements of the IEC 61508 standard, the PGA411-Q1 enables customers to fine tune their fault detection thresholds and filters to fit their sensor and system needs. Programmable features allow the PGA411-Q1 to easily be reprogrammed to fit the needs of a new sensor or new platform requirements.

The main feature of the PGA411-Q1 is the device's ability to report angle and velocity information about the motor shaft to the MCU. Most RDC solutions on the market today use ADCs to read the sine and cosine values into the device for processing. The PGA411-Q1 however, uses adjustable gain op amps to read in the signals of the sensor, keeping these values in the analog as long as possible. By doing this, the analog front end of the PGA411-Q1 eliminates the quantization noise that comes from digitizing the sensor values. This elimination of noise, allows the customer to reduce the overall noise floor in a system that already has noise from the motor and gate drivers.

Resolver sensors

Device	Description	Angular accuracy (arc min)	Output resolution (bits)	Max tracking (rpm)	Supply voltage (V)	Exciter amp (Iout) (mA)	Exciter freq. (kHz)	Phase correction	AFE gain	Operating temp range (° C)	Package	Price *
PGA411-Q1	Resolver-to-digital converter w/ integrated exciter amplifier, AFE and boost power supply	+/- 2.64 (12 bits) +/- 10.56 (10 bits)	12 10	72,000 (12 bits) 200,000 (10 bits)	5.0	145	10-20	Automatic & manual phase correction (+/- 90°)	Adjustable	-40 to 125	64 HTQFP	$12.96

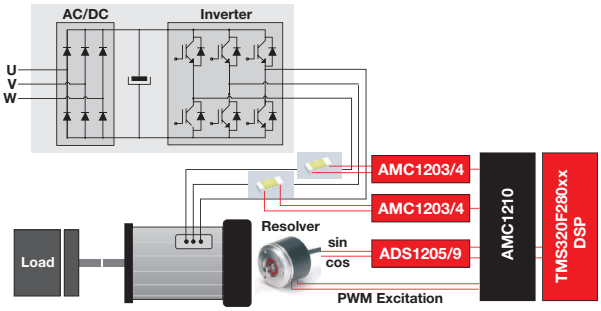
**Suggested resale price in U.S. dollars in quantities of 1,000.*

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.

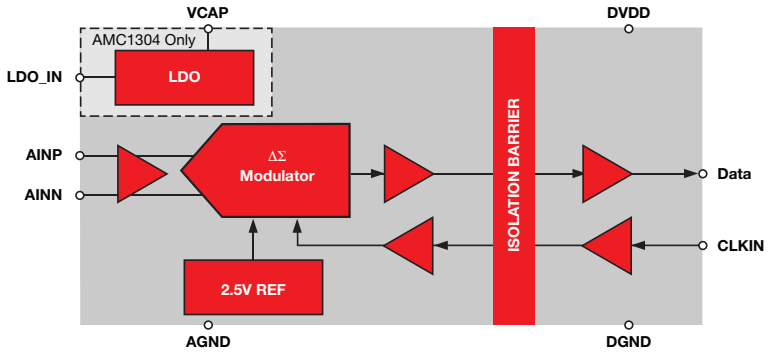
Analog front-end solution for motor control



20 MHz, 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, 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 ±50 mV shunt input range – enabling a 5x reduction in power consumed by the shunt resistor.



Key features

- ± 50 mV and ± 250 mV input ranges for current shunt resistors
- 5 MHz to 20 MHz external clock input enables synchronization of multiple devices
- Certified digital isolation: UL1577 and IEC60747-5-5 approved:
  - Working voltage: 1.0 kVRMS, 1.5 kVDC
  - Isolation voltage: 7 kVPEAK/ 10 kVSURGE (reinforced isolation)
  - Transient immunity: 15 kV/µs (min)
- Integrated LDO allows extremely wide input supply range of 4 V to 18 V (AMC1304)
- Extended industrial temperature range of –40°C 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/µs)	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	3.80
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	3.80/3.50
Isolated amplifier								
AMC1200/1200B	Isolated amplifier with G=8	±250	4000/4250	10	3.3/5	N	SOP-8, SOIC-8	2.20
AMC1301	Reinforced isolated amplifier with G=8	±250	7000/8400	15	3.3/5	N	SOIC-8	2.90
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**.*

Signal chain solutions
ADCs for motor control

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*
ADC3221	12	25 MSPS	2	Serial LVDS	2 Vp-p	Int/ext	60	ADC3224EVM	48QFN	14.25
ADC3241	14	25 MSPS	2	Serial LVDS	2 Vp-p	Int/ext	60	ADC3244EVM	48QFN	21.75
ADC3421	12	25 MSPS	4	Serial LVDS	2 Vp-p	Int/ext	44.25	ADC3424EVM	48QFN	21.38
ADC3441	14	25 MSPS	4	Serial LVDS	2 Vp-p	Int/ext	44.25	ADC3444EVM	48QFN	32.63
ADS7042	12	1 MSPS	1	Serial SPI	0 to 3.6	Int	0.234	ADS7042EVM-PDK	8VSSOP/8X2QFN	2.10
ADS7223	12	1 MSPS	4	Serial SPI	$\pm V_{REF}$	Int/ext	47.2	—	32VQFN	3.95
ADS7250	12	750 kSPS	2	Serial SPI	0 to 5.5	Ext	25	ADS8350EVM-PDK	16WQFN	3.00
ADS7251	12	2 MSPS	2	Serial SPI	0 to 5.5	Int	55	ADS7851EVM-PDK	16TSSOP/16WQFN	4.50
ADS7253	12	1 MSPS	2	Serial SPI	0 to 5.5	Int	42.5	ADS7853EVM-PDK	16TSSOP/16WQFN	3.50
ADS7254	12	1 MSPS	2	Serial SPI	0 to 5.5	Int	42.5	ADS7854EVM-PDK	16TSSOP/16WQFN	4.00
ADS7263	14	1 MSPS	4	Serial SPI	$\pm V_{REF}$	Int/ext	47.2	—	32VQFN	6.95
ADS7850	14	750 kSPS	2	Serial SPI	0 to 5.5	Ext	40	ADS8350EVM-PDK	16WQFN	5.00
ADS7851	14	1.5 MSPS	2	Serial SPI	0 to 5.5	Int	50	ADS7851EVM-PDK	16WQFN	7.00
ADS7852	12	500 kSPS	8	Parallel CMOS	+5	Int/ext	13	—	32TQFP	3.40
ADS7853	14	1 MSPS	2	Serial SPI	0 to 5.5	Int	42.5	ADS7853EVM-PDK	16TSSOP/16WQFN	6.00
ADS7854	14	1 MSPS	2	Serial SPI	0 to 5.5	Ext/int	45	ADS7854EVM-PDK	16TSSOP/16WQFN	6.50
ADS7861	12	500 kSPS	4	Serial SPI	±2.5 @ ±2.5	Int/ext	25	ADS7861EVM	24SSOP/32VQFN	4.05
ADS7862	12	500 kSPS	4	Parallel CMOS	±2.5 @ ±2.5	Int/ext	25	—	32TQFP	5.70
ADS7863A	12	2 MSPS	4	Serial SPI	$\pm V_{REF}$	Ext, int	35.5	ADS7863EVM	24SSOP/24VQFN	4.88
ADS7865	12	2 MSPS	6	Parallel	2. to 5.5	Ext, int	30	—	32TQFP	4.90
ADS8350	16	750 kSPS	2	Serial SPI	0 to 5.5	Ext	40	ADS8350EVM-PDK	16WQFN	8.00
ADS8353	16	600 kSPS	2	Serial SPI	0 to 5.5	Ext/int	42.5	ADS8353EVM-PDK	16TSSOP/16WQFN	9.00
ADS8354	16	700 kSPS	2	Serial SPI	0 to 5.5	Ext/int	45	ADS8354EVM-PDK	16TSSOP/16WQFN	9.50
ADS8361	16	500 kSPS	4	Serial SPI	±2.5 @ ±2.5	Int/ext	150	ADS8361EVM	24SSOP/32VQFN	9.19
ADS8363	16	1 MSPS	4	Serial SPI	$\pm V_{REF}$	Int/ext	47.2	ADS8363EVM	32VQFN	9.95
ADS8364	16	250 KSPS	6	Parallel	4.75 to 5.25	Ext, int	413	ADS8364M-EVM	64TQFP	18.10
ADS8365	16	250 KSPS	6	Parallel	4.75 to 5.25	Ext, int	190	ADS8365M-EVM	64TQFP	16.25
ADS8528	12	650 kSPS	8	Parallel or SPI	V_{REF}, 2 V_{REF}	Int/ext	335	ADS8568EVM-PDK	64LQFP/64VQFN	9.50
ADS8548	14	600 kSPS	8	Parallel or SPI	V_{REF}, 2 V_{REF}	Int/ext	335	ADS8568EVM-PDK	64LQFP/64VQFN	12.50
ADS8556	16	630 kSPS	6	Parallel or SPI	±1 to ±12	Int/ext	251.7	ADS8556EVM	64LQFP	12.95
ADS8557	14	670 kSPS	6	Parallel or SPI	±1 to ±12	Int/ext	253.2	ADS8557EVM	64LQFP	10.95
ADS8558	12	730 kSPS	6	Parallel or SPI	±1 to ±12	Int/ext	262.2	ADS8558EVM	64LQFP	8.95
ADS8568	16	500 kSPS	8	Parallel or SPI	V_{REF}, 2 V_{REF}	Int/ext	335	ADS8568EVM-PDK	64LQFP/64VQFN	15.90
ADS7869	12	1 MSPS	12	Parallel or SPI	0 to 5.5	Int	250	—	100TQFP	15.62

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

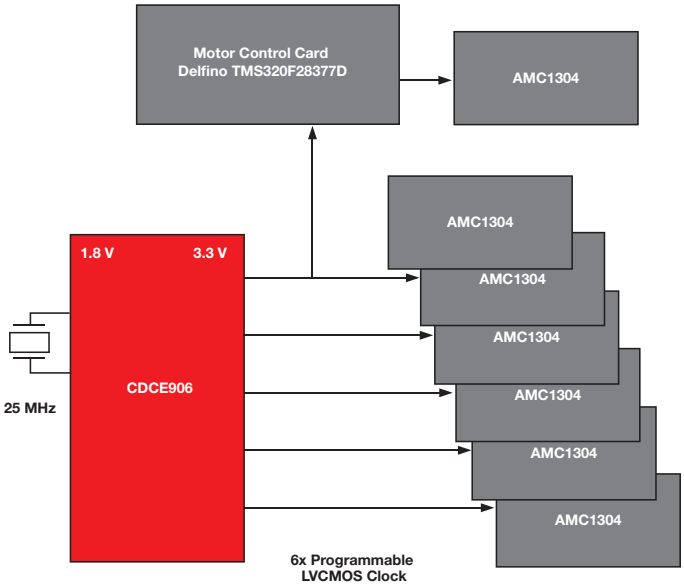
*New products are listed in **bold red**. Preview products are listed in **bold teal**.*

Signal chain solutions
Clock generation and distribution

TI's large clocking portfolio provides all you need to build up a solid and optimized clock tree in your design. For a complete list of TI clocking devices, see **www.ti.com/clocks**

Clock generation and distribution for sigma delta converters and ADCs

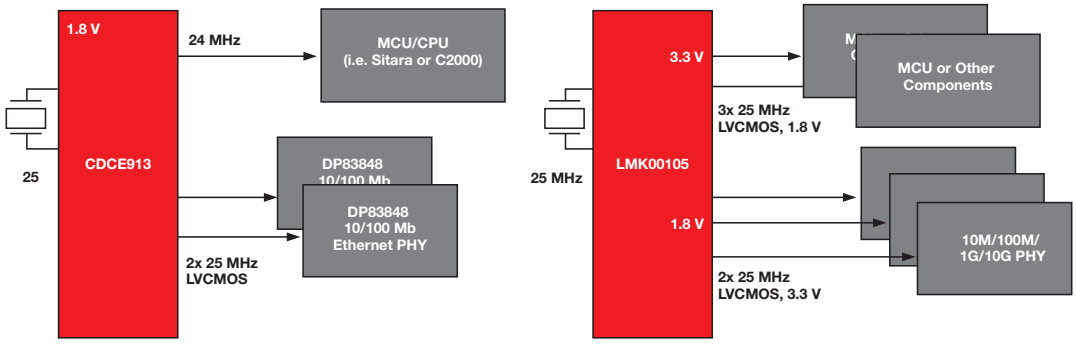
In order to generate clock signals or distribute existing clock signals to sigma delta converters, such as the AMC104/5, or to any low speed ADC, see the examples below. A well-designed clock tree ensures that all your sampling points are in sync, or in other words: all your ADCs receive the clock edge at the same point in time.



Clocking example for AMC1304 sigma delta modulator

Clock generation and distribution of Ethernet PHY interfaces

If your application features multiple Ethernet PHYs, you may consider using clock distribution instead of individual XOs at each PHY. This can potentially result in cost and area savings.



Examples for Ethernet PHY clocking

Clocks for motor control

Device	Description	Number of inputs	Input type	Number of outputs	Output type
CDCE906	Flexible clock generator with 6 outputs, 3 PLL and 4 independent clock domains; SSC supported	1	XTAL or LVCMOS	6	LVCMOS
CDCE913	Flexible clock generator with 3 outputs, 1 PLL and 2 independent clock domains; SSC supported (also other devices of CDCE9xx family)	1	XTAL or LVCMOS	3	LVCMOS
CDCLVC11xx	1:xx LVCMOS buffer	1	LVCMOS	2, 3, 4, 6, 8, 10 or 12	LVCMOS
LMK00101	1:10 clock buffer with 2 independent output voltage domains	1	XTAL or LVCMOS	10	LVCMOS
LMK00105	1:5 clock buffer with 2 independent output voltage domains	1	XTAL or LVCMOS	5	LVCMOS

Please note that TI also offers a rich portfolio of clocking solutions for high speed ADCs. Those are not listed here as usually those are not of interest for motor drive applications.

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.

