TI Motor Drive Webinar
May 2017

Tips and component recommendations: Easier, faster motor drive integration

Innocent Irakoze
Product marketing engineer for TI’s integrated motor controllers

Electric motor control system overview

Motor control

- Microcontroller
- Manages the control system, motor commutation, driver settings, fault handling

Gate driver

- MOSFET or IGBT gate driver
- Level shifts logic control signals
- Power stage fault detection and handling

Power stage

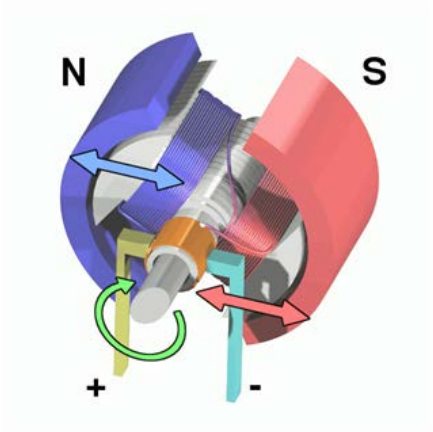
- Power MOSFET or IGBT
- Interface main power rail to electric motor
- Often in half-bridge, H-bridge, or inverter configuration

Feedback

- Signals from motor
- Position, torque, voltage, current

Motor Types

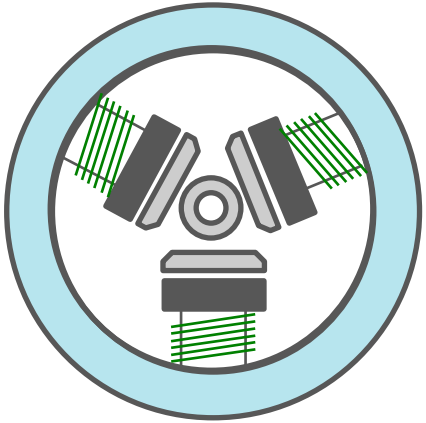
Brushed motor



+ Low cost
+ Easy to design

- Brushes wear out
- Inefficient

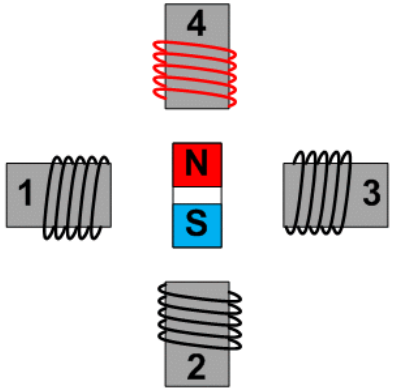
Brushless motor



+ Very efficient
+ Long life / reliable

- Expensive
- Complex design

Stepper motor



+ Open loop position / speed control
+ Simple control