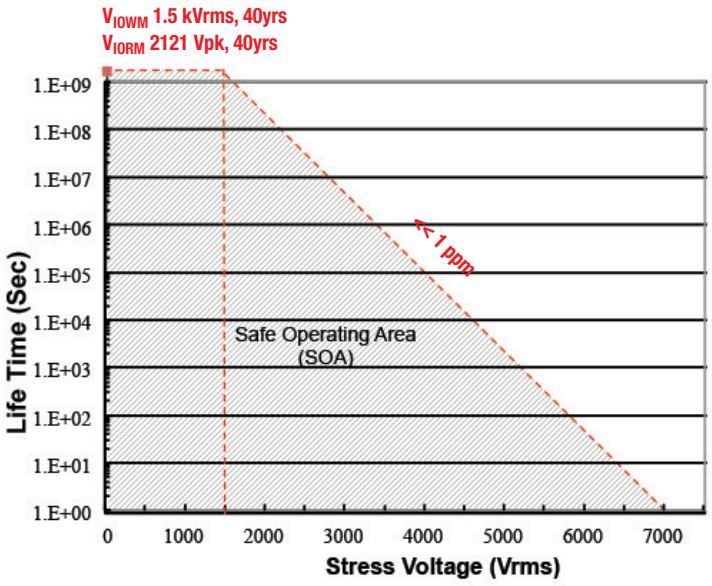
Signaling rate

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

Device	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*
ISO71xx	Small-footprint and low-power digital isolators with noise filter	2500	4242	560	4, 3	50	2.7	5	High/low (F)	23	–40 to 125	16/SSOP	1.60
ISO73xx	Low power digital isolators with noise filter	3000	4242	1414	4, 3, 2, 1	25	3.3	5	High/low (F)	31	–40 to 125	16/SOIC, 8/SOIC	0.90
ISO73xx-Q1	Low power digital isolators with noise filter, automotive qualified	3000	4242	1414	4, 3, 2, 1	25	3.3	5	High/low (F)	31	–40 to 125	16/SOIC, 8/SOIC	1.13
ISO78xx	High-immunity, 5.7 kVRMS reinforced digital isolators, 100 Mbps	5700	8000	2121	4, 3, 2, 1	100	2.25	5.5	High/low (F)	11	–55 to 125	16/SOIC	1.75

**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**.*

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

Signal chain solutions
Industrial communications

Industrial interface transceivers

Device	Description	Isolated	Bus fault voltage (V)	I_{CC} (max) (mA)	Common mode voltage (VCM)	Number of nodes	Data rate	Duplex	ESD	Supply voltage(s) (V)	Special features	Operating temperature range (°C)	Pin/ package	Price*
CAN transceivers														
SN65HVD255/ 256/257	'Turbo' CAN transceiver with fast loop times for highly loaded networks and features for functional safety	No	–27 to 40	85	–2 to 7	—	10 kbps to 1 Mbps	Half	±12 kV HBM ESD protection	2.8 to 5.5	High-speed, turbo short prop delay, redundancy and functional safety	–40 to 125	8/SOIC	0.50/0.60
SN65HVD265/ 266/267	'Turbo' CAN transceivers for CAN with flexible data rate (FD) and redundancy	No	–27 to 40	85	–2 to 7	—	2 Mbps FD	Half	+12 kV HBM ESD protection	2.8 to 5.5	Flexible data rate (FD) high speed, short prop delay, RXD IO supply, functional safety	–40 to 125	8/SOIC	0.59/0.71
SN65HVD1040	Industrial CAN transceiver with ultra low-power standby mode with bus wake-up	No	–27 to 40	70	–12 to 12	—	1 Mbps	Half	+12 kV HBM ESD protection	4.75 to 5.25	High speed bus wake-up split voltage source	–40 to 125	8/SOIC	0.50
ISO1050	Isolated 5 V high speed CAN transceiver	Yes	–27 to 40	73	–12 to 12	flexible design dependent	1 Mbps	—	±4 kV HBM	3.3 and 5	2.5 kVrms/4 kVpk isolation, driver (TXD) dominant time-out function	–55 to 105	8/SOP, 16/SOIC	1.90
RS-485 transceivers														
SN65HVD72/75/78	3.3 V, half-duplex RS-485, high IEC ESD	No	–13 to 16.5	1	–7 to 12	200/256	250 kbps, 20 Mbps, 50 Mbps	Half	+12 kV IEC and +15 kV HBM protection	3 to 3.6	High IEC ESD, large receiver hysteresis (80 mV)	–40 to 125	8/SOIC, 8/SON, 8/VSSOP	0.70/1.00
SN75176B	General purpose, standard 5.0 V RS-485 transceiver	No	–7 to 12	35	–7 to 12	32	10 Mbps	Half	2 kV	4.75 to 5.25	Economical	–40 to 105	8/SOIC, 8/SON, 8/PDIP	0.24
DS75176BT	5 V, multipoint RS-485/ RS-422 transceivers	No	–10 to 15	55	–7 to 12	32	10 Mbps	Half	500 V HBM	4.75 to 5.25	Economical, industry standard	–40 to 85	8/SOIC, 8/PDIP	0.52
DS485	5 V, low power, half-duplex RS-485/RS-422 multipoint transceiver	No	–14 to 14	0.9	–7 to 12	32	2.5 Mbps	Half	2 kV HBM	4.75 to 5.25	Economical, low power (typical I_{CC} = 200 uA)	–40 to 85	8/SOIC, 8/PDIP	0.87
SN65HVD10/11/12	3.3 V differential transceiver	No	–9 to 14	15.5	–7 to 12	64/256	32 Mbps, 10 Mbps, 1 Mbps	Half	16 kV HBM	3 to 3.6	Small package, hot pluggable	–40 to 85; –40 to 125	8/SOIC, 8/PDIP	1.40/1.50
SN65LBC184	Transient voltage suppression differential RS-485 transceiver	No	–15 to 15	25	–7 to 12	128	250 kbps	Half	+30 kV IEC and +15 kV HBM protection	4.75 to 5.25	High IEC ESD, integrated transient voltage suppression	–40 to 85	8/SOIC, 8/PDIP	1.38
SN65HVD308xE	Low-power RS-485 half and full-duplex drivers/ receivers	No	–9 to 14	<1	–7 to 12	256	200 kbps to 20 Mbps	Half/full	±15-16 kV HBM ESD protection	4.5 to 5.5	Failsafe, hot pluggable	–40 to 85	8/PDIP, 8/SOIC, 8/VSSOP, 10/VSSOP, 14/SOIC	0.9/1.35
SN65HVD76/77	3.3 V, full-duplex RS-485, high IEC ESD	No	–13 to 16.5	1.1	–7 to 12	96	50 Mbps	Full	+12 kV IEC and +30 kV HBM protection	3 to 3.6	High IEC ESD, large receiver hysteresis (70 mV)	–40 to 125	8/SOIC, 14/SOIC, 8/VSSOP, 10/VSSOP	1.90
SN65HVD1476/77	3.3 V, full-duplex RS-485, high IEC ESD, w/ enables	No	–13 to 16.5		–7 to 12	96	50 Mbps	Full	+16 kV IEC and +30 kV HBM protection	3 to 3.6	High IEC ESD, large receiver hysteresis (70 mV), with driver enables	–40 to 125	8/SOIC, 14/SOIC, 8/VSSOP, 10/VSSOP	2.25
SN65HVD1780/1/2	70 V fault-protected RS-485 transceiver	No	–70 to 70	6	–7 to 12	256	115 kbps, 1 Mbps, 10 Mbps	Half	+16 kV HBM	3.15 to 5.5	High fault protection	–40 to 105	8/SOIC, 8/PDIP	1.85/2.00
ISO308X	Isolated 5 V half-duplex RS-485 transceiver	Yes	—	15	—	256	200 kbps to 20 Mbps	Full	+30 kV HBM	3.3 to 5	2.5 kVrms/4 kVpk isolation, glitch–free power–up/down	–40 to 85	16/SOIC	2.60/3.00
PROFIBUS® transceivers														
SN65HVD1176	PROFIBUS® RS-485 transceiver	No	–9 to 14	6	—	160	40 Mbps	Half	+16 kV HBM	4.75 to 5.25	Optimized for PROFIBUS networks	–40 to 85	8/SOIC	1.54
ISO1176	Isolated PROFIBUS RS-485 transceiver	Yes	—	75	—	160	40 Mbps	Half	±12 kV HBM	3 to 5.5	2.5 kVrms/4 kVpk isolation, optimized for PROFIBUS networks	–40 to 85	16/SOIC	3.00
I²C interface														
ISO1540	Low-power bidirectional I²C isolator	Yes	—	3.8	—	112	3.4 Mbps	—	±8 kV	3 to 5.5	2.5 kVrms/4 kVpk isolation and 560 Vpk working voltage	–40 to 125	8/SOIC	2.00

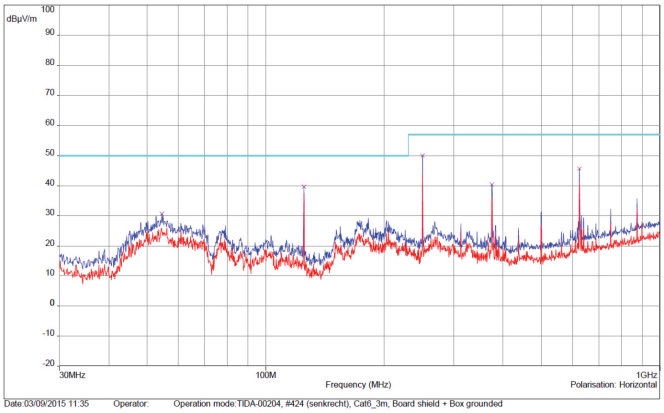
**Suggested resale price in U.S. dollars in quantities of 1,000.*

Signal chain solutions
Ethernet

New gigabit PHY customized for harsh industrial environments
DP83867

The DP83867 is a robust, low-power, fully-featured physical layer transceiver with integrated PMD sublayers to support 10BASE-T, 100BASE-TX and 1000BASE-T Ethernet protocols. Optimized for ESD protection, the DP83867 exceeds 8 kV IEC 61000-4-2 (direct contact). The DP83867 provides precision clock synchronization, including a synchronous Ethernet clock output. It has low latency and provides IEEE 1588 start-of-frame detection. The DP83867 consumes only 460 mW under full operating power. Wake on LAN (WoL) can be used to lower system power consumption.

Outstanding EMI/EMC Performance



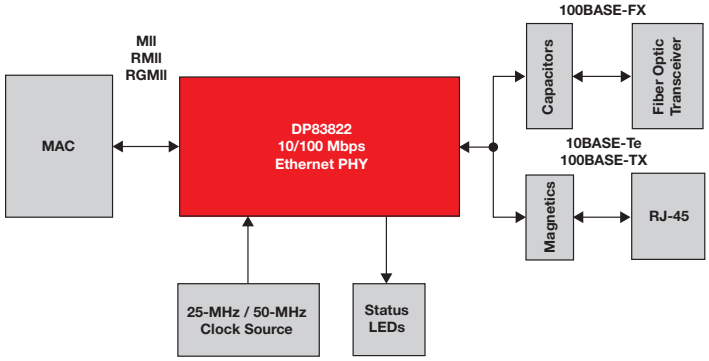
Measured EMI spectrum according to EN55011; 3 m near-field, horizontal polarization (pre-test)

Key features

- Low latency <90 ns TX and <290 ns RX
- Power consumption as low as 460 mW
- Exceeds 8 kV IEC 61000-4-2 ESD protection
- Integrated termination resistors
- WoL (Wake on LAN) packet detection
- 25 MHz or 125 MHz synchronized clock output
- Start of frame detect for IEEE 1588 time stamp
- GMII, RGMII and SGMII MAC interface options
- Configurable I/O voltage (3.3 V, 2.5 V, 1.8 V)
- Low transmit and receive latency
- JTAG support
- MDIO serial management interface
- Operating temperature range: –40°C to 105°C

New low power single-port 10/100 Mbps Ethernet PHY
DP83822

The DP83822 is a robust, low power single-port 10/100 Mbps Ethernet PHY supporting 100BASE-FX, 100BASE-TX and 10BASE-Te Ethernet protocols. The DP83822 offers an innovative, robust approach for reducing power consumption through energy efficient Ethernet (EEE) IEEE 802.3az, wake-on-LAN (WoL) support with magic packet detection and other programmable energy savings modes. It provides all the PHY layer functions needed to transmit and receive data over both standard twisted pair cables or through a connection to an external fiber optic transceiver. Connection to a MAC is provided through a standard MII, RMII or RGMII interface.



Key features

- Low deterministic transmit and receive latency
- +/-8 kV IEC 61000-4-2 ESD protection
- Start of frame detect for IEEE 1588 time stamp
- Fast link-down timing
- Configurable I/O voltage (3.3, 2.5, 1.8 V)
- MII, RMII, RGMII MAC interface options
- Power savings features:
  - Energy efficient Ethernet (EEE) IEEE 802.3az
  - WoL support with magic packet detection
  - Programmable energy savings modes
- Operating temperature range: -40°C to 125°C

Signal chain solutions
Ethernet

Industrial Ethernet

Device	Data rate (Mbps)	Interface	Cable length (m) @ 100 Mbps	No. LEDs	JTAG	Cable diagnostics	FX support	IEEE1588 HW support	25 MHz clock out	Temp. range (°C)	Package
DP83867IRPAP	10/100/1000	RGMII, GMII, MII	200	4	Yes	Yes	—	SFD*	Yes	–40 to 85	QFP-64
DP83867IRRGZ	10/100/1000	RGMII	200	4	Yes	Yes	—	SFD*	Yes	–40 to 85	QFN-48
DP83867IS	10/100/1000	SGMII, RGMIII	200	4	Yes	Yes	—	SFD*	Yes	–40 to 85	QFN-48
DP83867E	10/100/1000	SGMII, RGMII	200	4	Yes	Yes	—	SFD*	Yes	–40 to 105	QFN-48
DP83867CS	10/100/1000	SGMII, RGMII	200	4	Yes	Yes	—	SFD*	Yes	0 to 70	QFN-48
DP83867CR	10/100/1000	RGMII	200	4	Yes	Yes	—	SFD*	Yes	0 to 70	QFN-48
DP83848	10/100	MII, RMII, SNI	150	3	Yes	—	—	—	Yes	–40 to 85	QFP-48
DP83848Q	10/100	MII, RMII	150	1	—	—	—	—	Yes	–40 to 105	QFP-40
DP83848K	10/100	MII, RMII	137	2	—	—	—	—	—	–40 to 85	QFP-40
DP83848H	10/100	MII, RMII	137	1	—	—	—	—	Yes	–40 to 125	QFP-40
DP83848VYB	10/100	MII, RMII, SNI	150	3	Yes	—	—	—	Yes	–40 to 105	QFP-48
DP83848YB	10/100	MII, RMII, SNI	150	3	Yes	—	—	—	Yes	–40 to 125	QFP-48
DP83620	10/100	MII	150	3	Yes	Yes	Yes	—	Yes	–40 to 85	QFP-48
DP83630	10/100	MII, RMII	150	3	Yes	Yes	Yes	Yes	Yes	–40 to 85	QFP-48
DP83640	10/100	MII, RMII	150	3	Yes	Yes	Yes	Yes	Yes	–40 to 85	QFP-48
DP83822HF	10 / 100	MII, RMII, RGMII	150	3	No	Yes	Yes	SFD*	Yes	-40 to 125	32 QFN
DP83822H	10 / 100	MII, RMII, RGMII	150	3	No	Yes	No	SFD*	Yes	-40 to 125	32 QFN
DP83822IF	10 / 100	MII, RMII, RGMII	150	3	No	Yes	Yes	SFD*	Yes	-40 to 85	32 QFN
DP83822I	10 / 100	MII, RMII, RGMII	150	3	No	Yes	No	SFD*	Yes	-40 to 85	32 QFN

*SFD = Start of Frame Detect

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

ESD protection
High-performance TVS diodes

Texas Instruments offers transient voltage suppressor (TVS) based ESD protection diodes designed to protect your system from damage due to high voltage transients. With solutions for interfaces like Ethernet, LVDS and USB, TI delivers a broad portfolio to support your protection needs.

Key features

- Low capacitance
- Low leakage current
- Ultra small package
- High IEC protection

High-performance TVS diodes

Device	Interface	Number of channels	IO capacitance (typ) (pF)	Breakdown voltage (min) (V)	IEC 61000-4-2 Contact (± kV)	IEC 61000-4-2 Air gap (± kV)	Bi-/uni-directional	Operating temp. range (°C)	Package	Price*
TPD2E2U06	General purpose, LVDS, USB 2.0, Ethernet	2	1.5	6.5	25	30	Uni-directional	–40 to 125	SOT	0.15
TPD4E05U06	Ethernet, general purpose	4	0.5	6.5	12	15	Uni-directional	–40 to 125	USON	0.19
TPD4E1U06	Ethernet, general purpose, LVDS, USB 2.0	4	0.8	6.5	15	15	Uni-directional	–40 to 125	SC70, SOT-23	0.08
TPD1E10B06	General purpose, LVDS, USB 2.0, Ethernet	1	12	6	30	30	Bi-directional	–40 to 125	X1SON	0.05

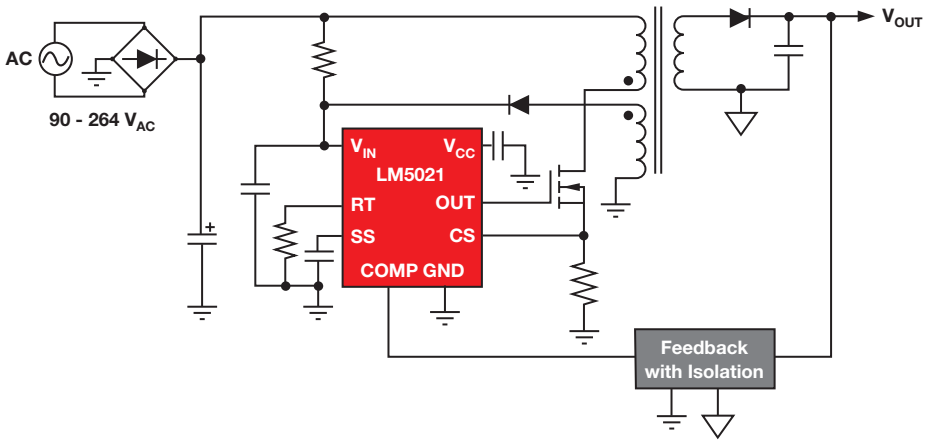
*Suggested resale price in U.S. dollars in quantities of 1,000.

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

AC/DC controller and converter for motor driver
LM5021/LM5021-Q1/UCC2863x family

LM5021 and LM5021-Q1

LM5021 and LM5021-Q1 use current mode control with fixed frequency up to 1 MHz. It is used as an auxiliary power AC/DC controller for a motor controller circuit.

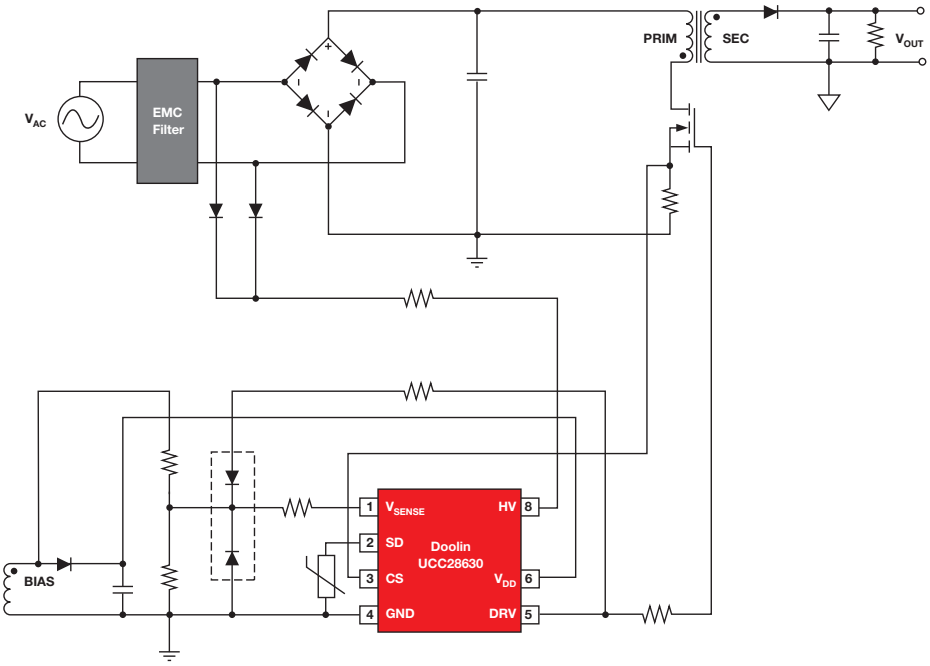


Key features

- Ultra-low startup current (25 µA maximum)
- Single resistor programmable oscillator and synchronizable
- Skip cycle mode for low standby power
- Adjustable soft-start
- Integrated 0.7 A peak gate driver
- Direct opto-coupler interface
- Maximum duty cycle limiting (80% for LM5021-1 or 50% for LM5021-2)
- Slope compensation (LM5021-1 only)
- Packages: VSSOP-8 or PDIP-8

UCC2863x family

UCC2863x family is a PSR controller with peak power capability up to 200% power at short time with a small transformer. It is suitable for the power supply to support peak power motor start condition applications such as printer power supply and dome supervision system.



Key features

- Integrated 700 V JFET for startup and <30 mW standby power
- Supports CCM and DCM operation
- Enables transient peak power with modest transformer size
- X-capacitor discharge for improved standby power
- ±5% voltage and current regulation
- 120 kHz max switching frequency enables high power density designs
- Frequency jitter scheme to ease EMI compliance
- 1 A gate driver
- Protection functions: over voltage, over current, over temperature, AC line UV/brownout
- NTC resistor interface, doubles as shutdown input
- SOIC-7 package

AC/DC controller and converter for motor driver

AC/DC controller and converter selection table

AC/DC controller and converter selection table

Device	Description	UVLO thresholds on/off (V)	Duty cycle (max) (%)	Frequency (max) (kHz)	Operating temperature range °C	Package	Price*
UCC28730	Zero standby PSR flyback controller with CVCC and wake-up monitoring	21/7	99	83	–40 to 125	SOIC	0.42
UCC28700-Q1	Compact primary-side regulation PWM controller with automotive grade	21/8	99	132	–40 to 125	SOT-23	0.41
LM5021-Q1	AC/DC current mode PWM controller	—	80	—	–40 to 125	VSSOP	0.59
UCC28633	High-power flyback controller with primary-side regulation and peak-power mode	14.5/8	70	120	–40 to 125	SOIC	0.60
UCC28632	High-power flyback controller with primary-side regulation and peak-power mode	14.5/8	70	120	–40 to 125	SOIC	0.60
UCC28631	High-power flyback controller with primary-side regulation and peak-power mode	14.5/8	70	120	–40 to 125	SOIC	0.60
UCC28712	Constant-voltage, constant-current controller with primary-side regulation	21/8	99	100	–40 to 125	SOIC	0.42
UCC28630	High-power flyback controller with primary-side regulation and peak-power mode	14.5/8	70	120	–40 to 125	SOIC	0.60
UCC28722	Low-cost CVCC flyback controller with primary-side regulation for bipolar power device	21/7.7	99	80	–40 to 125	SOIC	0.25
UCC28713	Constant-voltage, constant-current controller with primary-side regulation	21/8	99	100	–40 to 125	SOT-23	0.42
UCC28740	Constant-voltage, constant-current flyback controller using opto-coupler feedback	21/7.75	99	100	–40 to 125	SOIC	0.42
LM5021	AC/DC current mode PWM controller	—	80	—	–40 to 125	PDIP, VSSOP	0.50
UCC28720	Constant-voltage, constant-current controller with primary-side regulation for bipolar power devices	21/7.7	99	80	–40 to 125	SOIC	0.40
LM5023	AC/DC quasi-resonant current mode PWM controller	—	99	130	–40 to 125	VSSOP	0.38
UCC28703	Constant-voltage, constant-current PWM with primary-side regulation	21/8	99	132	–20 to 125	SOT-23	0.35
UCC28702	Constant-voltage, constant-current PWM with primary-side regulation	21/8	99	132	–20 to 125	SOT-23	0.35
UCC28711	Constant-voltage, constant-current PWM controller with primary-side regulation	21/8	99	100	–40 to 125	SOIC	0.35
UCC28710	Constant-voltage, constant-current PWM controller with primary-side regulation	21/8	99	100	–40 to 125	SOIC	0.42
UCC28701	Constant-voltage, constant-current PWM with primary-side regulation	21/8	99	132	–20 to 125	SOT-23	0.35
UCC28700	Constant-voltage, constant-current PWM with primary-side regulation	21/8	99	132	–20 to 125	SOT-23	0.35
UCC28600-Q1	Automotive 8-pin quasi resonant flyback green mode controller	10.3/9.3	99	130	–40 to 105	SOIC	0.47
UCC28610	12 W to 65 W green-mode flyback power supply controller	10.2/8	99	130	–40 to 125	PDIP, SOIC	0.40
UCC28600	8-pin quasi resonant flyback green mode controller	10.3/9.3	99	130	–40 to 105	SOIC	0.40

AC/DC converter selection table

Device	Description	UVLO thresholds on/off (V)	Power/Io Rating	Duty cycle (max) (%)	Frequency (max) (kHz)	Operating temperature range °C	Package	Price*
UCC28910	700 V flyback switcher with constant-voltage constant-current and primary-side control	9.5/6.5	<8 W	99	115	–40 to 125	SOIC	0.75
UCC28911	700 V flyback switcher with constant-voltage constant-current and primary-side control	9.5/6.5	<10 W	99	115	–40 to 125	SOIC	0.82
UCC28880	High-voltage switcher for non-isolated AC/DC conversion	3.9/3.6	<110 mA	55	66	–40 to 125	SOIC	0.55
UCC28881	High-voltage switcher for non-isolated AC/DC conversion	3.9/3.6	<225 mA	55	66	–40 to 135	SOIC	0.65

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

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

Selection guides for power management solutions
Input power protection/AC/DC (offline) chargers/transformer drivers

Input power protection

Device	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	10/VSSOP	1.47
TPS24750/1	12 A integrated hot-swap controller with current monitor	2.5	18	Externally adjustable	Yes	Latch off/retry	Overcurrent protection, soft start, PG, thermal shutdown, programmable fault timer	–40 to 85	36/VQFN	1.65

AC/DC (offline) chargers/auxiliary power supplies

Device	Description	Features	Operating temperature range (°C)	Pin/package	Price*
UCC28700/01/02/03	Constant voltage, constant current PWM controller with primary-side regulation	<30 mW 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	<10 mW no load power, internal 700 V 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 65 W, integrated 700 V 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 <10 mW at 230 V_{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	100 V push pull converter	Current control mode, shutdown feature to incorporate STO functionality, operates from 24 V 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 to 125	16/VSSOP	1.40

Transformer drivers for isolated power supplies

Device	V_{IN} (min) (V)	V_{IN} (max) (V)	V_{OUT} (min) (V)	V_{OUT} (max) (V)	Switching frequency (max) (kHz)	Soft start	Special features	Operating temperature range (°C)	I_{OUT} (A)	Pin/package	Price*
SN6505A	2.25	5.5	0	16	2000	Fixed	Enable, power good	–55 to 125	1	6SOT-23	2.75
SN6505B	2.25	5.5	0	16	2000	Fixed	Enable, power good	–55 to 125	1	6SOT-23	2.75
SN6501	3	5.5	0	11	620	—	Enable	–40 to 125	0.25	5SOT-23	0.80
SN6501-Q1	3	5.5	0	11	620	—	Enable	–40 to 125	0.25	5SOT-23	1.00

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Selection guides for power management solutions
DC/DC regulators

DC/DC regulators

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Device	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	2.95 V to 6 V input, 2 W, 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
TPS62400	Dual, 400 mA /600 mA, 2.25 MHz step-down converter in QFN	2.5	6	0.6	6	0.4	Buck, synchronous buck	1	0.032	100	Fixed	Internal	Enable, light load efficiency	–40 to 85	10/SON	0.85
TPS62150	3 V to 17 V 1 A step-down converter with DCS-control™	3	17	0.9	6	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	0.85
LMZ34002	4.5 V to 40 V input, up to 15 W 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	3.5 V to 60 V input, 1.5 A 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	4.7 V to 60 V input, 200 mA 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
TPS54360/ 560	4.5 V to 60 V input 3.5 A/5 A step-down DC/DC converter with Eco-mode™	4.5	60	0.8	58.8	3.5/5	Buck, inverting buck boost	5.5/7.5	146	98	No	External	Enable, frequency, synchronization, light load efficiency, adjustable UVLO	–40 to 125	8SO PowerPAD	2.30
TPS54361/ 561	4.5 V to 60 V input 3.5 A/5 A step-down DC/DC converter with soft-start and Eco-mode™	4.5	60	0.8	59	3.5/5	Buck	5.5/7.5	152	98	Adjustable	External	Enable, frequency, synchronization, light load efficiency, power good, tracking, adjustable UVLO	–40 to 125	10WSON	3.00
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
TPS82085	3 A module with integrated inductor, with DCS-control™ in 2.8 x 3 x 1.3 SON	2.5	6	0.8	6	3	Buck, synchronous buck	4.6	0.017	100	Adjustable	Internal	Enable, light load efficiency, power good, hiccup short circuit protection	–40 to 125	8/SON	2.75
TPS62175	Buck converter with snooze mode for low power MCUs	4.75	28	1	6	0.5	Buck, synchronous buck	1	0.0047	100	Fixed	Internal	Enable, light load efficiency, output discharge, power good	–40 to 125	10/SON	0.70
TPS54218/ 318	2.95 V to 6 V input, 2/3 A synchronous step-down SWIFT™ converter	2.9	6	0.8	4.5	2/3	Buck	2.9/4	0.35	98	Adjustable	External	Enable, frequency, synchronization, power good, tracking	–40 to 150	16/WQFN	140/ 1.80
TPS54320	4.5 V to 17 V input, 3 A synchronous step-down SWIFT™ converter	4.5	17	0.8	15	3	Buck	4.2	0.6	98	Adjustable	External	Enable, frequency, synchronization, power good, tracking	–40 to 150	14/VQFN	1.50
LM5017	Family of 100 V 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

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

Selection guides for power management solutions

LDO linear regulators/shunt regulator/reference

LDO linear regulators

Device	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 (µVrms)	Additional features	Operating temperature range (°C)	Pin/package	Price*
TPS7A30	V_{IN} 3 V to 36 V, 150 mA, 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
TPS7A49	V_{IN} –3 V to –36 V, –200 mA, 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
TPS7A47	V_{IN} 3 V to 36 V, 1 A, ultra-low noise, high PSRR, low-dropout linear regulator	Adjustable output	1	3	36	1.2	34	0.58	307	4.2	Enable, overcurrent protection	–40 to 125	DSBGA/SOT-23/ X2SON	0.14
TPS709	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
TLV733P	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	—	—	0.17
LP5907	250 mA, 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	500 mA 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
TLV1117	Single output LDO, 800 mA, fixed and adj., internal current limit, thermal overload protection	Adjustable output	0.8	2.7	15	1.25	13.7	0.08	1200	—	Overcurrent protection, thermal shutdown	–40 to 125, 0 to 125	DDPAK/TO-263, SON, SOT-223, TO-220, TO-252	0.18
LM317	3/4 pin 1.5 A adjustable positive voltage regulator	Adjustable output, programmable output	1.5	3	40	1.25	37	0.05	2000	—	Overcurrent protection, thermal shutdown	0 to 125	DDPAK/TO-263, PFM, SOT-223, TO-220	0.18
UA78L05	3/8 pin 100 mA fixed 5 V positive voltage regulator	Fixed output	0.1	7	20	5	5	3.8	1700	42	Overcurrent protection, thermal shutdown	0 to 125	SOIC, SOT-89, TO-92	0.09
LP2985-50	Single output LDO, 150 mA, fixed (5.0 V), 1.5% tolerance, low quiescent current, low noise	Fixed output	0.15	2.2	16	5	5	0.85	280	30	Overcurrent protection, thermal shutdown	–40 to 125	SOT-23	0.18
LP2985-N	Micropower 150 mA low-noise ultra-low-dropout regulator in SOT-23 and DSBGA packages	Fixed output	0.15	2.2	16	1.8	6.1	0.085	280	30	Overcurrent protection, thermal shutdown	–40 to 125	SOT-23, DSBGA	0.24
LP2951-N	100 mA LDO with lower quiescent current and low dropout	Adjustable output	0.1	2.3	30	1.24	29	0.075	380	160	Overcurrent protection, thermal shutdown, power good	–40 to 125	PDIP, SOIC, VSSOP, WSON	0.25

Shunt regulator/reference

Device	Description	Reference voltage	V_O (V)	V_O adj. (min) (V)	V_O adj. (max) (V)	Initial accuracy (max) (%)	Min I_Z for regulation (uA)	I_{OUT}/I_Z (max)(mA)	Temp. coeff (max) (ppm/ degree °C)	Operating temperature range (°C)	Package group
ATL431	2.5 V low Iq adjustable precision shunt regulator	Adjustable	2.5	2.5	36	0.5, 1	20	100	92	–40 to 125, –40 to 85	SOT-23
TL431B	Adjustable precision shunt regulator	Adjustable	2.495	2.495	36	0.5	400	100	92	–40 to 125, –40 to 85, 0 to 70	SC70, SO, SOIC, PDIP, SOT-23, SOT-89, TO-92, TSSOP
TL431A	Adjustable precision shunt regulator	Adjustable	2.495	2.495	36	1	400	15	92	–40 to 125, –40 to 85, 0 to 70	PDIP, SC70, SO, SOT-23, SOT-89, TO-92, SOIC, TSSOP
TLV431B	Low-voltage adjustable precision shunt regulator	Adjustable	1.24	1.24	6	0.5	55	15	138	–40 to 125, –40 to 85, 0 to 70	SC70, SOT-23, SOT-89, TO-92
TLV431A	Low voltage adjustable precision shunt regulator	Adjustable	1.24	1.24	6	1	55	15	138	–40 to 125, –40 to 85, 0 to 70	SC70, SOT-23, SOT-89, TO-92
LM4040B30	3 V precision micropower shunt voltage reference, 0.2% accuracy	Fixed	3	3	3	0.2	47	25	100	–40 to 85	SC70, SOT-23, TO-92
LM4040A25	2.5 V precision micropower shunt voltage reference, 0.1% accuracy	Fixed	2.5	2.5	2.5	0.1	45	25	100	–40 to 85	SC70, SOT-23, TO-92
LM4040C50	5 V precision micropower shunt voltage reference, 0.5% accuracy	Fixed	5	5	5	0.5	65	25	100	–40 to 125, –40 to 85	SC70, SOT-23, TO-92

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

Selection guides for power management solutions

Voltage monitor and reset ICs/window comparator/PMICs

Voltage monitor and reset ICs

Device	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

Window comparator

Device	Description	V_s (min) (V)	V_s (max) (V)	t_{RESP} low-to-high (µs)	V_{os} (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 (18 V) window comparator with over- and undervoltage detection	1.8	18	29	5.5	0.013	Open drain	25	1	Hysteresis, internal reference	In	–40 to 125	6/SOT, 6/WSON	0.70
TPS3701	High-voltage (36 V) window comparator with over- and undervoltage detection	1.8	36	28	3	0.011	Open drain	25	1	Hysteresis, internal reference	In	–40 to 125	6/SOT	0.89

Power management integrated circuits (PMICs)

Device	Description	V_{IN} (min) (V)	V_{IN} (max) (V)	V_{OUT} (max)	I_{OUT} (max) (A)	Special features	Pin/package	Price*
TPS65090	Integrated 5-channel PMIC with 3 DC/DCs, 2 LDOs and switchmode charger for 2-3 cells in series	6	17	5	5	Comm control, power good	100VQFN	4.95
TPS6507x	Integrated 5-channel PMIC with 3 DC/DCs, 2 LDOs	1.8	6.3	3.3	1.5	Comm control, power good, power Sequencing	48VQFN	3.60
TPS65217	Integrated 7-channel PMIC with 3 DC/DCs, 4 LDOs, linear battery charger and white LED driver	2.7	5.8	3.3	1.2	Comm control, power good, power sequencing	48VQFN	3.45
TPS6501x	Integrated 4-channel 1-cell Li-Ion PMIC with USB/AC charger, 2 DC/DCs, 2 LDOs and I^2C interface	1.8	6.5	6.5	1	Power good, power sequencing	48VQFN	2.55
TPS6500x	Integrated 3-channel PMIC with 1 DC/DC, 2 LDOs and SVS	1.6	6	6	0.6	Power good	20WQFN	1.70

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

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

Selection guides for power management solutions

DC/DC solutions for driving FPGAs

TI's expansive portfolio of LDOs, power modules options, PMICs, as well as DC/DC controllers and converters with PMBus, are easy-to-use solutions that feature the high-performance and power density to support the range of voltages and currents required by FPGA-powered motor drive systems.

DC/DC solutions for driving FPGAs

Device	Description	V_{IN} (range) (V)	V_{OUT} (range) (V)	I_{OUT} (max) (A)	Pin/package	Special features	Price*
TPS54020	4.5 V to 17 V input, 10 A synchronous step-down SWIFT™ converter with out-of-phase synchronization	4.5 to 17	0.6 to 5	10	15VQFN	Enable, frequency synchronization, power good, tracking, adjustable current limit, phase interleaving, light load efficiency synchronous rectification	3.10
LMZ21701	SIMPLE SWITCHER® 3 V to 17 V, 1 A high density nano module	3 to 17	0.9 to 6	1	8uSiP	EMI tested, enable, light load efficiency, power good	1.75
TPS65400	4.5 V to 18 V input, 4 A/4 A/2 A/2 A synchronous quad converter with PMBus/I²C interface	4.3 to 18	0.6 to 16	4	48VQFN	Adjustable current limit, adjustable UVLO, dynamic voltage scaling, enable, frequency synchronization, light load efficiency, PMBus, phase interleaving, power good, pre-bias start-up, synchronous rectification, telemetry	3.20
TPS544C20	4.5 V to 18 V, 30 A SWIFT with PMBus programmability and voltage, current and temperature monitoring	4.5 to 18	0.6 to 15	30	40LQFN-CLIP	Adjustable current limit, adjustable UVLO, dynamic voltage scaling, enable, PMBus, power good, pre-bias start-up, remote sense, synchronous rectification, telemetry, voltage margining	3.90
TPS544B20	4.5 V to 18 V, 20 A SWIFT with PMBus programmability and voltage, current and temperature monitoring	4.5 to 18	0.6 to 5.5	20	40LQFN-CLIP	Adjustable current limit, adjustable UVLO, dynamic voltage scaling, enable, PMBus, power good, pre-bias start-up, remote sense, synchronous rectification, telemetry, voltage margining	3.55
TPS544B25	4.5-V to 18-V, 20 A SWIFT synchronous buck converter with PMBus and frequency synchronization	4.5 to 18	0.5 to 5.5	20	40LQFN-CLIP	Adjustable current limit, adjustable UVLO, dynamic voltage scaling, enable, PMBus, power good, pre-bias start-up, remote sense, synchronous rectification, telemetry, voltage margining	4.08
TPS544C25	4.5-V to 18-V, 30 A voltage mode PMBus SWIFT step-down DC/DC converter with FSYNC	4.5 to 18	0.5 to 5.5	30	40LQFN-CLIP	Dynamic voltage scaling, enable, PMBus, power good, pre-bias start-up, remote sense, synchronous rectification, telemetry, tracking	4.49
TPS40400	3.0 V to 20 V PMBus synchronous buck controller	3 to 20	0.6 to 5	30	24VQFN	Adjustable current limit, adjustable UVLO, dynamic voltage scaling, enable, PMBus, power good, pre-bias start-up, remote sense, synchronous rectification, telemetry, tracking, voltage margining	2.00
TPS40422	Dual output or multiphase synchronous buck controller with PMBus	4.5 to 20	—	60	40VQFN	Dynamic voltage scaling, enable, frequency synchronization, PMBus, remote sense	2.90
TPS40428	Dual output, 2-phase, stackable PMBus synchronous buck driverless controller	4.5 to 20	4.5 to 20	60	40VQFN	Adjustable current limit, adjustable UVLO, dynamic voltage scaling, enable, frequency synchronization, PMBus, phase interleaving, power good, pre-bias start-up, remote sense, synchronous rectification, telemetry, voltage margining	4.80
TPS53647	4-phase, D-CAP+TM step-down buck controller with NVM and PMBus interface for ASIC	4.5 to 17	0.5 to 2.5	240	40WQFN	Adjustable current limit, adjustable UVLO, dynamic voltage scaling, enable, frequency synchronization, PMBus, phase interleaving, power good, pre-bias start-up, remote sense, synchronous rectification, telemetry, voltage margining	3.85
TPS53513	1.5 V to 18 V input (4.5 V to 25 V bias), 8-A synchronous step-down SWIFT converter	1.5 to 18	0.6 to 5.5	8	28VQFN-CLIP	Enable, light load efficiency, output discharge, power good, synchronous rectification	2.55
TPS53515	1.5 V to 18 V input (4.5 V to 25 V bias), 12-A synchronous step-down SWIFT converter	1.5 to 18	0.6 to 5.5	12	28VQFN-CLIP	Enable, light load efficiency, output discharge, power good, synchronous rectification	2.70
TPS53915	1.5 V to 18 V input (4.5 V to 25 V bias), 12-A synchronous step-down SWIFT converter with PMBus	1.5 to 18	0.6 to 5.5	12	28VQFN-CLIP	Dynamic voltage scaling, enable, light load efficiency, PMBus, power good, synchronous rectification, voltage margining	2.70
TPS53353	High-efficiency 20 A synchronous buck converter with Eco-mode	1.5 to 15	0.6 to 5.5	20	22LSON-CLIP	Adjustable current limit, enable, light load efficiency, power good, synchronous rectification	3.50
TPS53355	1.5 V to 15 V input (4.5 V to 25 V bias), 30 A synchronous step-down SWIFT converter with Eco-mode	1.5 to 15	0.6 to 5.5	30	22LSON-CLIP	Adjustable current limit, enable, light load efficiency, power good, synchronous rectification	3.75
TPS56121	4.5 V to 14 V input, 15 A synchronous step-down SWIFT converter	4.5 to 14	0.6 to 12	15	22LSON-CLIP	Enable, power good, adjustable current limit, synchronous rectification	3.50
TPS56221	4.5 V to 14 V input, 25 A synchronous step-down SWIFT converter	4.5 to 14	0.6 to 12	25	22LSON-CLIP	Enable, light load efficiency, synchronous rectification	3.75
TPS54620	4.5 V to 17 V input, 6 A synchronous step-down SWIFT converter	4.5 to 17	0.8 to 15	6	14VQFN	Enable, frequency synchronization, power good, tracking, synchronous rectification	2.50
TPS54622	4.5-V to 17-V input, 6-A synchronous step-down SWIFT converter with hiccup protection	4.5 to 17	0.6 to 15	6	14VQFN	Enable, frequency synchronization, power good, tracking, synchronous rectification	2.50
TPS54623	4.5 V to 17 V input, 6 A synchronous step-down SWIFT converter with light load efficiency	4.5 to 17	0.6 to 15	6	14VQFN	Enable, frequency synchronization, light load efficiency, power good, tracking, synchronous rectification	3.00
TPS54320	4.5 V to 17 V input, 6 A synchronous step-down SWIFT converter	4.5 to 17	0.8 to 15	3	14VQFN	Enable, frequency synchronization, power good, tracking, synchronous rectification	1.50
TPS54541	4.5 V to 60 V input 3.5 A/5 A step-down DC/DC converter with soft-start and Eco-mode	4.5 to 40	0.8 to 38	5	10WSON	Enable frequency, synchronization light load, efficiency power good, tracking, adjustable UVLO	2.30

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

Selection guides for power management solutions

PMICs for driving FPGAs/LDOs for driving FPGAs

PMICs for driving FPGAs

Device	Description	V_{IN} (min) (V)	V_{IN} (max) (V)	V_{OUT} (max)	I_{OUT} (max) (A)	Special features	Pin/package	Price*
TPS65086	Integrated 10-channel PMIC with 3 DC/DCs, 3 controllers and 4 LDOs	5.4	21	3.575	21	Comm control, power good, power sequencing, DVS	64QFN	3.75
TPS65911	Integrated 13-channel PMIC with 3 DC/DCs, 1 controller, 9 LDOs and RTC	2.7	5.5	3.3	10	Comm control, power good, power sequencing, DVS	98BGA	3.75
TPS65912	Integrated 14-channel PMIC with 4DC/DCs, 10 LDOs, 3 LED outputs and 32 kHz RC oscillator	0.8	5.5	3.8	2.5	Comm control, power good, power sequencing, DVS	81DSBGA	3.99
TPS65218	Integrated 7-channel PMIC with 5 DC/DCs, 1 buck-boost and 1 LDO	2.2	5.5	3.5	1.8	Comm control, power good, power sequencing, DVS	48HTQFP, 48VQFN	3.45
TPS65023	Integrated 6-channel PMIC with 3 DC/DCs, 3 LDOs, I^2C interface and DVS	1.5	6.5	6	1.7	Comm control, power good, power sequencing, DVS	40WQFN, 49DSBGA	2.95
TPS65910	Integrated 12-channel PMIC with 4 DC/DCs, 8 LDOs and RTC	1.7	5.5	3.3	1.5	Comm control, power good, power sequencing, DVS	48VQFN	2.75

LDOs for driving FPGAs

Device	Description	V_{OUT} (max) (V)	I_{OUT} (max) (A)	V_{DO} (typ)(mV)	Pin/package	Special features	Price*
TPS7A8300	2 A, low-dropout, low-noise voltage regulator	5	2	125	VQFN	Enable, fast transient response, output discharge, power good, soft start	2.45
TPS7A8400	3 A, low-dropout, low-noise voltage regulator	5	3	200	VQFN	Enable, fast transient response, output discharge, power good, soft start	3.05
TPS7A8500	4 A, low-dropout, low-noise voltage regulator	5	4	250	VQFN	Enable, fast transient response, output discharge, power good, soft start	3.50
TPS7A8801	Dual 1 A, low noise linear voltage regulator	5	1	200	QFN	Enable, fast transient response, output discharge, power good, soft start	2.10
TPS74201	1.5 A, ultra low-dropout linear regulator with programmable soft-start	3.5	1.5	55	DDPAK/TO-263, VQFN	Enable, fast transient response, power good, soft start	2.00
TPS74401	3 A, ultra low-dropout linear regulator with programmable soft-start	3.6	3	115	DDPAK/TO-263, VQFN	Enable, fast transient response, power good, soft start	2.75

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

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

TI Designs
Reference designs for motor drives

Jump start system design and speed time to market

Our comprehensive designs include schematics or block diagrams, BOMs, design files and test reports created by experts with deep system and product knowledge. Our reference design library spans our broad portfolio of analog, embedded processor and connectivity products to support your motor drive and control application.

To view all reference designs for motor drive and control systems, visit **www.ti.com/motordesigns**

Reference design	Description	Key features
TIDA-00405: 3D printer controller (12 V)	This reference design is a complete system for controlling 3-axis, single extruder-based 3D printers. The system is managed by the MSP430F5529 LaunchPad and utilizes the DRV8846 for precision stepper motor control. The CSD18534Q5A is used as a low-side switch for the hot bed heater, extruder heater and cooling fan. The DRV5033 Hall sensor acts as a contactless limit switch.	• Complete 3D printer controller with MCU, stepper drivers, heater outputs, sensor inputs, and SD card slot • Precise stepper motor current regulation using DRV8846 adaptive decay • Hall sensor limit switches are immune to contaminants and never wear out • High-current heater outputs from the CSD18534Q5A with low 7.8 mΩ RDS_{ON} • Powered from a single 12 V supply • System has been fully tested and proven
TIDA-00643: 4.4 V to 30 V, 15 A, high performance brushless DC drone propeller controller reference design	This reference design is a 4.4 V to 30 V brushless DC motor controller for high power drone, quadcopter, propeller, fan, and pump applications. It uses the Texas Instrument's DRV8305 brushless DC motor gate driver, CSD17573Q5B 30 V NexFET power MOSFETs, TPD4E05U06 TVS protection IC, C2000™ motor control MCU, and LMR16006 3.3 V buck converter. It utilizes InstaSPIN™-FOC for sensorless field oriented motor control and commands the motor speed through an external reference signal from a central controller. This design is focused on demonstrating a highly efficient and high power BLDC motor system.	• 4.4 V to 30 V input voltage range • 15 A RMS, 23 A peak output current capability • Ultra small form factor (L x W): 2.2" x 1.0" • Onboard 3.3 V, 0.6 A buck converter • Motor control through InstaSPIN-FOC sensorless field oriented control • Wide array of system protection features included MOSFET overcurrent and supply undervoltage protection
TIDA-00484: Automotive hall Sensor Rotary Encoder	This reference design is an incremental rotary encoder that uses contactless magnetic sensing to detect rotational speed and direction. The two Hall effect sensors measure the 66-pole ring magnet and output two signals in quadrature. This automotive-qualified solution is a low-cost and far more reliable alternative to conventional mechanical contact-based encoders, as it uses solid-state sensing that is immune to physical wear, dirt, corrosion, and RF noise.	• Extremely simple, reliable, and low-cost • Greater design flexibility and ESD immunity over mechanical encoder modules • 66-pole magnet provides 132 detections per 360° of rotation (1 per 2.7°) • >20 kHz Hall effect sensor bandwidth provides low 15 µs latency • Digital sensing and digital signaling offer noise immunity • Automotive qualified to AEC-Q100
TIDA-00173: 400 V to 690 V_{AC} input, 50 W flyback isolated power supply reference design for motor drives	This reference design provides isolated +24 V (45 W), ±16 V (4.5 W), and +6 V (0.5 W) outputs to power the control electronics in variable speed drives. The power supply can be either powered directly from 3-phase AC mains (380 V_{AC} to 690 V_{AC}) or can be powered from the DC-link voltage (400 V_{DC} to 1200 V_{DC}). This design uses a quasi-resonant flyback topology and is rated for 50-Watt total output power. The line and load regulation of the power supply is designed to be within 5% using primary-side regulation (eliminating costly feedback components). The power supply is designed to meet the clearance, creepage and isolation test voltages as per IEC61800-5 requirements.	• Versatile input: can be either 400 V to 1200 V_{DC} or 380 V to 690 V_{AC} • <5% line and load regulation • Protection against input UV/OV, output overload, short-circuit and loss of feedback • Low-cost solution by implementing primary-side regulation (eliminates feedback loop) and use of 1000 V rated MOSFETs • Quasi-resonant mode controller improves EMI performance • Designed to comply to IEC 61800-5
TIDA-00179: Universal digital interface to absolute position encoders reference design	This reference design is an EMC compliant universal digital interface to connect to absolute position encoders, like EnDat 2.2, BiSS®, SSI or HIPERFACE DSL®. The design supports a wide input voltage range from 15 V to 60 V (24 V nom). A connector with 3.3 V logic I/O signals allows for direct interface to the host processor to run the master protocol. The design allows the host processor to select between a 4-wire encoder interface like EnDat 2.2 and BiSS or a 2-wire interface with power over RS485 like HIPERFACE DSL. To meet the selected encoder's supply range, the design offers a programmable output voltage with either 5.25 V or 11 V. This design's power supply offers protection against over-voltage and short circuit according to the selected encoder's voltage range to prevent damage during a cable short. TIDA-00179 has been tested up to 100 m cable length with EnDat 2.2 and 2-wire HIPERFACE DSL encoders.	• Universal hardware to interface to EnDat 2.2, BiSS, SSI and 4-wire or 2-wire HIPERFACE DSL encoders. Supports all corresponding standard data rates up to at least 100 m cable length • 3.3-V supply half-duplex RS485 transceiver SN65HVD78 with 12 kV IEC-ESD and 4 kV EFT eliminates cost for external ESD components • Encoder P/S with wide input range (15 V to 60 V) offers programmable output voltage 5.25 V or 11 V, compliant to EnDat 2.2, BiSS or HIPERFACE DSL encoders • OV, UV and precise over-current limit with short-circuit protection leveraging TI eFuse technology with current monitor and fault indicator • Logic interface (3.3 V I/O) to host processors like Sitara AM437x or C2000™ MCU to run the EnDat 2.2, BiSS, SSI or HIPERFACE DSL master • Design exceeds EMC immunity for ESD, fast transient burst and surge and conducted RF with levels according to IEC61800-3

TI Designs
Reference designs for motor drives

Reference design	Description	Key features
TIDA-00195: Isolated IGBT gate driver evaluation platform for 3-phase inverter system reference design	This reference design consists of a 22 kW power stage with TI's new reinforced isolated IGBT gate driver ISO5852S intended for motor control in various applications. This design allows performance evaluation of the ISO5852S in 3-phase inverter incorporating 1200 V rated IGBT modules of current ratings ranging from 50 A to 200 A. Some of the important functionality and performance evaluated are short circuit protection using DESAT detection, soft-shutdown, effectiveness of the active Miller clamp at different inverter dv/dt, and ESD/EFT performance of IGBT gate driver at system level derived from adjustable speed electrical power drive systems (IEC61800-3). Piccolo™ LaunchPad LAUNCHXL-F28027 is used to generate the PWM signals required for controlling the inverter.	• 3-phase inverter system with: ○ 1200 V rated IGBT module of current ratings from 50 A to 200 A (supporting multiple vendors) ○ 7 reinforced isolated IGBT gate drivers – ISO5852s with working voltage isolation of 1.5 kVrms with minimum CMTI of 50 kV/µs • Incorporates protection against over current and false turn ON using: ○ DESAT detection ○ Soft shutdown ○ Active Miller clamp • Meets IEC61800-3 EMC immunity requirements: ○ ±8 kV ESD CD per IEC 61000-4-2 ○ ±4 kV EFT per IEC 61000-4-4 • On board half-bridge isolated power supply generating +16 V/–8 V for gate drivers with a provision to operate gate drivers with unipolar or bipolar supply with external BJT/MOSFET buffers • Gate driver input can be configured for inverting/non inverting operation • Option to evaluate the system with: ○ Twisted pair cable between the gate driver and IGBT ○ External capacitance between gate and emitter
TIDA-00204: EMI/EMC compliant industrial temp dual port gigabit ethernet reference design	This design allows for performance evaluation of two industrial grade DP83867IR gigabit Ethernet PHYs and Sitara™ host processors with integrated Ethernet MAC and switch. It was developed to meet industrial requirements for EMI and EMC. The application firmware implements a driver for the PHY, UDP and TCP/IP stack and HTTP web server examples. The host processor is configured to boot the pre-installed firmware from an on-board SD-card. A USB virtual COM port offers optional access to the PHYs registers. A JTAG interface allows for your own firmware development.	• EMI- and EMC-compliant design with wide input voltage range (17 V to 60 V) using two DP83867IR Gigabit Ethernet PHYs and AM3359 Sitara™ processor to work in harsh industrial environments • Exceeds CISPR 11/EN55011 class A radiated emission requirement by >4.6 dB • Exceeds IEC61800-3 EMC immunity requirements: ○ ±6 kV ESD CD per IEC 61000-4-2 ○ ±4 kV EFT per IEC 61000-4-4 ○ ±2 kV Surge per IEC 61000-4-5 • Sitara™ AM3359 firmware, including UDP and TCP/IP stack and HTTP web server examples, boots from on-board SD-card allowing easy standalone operation • Access to DP83867IR registers via USB virtual COM port allows for custom specific PHY configurations, like RGMII delay mode • Hardware support for start-of-frame detect allows implement IEEE1588 PTP
TIDA-00176: interface to sin/cos incoders with high-resolution position interpolation reference design	This reference design is an EMC compliant industrial interface to Sin/Cos position encoders. Applications include industrial drives, which require accurate speed and position control. The design utilizes a 16-bit dual sample ADC with drop-in compatible 14- or 12-bit versions available, allowing for optimization of performance and cost. TIDA-00176 is also provides a simple connection to external processors using SPI and QEP interfaces and allows for the use of optional, embedded ADCs. For quick evaluation an example firmware for Piccolo F28069M MCU LaunchPad is provided, which outputs the measured angle from the Sin/Cos encoder with up to 28-bit resolution through the MCU's USB virtual COM port.	• EMC compliant industrial interface design for Sin/Cos encoders with 1 Vpp differential output at 2.5 V offset, input frequencies up to 500 kHz • High-resolution interpolated position, up to 28-bits resolution, cable length tested up to 70 m • Dual analog signal chain for simultaneous use of 16-bit dual SAR ADC and MCU embedded ADCs allows for evaluation of both paths and/or optimization of one path for increased noise immunity with reduced bandwidth • Easy to connect to MCU with SPI and QEP interface and option for cost optimization pending resolution requirements, thanks to drop-in compatible 14 bit or 12 bit ADC • Example firmware for C2000™ MCU with high-resolution angle calculated at 16 kHz and angle data send via USB virtual COM port for easy performance evaluation • Tested for IEC61000-4-2, 4-4 and 4-5 (ESD, EFT and surge EMC immunity requirements)
TIDA-00171: Isolated current shunt and voltage measurement reference design for motor drives	This evaluation kit and reference design implements the AMC130x reinforced isolated delta-sigma modulators along with integrated sinc filters in the C2000 TMS320F28377D Delfino™ microcontroller. The design provides an ability to evaluate the performance of these measurements: three motor currents, three inverter voltages and the DC link voltage. Provided in the kit is firmware to configure the Sinc filters, set the PLL frequency and receive data from sinc filters. A versatile run-time GUI is also provided to help the user validate the AMC130x performance and supports configuration changes to sinc filter parameters in the Delfino controller.	• Isolated shunt feedback measurements of 3-phase motor currents and voltages using the new AMC130x reinforced isolated delta-sigma modulator • Integrated Sinc3 digital filters using new C2000™ F2837xD dual-core Delfino microcontroller • Calibrated accuracy of ±0.2%, uncalibrated accuracy <2% • <4 µs response time for fault protection • Run-time GUI for complete performance analysis of modulator clock, sinc filter parameters and current and voltage waveforms • Tested for IEC61800 (EMC requirements)

TI Designs
Reference designs for motor drives

Reference design	Description	Key features
TIDA-00439: Shunt based ground fault protection for Inverters powered from 100/110 V_{AC} supply reference design	This TI design provides a reference solution for detecting ground fault in inverter based drives. Inverter current is measured on both DC positive and DC negative bus using shunt resistors. INA149 current sense amplifier having common mode voltage range of +275 V is being used to measure current on DC positive bus. Current on DC negative bus is sensed using precision op amp's. The difference between the two measured currents is compared against a fixed threshold to determine the ground fault condition using high speed comparators.	• Shunt based current sensing for inverter control and protection • Rated to measure DC link current of ±20 APK (design tested for ±5 A) • High side current sense circuit with high common mode voltage of +275 V supporting 100/110 V_{AC} mains powered drives • Calibrated high-side and low-side measurement error over operating temperature range of –10°C to 55°C < 1.5% • Ground fault: minimum fault current detection of 300 mA, detection time of less than 50 µs • Designed to be interfaced with built-in 3.3 V_{ADC} of MCU
TIDA-00368: reference design for interfacing current output hall sensors and CTs with differential ADC/MCU	This reference design provides a reference solution for interfacing current output Hall sensors and current transformers to differential ADC (standalone and integrated into MCU). The differential signal conditioning circuit is designed to measure motor current with an accuracy of ±0.5% across operating temperature range from –25°C to +75°C. The output common-mode voltage of the differential amplifier can be selected to either 1.25 V or 2.5 V.	• On board current-output Hall sensor to measure nominal current up to 25 A RMS • Current measurement accuracy of 0.5% • Common reference solution for interfacing both CT and current output Hall sensor with pseudo-differential ADC/MCU • Selectable output common-mode voltage for the differential amplifier • Provision to evaluate with Delfino™ F2837x control Card • Provision to evaluate with external ADC (ADS8354) for interfacing with motor controller
TIDA-00716: Xilinx® Spartan® 6 FPGA power reference design with TPS650250	This reference design is a compact, integrated solution for the Xilinx Spartan 6 FPGA. This design showcases the TPS650250 as an all-in-one IC used to supply the rails needed for powering the Spartan 6. This design is based on the Spartan 6 LXT family, but can be repurposed to power the Spartan 6 LX family. With user controlled external sequencing, separate enables and external resistor dividers, the TPS650250 offers a simple and flexible solution that can be leveraged across multiple designs across the Spartan 6 family. This power management IC has an input voltage range between 3.5 V and 5.5 V and can be run from a 5 V supply or a single cell Li-Ion battery. This design has been tested and verified for industrial applications (–40°C to 85°C).	• Offers 3 highly efficient step-down converters to power the Spartan 6 • Additional 200 mA LDOs to power peripheral rails or other IO rails on the FPGA • Separate enables for DC/DC converters and LDOs • Adjustable output voltage via resistor divider • This design includes a test report, an EVM guide, and design files to help accelerate the evaluation process
TIDA-00606: Altera® Cyclone® V power reference design with TPS65218	This reference design is a compact, integrated power solution for Altera Cyclone V (E, GX, GT) SoC (out of the Cyclone series family of products). This design showcases TPS65218 as an all-in-one IC used to supply the rails needed for powering the Cyclone V E, GX & GT SoC. The total board area needed for TPS65218, including passive components, to supply the five power rails to the Cyclone V is just 1.594 in^2. The TPS65218 has the flexibility to support either DDR3L or DDR3 memory. This power management IC can be run from a single 5 V supply or from a single cell Li-Ion battery. This design has been tested and verified for industrial applications (–40°C to 105°C).	• Offers 4 highly efficient, adjustable DC/DC converters with integrated FETs to power the Altera Cyclone V • Additional 400 mA LDO to power peripheral rails or other IO rails on the FPGA and 3 integrated load switches • Built-in voltage supervisor with over/under voltage monitoring • Qualified for industrial applications (–40°C to 105°C) • This design includes a test report, an EVM guide, and design files to help accelerate the evaluation process
TIDEP0022: ARM® MPU with integrated BiSS-C master interface reference design	Impelementation of BiSS-C Master protocol on Industrial Communication Sub-System (PRU-ICSS). The design provides full documentation and source code for programmable realtime unit (PRU).	• BiSS-C Master protocol running on ICSS • Interface speed of 1, 2, 5 and 10 MHz • 8x oversampled input capture • Line delay compensation with filtered sample point • De-bouncing filter on oversampled input • Variable frame format with CRC check • Command (CDS/CDM) interface • Supports up to 100 m cable • Runs on AM335x and AM437x with ICSS
TIDM-LPBP-BLDCMOTORDRIVE: three-phase brushless DC motor driver	The three-phase brushless DC motor driver reference design is a 10 A, 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 1.5 A step-down buck converter, is fully protected with short circuit, thermal, and shoot-through protection and is easily configured via an 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 14 A peak, 10 A continuous current output • Supports voltage and current feedback for InstaSPIN™-FOC sensorless control solution • 3x low-side current sense amps, 6x Power FETs (<6.5 mΩ) and 1.5 A 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
TIDA-00172: reference design for an interface to a position encoder with EnDat 2.2	This TI Design implements a hardware interface solution based on the HEIDENHAIN EnDat 2.2 standard for position or rotary encoders. The building blocks include the power supply for the encoder — with innovative smart e-Fuse technology and robust half-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 EnDat 2.2 Master protocol stack. This design is fully tested to meet EMC immunity requirements for ESD, fast transient burst and surge according to IEC61800-3.	• Design meets EMC immunity requirements for ESD, fast transient burst and surge according to IEC61800-3 • High-speed RS-485 transceivers robust to 15 kV ESD immunity • Wide input (15 V_{DC} to 30 V_{DC}) high-efficiency (>85%) DC/DC power supply configurable from 3.6 V to 14 V (defaulted to 8 V) with 200 mA, low-ripple (<20 mVpp) output • Protected power supply with innovative eFuse technology to protect against over-current, over-power, 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 • Level shifter to support 3.3 V, 2.5 V or 1.8 V I/O interface to processors like Sitara AM4x for EnDat 2.2 Master

TI Designs
Reference designs for motor drives

Reference design	Description	Key features
TMDXIDDK377D: C2000™ DesignDRIVE development kit for industrial motor control	TI's new DesignDRIVE Development Kit (IDDK) hardware offers an integrated design with full power stage to drive a three-phase motor, easing evaluation of a diverse range of feedback sensing and control topologies. The sophisticated sensing peripherals on the C2000™ MCU, including eight delta-sigma sinc filters, four high-performance 16-bit ADCs and eight windowed comparators, enable the DesignDRIVE Kit to support shunt, fluxgate/Hall and delta-sigma current sensing simultaneously. For position feedback, the kit leverages integrated MCU support for interfacing to resolvers and incremental encoders. In addition, customers can also explore configuration options that allow the MCU to be placed on either side of the high-voltage isolation barrier. The IDDK plugs into 110 V/220 V_{AC} mains, delivers up to 8 A and is rated to drive motors up to one horsepower.	• DesignDRIVE Kit is a single platform to develop and evaluate TI solutions for many drive topologies: ○ Integrated full power stage to drive a three-phase motor – 1HP ○ Multi-sense current topologies – sigma-delta, fluxgate/Hall, shunt ○ Configurable isolation partitioning – hot-side control ○ High-performance, real-time control with TMS320F28377D MCU – 800 MIPS, trigonometry and FFT acceleration ○ Multi-protocol encoder interface circuits on-board ○ Flexible real-time connectivity ○ Functional safety expansion port
TMDSRSLVR: C2000 resolver to digital conversion kit	TMDSRSLVR is a motherboard-style Resolver to Digital conversion kit used to experiment with various C2000 microcontrollers for software-based resolver to digital conversion using on-chip ADCs. The Resolver Kit also allows interface to resolvers and inverter control processor.	• Resolver motherboard features ○ controlCARD DIMM100 style interface ○ XDS100v2 USB to JTAG emulation (with additional UART) ○ Four PWM DAC pins to easily view system on an oscilloscope ○ Sinewave carrier interface and filter ○ Resolver feedback interface to MCU ADC ○ 8-pin resolver connector interface ○ 20-pin SPI connector • 15 V_{DC} power supply with filter for 5 V and 3.3 V signals • Software available through controlSUITE to demonstrate resolver to digital conversion on multiple C2000 MCU variants • Full hardware development package for re-use of circuitry schematic, layout and BOM • controlCARDs with software support ○ TMDSCNCD28027 - Piccolo™ TMS320F28027, superset of TMS320F280200 ○ TMDSCNCD28035 or TMDSCNCD28035ISO - Piccolo TMS320F28035, superset of TMS320F28030 ○ TMDSCNCD28335 - Delfino™ TMS320F28335
TIDA-00261: High-performance bipolar stepper drive stage reference design with 256 microstep support	The TIDA-00261-BOOST-DRV8711 is an 8 V to 52 V, 4.5 A, 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.	• 8 V to 52 V supply input with up to 4.5 A 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
TIDA-00199: Wide-input isolated IGBT gate-drive fly-buck power supply for three-phase inverters reference design	This reference design provides isolated positive and negative voltage rails required for Insulated gate bipolar transistor (IGBT) gate drivers from a single 24 V DC input supply. Utilizing a Fly-Buck™ control topology, this reference design uses a single transformer for generating power rails for all three arms of the 3-phase inverter. It uses primary-side regulation and can achieve good cross regulation without opto-coupler feedback or an auxiliary winding. The isolated outputs are generated through the coupled windings of the transformer. The voltage rails for all the high-side IGBTs are individually isolated, whereas the voltage rails for all low-side IGBTs are combined.	• Isolated power supply with 24 V ±20% input range that supports 6 IGBT gate drivers for 3-phase inverter (each arm in half-bridge configuration) • Low-ripple (<200 mV) bias outputs (+15 V and –8 V) with output power of 2.3 W for each IGBT of the 3-phase inverter • Fly-Buck topology provides easy-to-design multi-output isolated power supply solution with primary side regulation • Peak efficiency of 82% at balanced full-load • Output capacitors rated to support up to 6 A peak gate drive current
TIDA-00315: 100/200 V_{AC} input, 30 W isolated power supply reference design for servo drives	This reference design provides isolated 24 V_{DC}, 16 V_{DC} (x3) and 6 V outputs to power the control electronics, IGBT module and fan for 100 V_{AC}/200 V_{AC} input servo drives. The power supply can be either powered directly from a single or 3-phase AC mains or can be powered from the DC link voltage. This reference design uses primary-side regulation, quasi-resonant flyback topology and is rated for 30 W output. The line and load regulation of the power supply is designed to be within 5%. The power supply is designed to meet the clearance, creepage and isolation test voltages as per IEC61800-5 requirements.	• 30 W isolated main power supply for servo drives • Can operate with DC link (450 V_{DC} max) or AC input (200 V_{AC}) • Load and line regulation: 5% • Input UV/OV, output overload and SC protection • Protection against loss of feedback • Lower system cost solution using UCC28711 through primary side regulation, eliminating feedback loop • Quasi-resonant mode controller improves EMI • Operating temperature range: –10ºC to 65ºC • Designed to comply with IEC 61800-5

TI Designs

Reference designs for motor drives

Reference design	Description	Key features

TIDA-00202: Interface to a HIPERFACE position encoder reference design	The TIDA-00202 reference design implements an EMC compliant industrial hybrid analog and digital interface to a HIPERFACE position encoder. A 3.3 V supply RS485 transceiver with IEC-ESD and IEC-EFT protection is used for the bidirectional parameter channel. For the analog sine/cosine signal channel, two options are provided to offer flexibility for connection to processors with and without embedded ADC or redundancy by using both options simultaneously: a fully differential dual 12-bit ADC with SPI output or a dual differential input with single-ended analog output (0-3.3 V). The design features an industrial compliant 24 V input with wide range from 16 V to 36 V. The power supply for the encoder can be configured from 7 to 12 V (default 11 V) and offers short-circuit protection. A 3.3 V I/O connector with analog and logic signals provides an easy interface to a host processor with HIPERFACE master IP core. For quick evaluation an example firmware is available for a C2000™ Piccolo MCU to calculate the absolute angle position and display it through a virtual COM port.	• EMC compliant interface to HIPERFACE position encoders with digital bidirectional parameter channel up to 38400 baud and analog sin/cos channel with at least 150 kHz bandwidth
		• 3.3 V supply half-duplex RS485 transceiver with 12 kV IEC-ESD and 4 kV IEC-EFT
		• Dual signal path option for sine and cosine signals offer flexibility for connection to MCU with and without embedded ADC
		  ○ Dual 12-bit ADC with SPI output
		  ○ Dual analog output (0-3.3 V)
		• Host processor interface (3.3 V I/O) for easy connection to MCUs like C2000™ for the HIPERFACE master
		• Example firmware on C2000™ Piccolo MCU to calculate and display the interpolated absolute angle from HIPERFACE position encoders
		• Designed to meet EMC immunity for ESD, fast transient burst and surge with levels according to IEC61800-3

TIDA-00445: Shunt-based 200 A peak current measurement reference design using isolation amplifier	The TIDA-00445 design provides a reference solution for isolated current measurement using shunt and isolated amplifier. By limiting the shunt voltage to 25 mV, this design is able to reduce power dissipation in the shunt and achieves a high current measurement range of up to 200 A. Shunt voltage is further amplified by precision op amps in the instrumentation amplifier based configuration with a gain of 10 to match the input range of the isolation amplifier. The output of isolation amplifier is level shifted and scaled to utilize the complete input range of 3.3 V ADC. This design uses a free running transformer driver for generating isolated supply voltage for the high voltage side of the circuit. A small form factor for the power supply is achieved by the operation of driver at 400 kHz.	• Shunt based isolated 200 Apk current measurement solution • Limiting shunt voltage to 25 mV helps achieving less power dissipation • High-side current sense circuit with high common mode voltage of 1200 V peak supporting up to 690 V AC main powered drives • Calibrated AC accuracy of <1% across temperatures -25°c to +85°c • Can be interfaced directly with differential or single ended ADC • Small form factor push-pull based isolated power supply to power high side circuit • Inbuilt 1.65 VREF for level shifting the output
TIDA-00203: Compact CAN-to-Ethernet converter using 32 bit ARM® Cortex™-M4F MCU reference design	This TIDA-00203 demonstrates a small form-factor controller access network (CAN)-to-Ethernet converter using the TM4C129XNCZAD 32-bit ARM® Cortex™-M4F MCU. Supporting 10/100 Base-T compliant with IEEE 802.3 standard, this reference design is useful for industrial drives monitoring and control, as well as supervisory control and data acquisition (SCADA) systems. The same hardware can be used as a CAN-to-Ethernet gateway or bridge with simple changes in the firmware. The gateway application is useful for monitoring remote CAN networks over Ethernet, while the bridge application is useful for coupling CAN networks via the internet or local area network (LAN).	• Fully integrated 10/100 Ethernet MAC and PHY with advanced IEEE 1588 precision time protocol (PTP) hardware and both media independent interface (MII) and reduced MII (RMII) support • Onboard non-isolated controller area network (CAN) and RS-485 PHYs provides easy interface to a variety of fieldbus solutions • JTAG connector for easy programming • Expansion connectors provide access to communication, analog-to-digital converters (ADCs) and general purpose input and output (GPIO) interfaces for maximum flexibility • 50 pin SDCC connector provides easy interface to MII and RMII Ethernet PHY for use with other controllers
TIDA-00207: EN55011 compliant, industrial temperature, 10/100 Mbps Ethernet PHY brick reference design	This Ethernet PHY brick reference design enables TI customers to quickly design systems and release them to market, using TI industrial Ethernet PHY transceiver devices, fully compliant to EN5501 Class A EMI requirements. A 50 pin interface has been provided to interface with 32 bit Cortex™ M4 processor based controller board. The board's small form factor (2 in x 3 in) makes it easy to fit into existing products. This reference design demonstrates the advanced performance of the DP83848K Ethernet PHY transceiver devices, supports 10/100 Base-T and is compliant with IEEE 802.3 standard. The entire reference design operates from a single power supply (5 V with on-board regulator or 3.3 V). All other voltages required for the Ethernet PHY transceiver are internally generated.	• Meets EN55011 Class A radiated emission requirements • Low power consumption = 264 mW • 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 4 kV
TIDA-00180: Power supply with programmable output voltage and protection for position encoder interfaces	The TIDA-00180 design implements a universal power supply with programmable output voltage and innovative smart eFuse technology for use in a multi-standard position encoder interface module on an industrial drive. The eFuse provides inrush-current and over-current protection as well as user programmable over- and under-voltage protection with limits accurate across the industrial temperature range. This design is realized to meet EMC immunity requirements for ESD, fast transient burst and surge according to IEC61800-3.	• Power supply design supports different supply voltage requirements for a wide range of position encoders with digital or analog interface • Wide input voltage range, 18-36 V (24 V nominal) and high efficiency (>80%) • Output voltage programmable from 5 V to 15 V with <15 mVpp ripple at 300 mA load current • Output protection with innovative eFuse technology, inrush-current limitation and protection against overcurrent, over- and under-voltage ○ Protection limits are constant across the industrial temperature range • Fault handling: disconnect in case of fault, enable pin for power supply reset. • Fault and power good indicator flags for diagnostics • Designed to meet EMC requirements for ESD, EFT, surge according to IEC61800-3

TI Designs
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Reference design	Description	Key features

TIDA-00446: Small form-factor reinforced isolated IGBT gate drive reference design for 3 phase inverter	The TIDA-00446 reference design consists of six reinforced isolated IGBT gate drivers along with dedicated gate drive power supplies. This compact reference design is intended to control IGBT's in 3-phase inverters like AC drives, uninterruptible power supplies (UPS) and solar inverters. The design uses a reinforced isolated IGBT gate driver with DESAT feature and built-in miller clamp protection, enabling use of unipolar supply voltage for the gate drive. Open loop push-pull topology based power supply for each gate driver provides flexibility in PCB routing. The push-pull transformer driver used in TIDA-00446 operates at 420 kHz to reduce the size of the isolation transformer leading to compact power supply solution. Gate drive power supply can be disabled to facilitate safe torque off (STO).	• Suited for low voltage drives (400 Vac and 690 Vac)
		• ntegrated 2.5 A source and 5 A sink current suits driving IGBT modules with currents up to 50 A
		• Built in miller clamp functionality enables use of unipolar supply voltage (+17 V) for driving IGBT
		• Built in protection functionalities
		  ○ Short circuit protection through DESAT detection
		  ○ Supply undervoltage protection
		• Provision for separate Rg(ON) and Rg(OFF)
		• 8000 Vpk reinforced isolation
		• Very high CMTI of > 100 kV/µs
		• Spread spectrum operation of transformer driver helps reduce EMI
		• PWM and fault signals of gate drivers can be directly interfaced to controller (3.3 V operation)

TIDA-00440: Leakage current measurement reference design for determining insulation resistance	This TI design provides a reference solution to measure insulation resistance up to 100 MΩ. It has an on-board isolated 500 Vdc power supply and an isolated signal conditioning circuit to measure the leakage current. This design is useful to find leakage due to insulation breakdown in transformer and motor windings.	• Leakage current measurement circuit with option for: programmable current sense amplifier and switchable shunt resistors • Range of measurement: 0 to 100 MΩ with accuracy of 5% (uncalibrated) • Test voltage level derived from IEEE 43-2000 ("Recommended Practice for Testing Insulation Resistance of Rotating Machinery") • On-board isolated 500 V power supply to measure the insulation resistance • Provision for calibration resistor on board • Hardware support for start-of-frame detect allows implementation of IEEE1588 PTP

TIDA-00285: 1 kW/36 V power stage for brushless motor in battery powered garden and power tools reference design	This TIDA-00285 is a power stage for brushless motors in battery-powered garden and power tools rated up to 1 kW. The power stage operates from a 10-cell lithium-ion battery with a voltage range from 36 to 42 V. The design uses CSD18540Q5B NexFETs featuring a very low drain-to-source resistance (RDS_ON) of 1.8 mΩ in a SON5x6 SMD package, which results in a very small form factor of 57 × 59 mm. The three-phase gate-driver DRV8303 is used to drive the three-phase MOSFET bridge, which can operate from 6 to 60 V and support programmable gate current with maximum setting of 2.3-A sink / 1.7-A source. The power stage can be configured for a single-shunt or three-shunt current sensing. The design supports sensorless control for brushless DC (BLDC) and permanent magnet synchronous motors (PMSM) using trapezoidal control or field oriented control (FOC). The C2000™ Piccolo™ LaunchPad™ is used with the power stage to implement InstaSPIN™-FOC using the motor current and voltage feedback. The corresponding test report evaluates the thermal performance of the board and overcurrent protection features such as cycle-by-cycle control and latch control of the DRV8303.	• 1 kW power stage with field oriented control for permanent magnet synchronous motors, designed to operate from 10-cell Li-Ion battery voltage ranging from 30 to 42 V
		• Delivers up to 30 A RMS continuous motor current with an airflow of 400 LFM
		• Small PCB form factor of 57 × 59 mm using 60 V/400 A PEAK, 1.8 mΩ RDS_ON, SON5x6 package MOSFETs for power stage
		• Uses DRV8303 three-phase gate driver
		  ○ 6 to 60 V input
		  ○ Programmable gate current with max setting of 2.3 A sink / 1.7 A source
		• Overcurrent protection configurable for cycle-by- cycle control or latch shutdown
		• Operates at ambient temperature of 20°C to 55°C

TIDA-00436: 36 V/1 kW brushless DC motor drive with stall current limit of <1 µs response time reference design	This reference design is a power stage for brushless motors in battery-powered garden and power tools rated up to 1 kW, operating from a 10-cell lithium-ion battery with a voltage range from 36 to 42 V. The design uses 60 V, N-channel NexFETs™ featuring a very low drain-to-source resistance (RDS_ON) of 1.8 mΩ in a SON5x6 SMD package, resulting in a very small PCB form factor of 57 × 59 mm. The three-phase gate-driver drives a three-phase MOSFET bridge, which can operate from 6 to 60 V and supports programmable gate current with maximum setting of 2.3 A sink / 1.7 A source. The C2000™ Piccolo™ LaunchPad™ LAUNCHXL-F28027 is used along with this power stage and 120 degree trapezoidal control of BLDC motor with Hall sensors is implemented in software. The cycle-by-cycle current limit feature in the gate-driver protects the board from excessive current that is caused during motor stalls, by limiting the maximum current allowed in the power stage to a safe level.	• 1 kW power stage with Hall sensor based trapezoidal control for brushless DC motor implemented on TMS320F28027 MCU
		• Operates from 10-cell Li-Ion battery (30 V to 42 V)
		• Delivers up to 32 ARMS continuous motor current with an airflow of 400 LFM
		• Small PCB form factor of 57mm x 59 mm
		• Uses DRV8303 three-phase gate driver
		  ○ 6 to 60 V input
		  ○ Programmable gate current with maximum setting of 2.3 A sink / 1.7 A source
		• Hardware cycle-by-cycle overcurrent limit with configurable threshold for motor stall protection
		• Provision for sense feedback of individual phase voltage, DC bus voltage, DC bus current sense and low-side current sense on each phase for sensorless control
		• TPS54061 based 3.3 V/0.15 A step-down buck converter for powering MCU
		• Operates at an ambient temperature of –20°C to 55°C

TI Designs
Reference designs for motor drives

Reference design	Description	Key features
TIDA-00771: 10.8 V/250 W, 97% efficient, compact brushless DC motor drive w/stall current limit reference design	The TIDA-00771 is a 20 A RMS drive for a three-phase brushless DC (BLDC) motor in power tools operating from a 3-cell Li-ion battery with a voltage range of 5 V to 12.6 V. This design is a 45 x 50 mm compact drive implementing sensor-based trapezoidal control. The design uses a discrete, compact MOSFET-based three-phase inverter delivering 20 A RMS continuous (70 A peak for 1 second) winding current, without any external cooling or heat sink. The slew rate control and charge pump of the gate drive ensures maximum inverter efficiency (>97% at 10.8 V DC) from 5 V to 12.6 V and optimum EMI performance. The cycle-by-cycle overcurrent protection feature protects the power stage from large stall currents and the board can work up to 55°C ambient. The small form factor enables placement of board close to the battery pack, high efficiency brings more battery duration and the 70 A peak current capability provides high momentary peak torque in power tools.	• Operating voltage 5 V to 12.6 V (3-cell Li-ion Battery) ○ Up to 20 A RMS continuous (70 A peak for 1 second) winding current without heat sink or airflow • Small PCB form factor of 45mm x 50mm • Optimum inverter efficiency (>97% at 10.8 V) from 5 V to 12.6 Vand EMI performance using the slew rate control and charge pump feature of the gate driver • Cycle–by-cycle overcurrent protection with <1 µs response time and short circuit latch protection by VDS sensing • Shoot-through, under voltage, over temperature and blocked rotor protection
TIDA-00772: 18 V/400 W 98% efficient compact brushless DC motor drive w/stall current limit reference design	The TIDA-00772 is a 18 A RMS drive for a three-phase brushless DC (BLDC) motor in power tools operating from a 5-cell Li-ion battery with a voltage up to 21 V. This design is a 45 x 50 mm compact drive implementing sensor-based trapezoidal control. The design uses a discrete, compact MOSFET-based three-phase inverter delivering 18 A RMS continuous (60 A peak for 1 second) winding current, without any external cooling or heat sink. The slew rate control and charge pump of the gate drive ensures maximum inverter efficiency (>98% at 18 V DC) and optimum EMI performance. The cycle-by-cycle overcurrent protection feature protects the power stage from large stall currents and the board can work up to 55°C ambient. The small form factor enables flexible mounting of board, high efficiency brings more battery duration and the 60 A peak current capability provides high momentary peak torque in power tools.	• Operates at voltage from 5 V to 21 V (5-cell Li-ion battery) ○ Up to 18 A RMS continuous (60 A peak for 1 second) winding current without heat sink or airflow • Small PCB form factor of 45mm x 50mm • Optimum inverter efficiency (>98% at 18 V) and EMI performance by using low RDS_ON NexFETs and utilizing the slew rate control and charge pump feature of the gate driver • Cycle-by-cycle overcurrent protection with <1 µs response time and short circuit latch protection by VDS sensing • Shoot-through, under voltage, over temperature and blocked rotor protection

TIDA-00210: 75 V/10 A protected full-bridge power stage reference design for bipolar stepper drives	For stepper drives which require higher torque and power, often voltages above 48 VDC up to 100 VDC, the TIDA-00210 provides a solution. It uses two protected full-bridge power stages based on TIDA-00365 in parallel configuration. Each full-bridge operates nominally 75 VDC and 10 A RMS phase current and features bipolar high-side current sensing leveraging a 100 V full-bridge gate driver SM72295 with integrated amplifiers and four 100 V NexFET™ power MOSFETs with ultra-low gate charge and small SON5x6 package with low thermal resistance. The power stage is fully protected against over-temperature, overcurrent and short-circuit between the motor terminals and motor terminals to ground. Onboard power supplies provide a 12 V and a 3.3 V rail for the gate driver and signal chain. The host processor interface is 3.3 V I/O to connect a host MCU like C2000™ Piccolo for stepper motor control.	• Protected full-bridge power stage with input voltage up to 100 VDC (75 VDC nominal) and 10 A RMS phase current
		• BOM reduction using SM72295 100 V full-bridge gate driver with integrated amplifiers used for high-side bipolar phase current sensing, supporting up to 256 micro steps
		• 95% efficiency at 16 kHz PWM, nominal load
		  ○ Very low switching losses to support higher PWM frequencies
		  ○ No heatsink required at 25C ambient and nominal load
		• Full-bridge optimized for low EMI (25ns with no overshoot on switch-node voltages)
		• Over-temperature, overcurrent and short circuit protection
		• 3.3 V host processor interface

TIDA-00366: Reference design for reinforced isolation 3-phase inverter with current, voltage and temp protection	The TIDA-00366 reference design provides a reference solution for a 3-phase inverter rated up to 10 kW, designed using a reinforced isolated dual IGBT gate driver UCC21520, reinforced isolated amplifier AMC1301 and an MCU (TMS320F28027). Lower system cost is achieved by using AMC1301 for motor current measurement interfaced with internal ADC of MCU and use of bootstrap power supply for IGBT gate drivers. The inverter is designed to have protection against overload, short circuit, ground fault, under/over DC bus voltage and IGBT module over-temperature.	• Reinforced isolated inverter suited for 200-690 V AC drives rated up to 10 kW • Simple yet effective gate driver with 4 A source, 6 A sink output current capability • 250 kHz isolated amplifier for inverter current, DC link voltage and IGBT module temperature measurement - enables use of internal ADC of MCU • Calibrated current measurement accuracy of ±0.5% across temperature range from -25°C to 85°C • Protection against DC bus under-voltage, over-voltage, overcurrent, ground fault and over-temperature • Bootstrap based power supply for high side gate driver reduces overall cost for power supply requirement • 19 ns (typical) propagation delay optimizes dead band distortion
TIDA-00912: Shunt-based high current measurement (200 A) reference design with reinforced isolation amplifier	The TIDA-00912 TI Design provides a complete reference solution for isolated current measurement using external shunts, reinforced isolation amplifiers and isolated power supply. The shunt voltage is limited to 25 mV max. This reduces power dissipation in the shunt to enable a high current measurement range up to 200 A. Shunt voltage is amplified by an instrumentation amplifier configuration with a gain of 10 to match the input range of the isolation amplifier for better signal to noise ratio. The output of the isolation amplifier is level shifted and scaled to fit the complete input range of 3.3 V ADCs. This design uses a free running transformer driver operating at 410 kHz for generating isolated supply voltage in a small form factor to power the high voltage side of the circuit.	• Shunt-based 200 A peak current measurement solution with reinforced isolation • Limiting shunt voltage to 25 mV reduces power dissipation • High-side current sense circuit with high common-mode voltage of 1500 Vpeak, supporting up to 690 V AC mains powered drives • Calibrated AC accuracy of <1% across temperatures -25°C to 85°C • Can interface directly with differential or single-ended ADC • Small form factor push pull-based isolated power supply to power high-side circuit

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Reference design	Description	Key features
TIDA-00472: 230 V/250 W, hi-η sensorless brushless DC motor drive with 30% reduced bulk capacitor reference design	The TIDA-00472 is a discrete IGBT-based three-phase inverter for driving brushless DC (BLDC) motors rated up to 250 W, for example, used in cooker hoods, using a sensorless, trapezoidal control method. The design provides software implementation for DC bus voltage ripple compensation resulting in 30% reduction in the DC bus capacitor requirement and reduced overall BOM cost. The cycle-by-cycle overcurrent protection feature protects the power stage from large current spikes and the board can work up to 65°C ambient. This design has also been tested to pass EN55014 standards for conducted emissions, surge and EFT.	• 250 W mains powered BLDC motor drive with sensorless trapezoidal control using InstaSPIN™-BLDC • Software implementation for DC bus ripple compensation resulting in 30 % reduced DC bus capacitor • Current sensing using single shunt on the DC bus return for cycle-by-cycle current limit and protection • High efficient circuit board enables up to 200 W without heat sink up to 65 °C ambient temperature • Hardware design to meet surge, EFT and conducted emission as per EN55014 • Tested, ready to use hardware and software platform for driving high voltage BLDC motors
TIDA-00447: 24 V, 100 W/30 W dual sensorless brushless DC motor drive reference design	TIDA-00447 is a 24 V, dual brushless DC (BLDC) motor drive reference design to be used in major home appliances to drive low voltage BLDC motors such as pumps and fans, e.g. for circulation pump and drain pump of dishwashers. The power stages of motor drive are designed for 100 W and 30 W of continuous operation respectively. The design is fully protected with on chip advanced and extensive built-in protection features to minimize design complicity, enable system safety and improve high reliability for home appliances. The MCU is programmed with InstaSPIN-BLDC software that implements sensorless trapezoidal control of BLDC motor using back-EMF integration method and it is also used to configure & control the speed of drain pump stage. Isolated UART interface enables communication of the drive unit with the main user interface controller. This reference design is fully tested for full load operation, over current and motor stall protections.	• 24 V dual brushless motor driver platform • Sinusoidal motor control • Up to 30 W continuous operation based on a single chip for the lower powered motor • 5 V/3.3 V buck/linear converter • Up to 100 W continuous operation achieved using discrete approach having a MCU, external MOSFET driver with built-in protections & current sensing amplifier for higher powered motor • Discrete implementation of water circulation pump offers easy scaling of power level • Sensorless trapezoidal control of BLDC motor with MCU programmed with InstaSPIN-BLDC software
TIDA-00919: Single-layered, refrigerator fan reference design enabling high efficiency drive	he TIDA-00919 reference design is a single-layered, cost-effective, small-form-factor, three-phase sinusoidal motor drive for sensored BLDC fan motors specified up to a maximum current of 1 A RMS at 18 V maximum. The unique, single-sided design helps to bring down the system cost. The on-board Hall sensors facilitate the board mounting inside the motor itself. The design also demonstrates the features of DRV10970 such as single Hall operation for further cost optimization, sinusoidal drive with adaptive drive angle adjustment for better system efficiency and overall performance, speed control via external pulse-width modulation (PWM) input which brings an ease of speed control, etc.	• Ready to use hardware and software platform for driving 12 V/24 V, <50 W BLDC motors with sinusoidal commutation • MSP430G2303 functions to accept the IR input and close external speed loop • Sensorless Control Scheme provides a continuous sinusoidal drive and significantly reduces pure tone acoustics that typically occur as a result of commutation • Hardware design tested at 50 W with good thermal performance • Fully integrated buck/linear regulator to efficiently step down supply voltage to 3.3 V for powering both internal and external circuits (TI MSP430™ MCU in this design)
TIDA-00652: 90-265 VAC, 91% efficiency, >0.94 PF buck-PFC plus 24 V, 30 W brushless DC motor drive reference design	For achieving energy efficiency, ceiling fans and ventilation fans are moving from simple AC induction motors to brushless DC motors (BLDC). Operation of BLDC motors from an AC supply requires AC-DC conversion with high efficiency and power factor. It also needs an inverter which is controlled efficiently for low noise operation. The reference design TIDA-00652 helps to meet these challenges of higher efficiency and power factor in a simpler way, by using a single stage power supply to convert the AC main input into low voltage DC output. It also combines a fully integrated and well protected single chip sensorless sinusoidal brushless motor controller for low noise operation.	• High efficiency, single power stage to convert 230 VAC to 24 VDC • Buck PFC topology, to achieve high input power factor (>0.94) and high efficiency (>91%) • Universal input capability (50/60 Hz, 90-265 VAC) with minimum variation in efficiency • Startup and full speed operation even at 90 VAC input • Highly integrated and protected single chip, sinusoidal brushless motor controller reduces external parts count and helps avoid motor control programming overhead • IR remote based speed control

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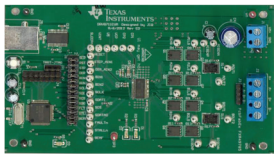

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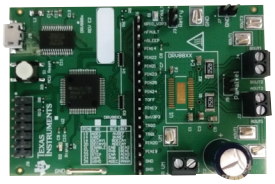
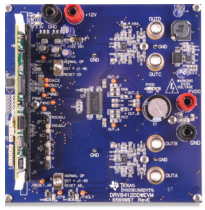
- Open source: BOM, schematics, Gerbers

DRV8880EVM - $49.99



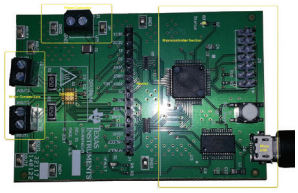
- DRV8880-based stepper motor controller capable of operating at 6.5 V to 45 V
- Features AutoTune™ automatic adaptive current decay modes for easy, automatic tuning of stepper motors
- Supports 12, 24, 36 and 42 V stepper motors
- GUI for motor tuning and selection of current decay modes when not utilizing the AutoTune™ feature
- Capable of delivering 2.0 A full-scale/1.4 A RMS current output to a stepper motor

DRV8412-C2-KIT – $199



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

DRV8846EVM - $49.99



- DRV8846-based stepper motor controller capable of operating at 4 V to 18 V
- Easy-to-use STEP/DIRECTION interface with up to 1/32 µ-step indexer integrated on-chip
- Capable of delivering 1 A RMS/ 1.4 A full-scale output current per H-bridge
- Featuring AutoTune™ automatic adaptive current decay modes
- Optimized for 12 V or low voltage battery powered operation

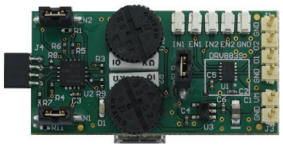
Tools and EVMs

Complete TI motor drive solutions

Brushed DC motors

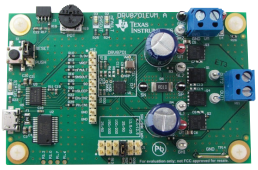
DC motors are used when simple control and cost effectiveness are required in applications such as toys and small consumer appliances.

DRV8839EVM – $25



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

DRV8701EVM - $49.99

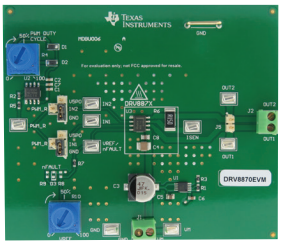


- DRV8701-based H-bridge controller capable of 5.9 V to 45 V operation using four external CSD18532Q5B NexFET™ power MOSFETs
- Capable of delivering 15 A continuous/20 A peak
- Compact 3.5" x 2.2" form factor
- User-friendly GUI via MSP430 and USB interface

RDK-BDC24 – $219

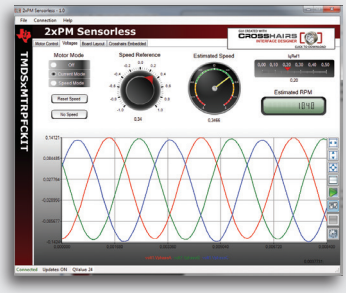
- Controls brushed 24 V DC motors with up to 40 A continuous
- Three options for open-loop voltage control and two options for closed-loop, speed, position or current control
- CAN and RS-232 communication

DRV8871EVM - $49.99



- 6.5 V to 45 V brushed DC motor controller featuring integrated current sensing and regulation
- Removes unnecessary current sense resistor for power and board space reductions
- Adjustable PWM duty cycle potentiometer
- Adjustable current regulation potentiometer

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

Tools and EVMs
Complete TI motor drive solutions

Brushless DC (BLDC) motors and permanent magnet synchronous motors (PMSMs)

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

- 50 V, 3.5 A ,3-phase motor driver stage
- NEMA17 BLDC/PMSM 55 W 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

- 60 V, 60 A, 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

DRV10983EVM - $149 each

- 28 V, 3 A, 3-phase BLDC motor control kit
- ZWL12_22_2.5 A motor
- Spin EVM motor or your own motor out of box with USB2ANY programming tool and GUI
- True sinusoidal motor current, smooth and silent motor operation

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**
DRV8302-HC-C2-KIT: **www.ti.com/tool/drv8302-hc-c2-kit**
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BOOSTXL-DRV8301: **www.ti.com/tool/boostxl-drv8301**
BOOSTXL-DRV8305: **www.ti.com/tool/boostxl-drv8305**

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

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

Third party	Website	Service
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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

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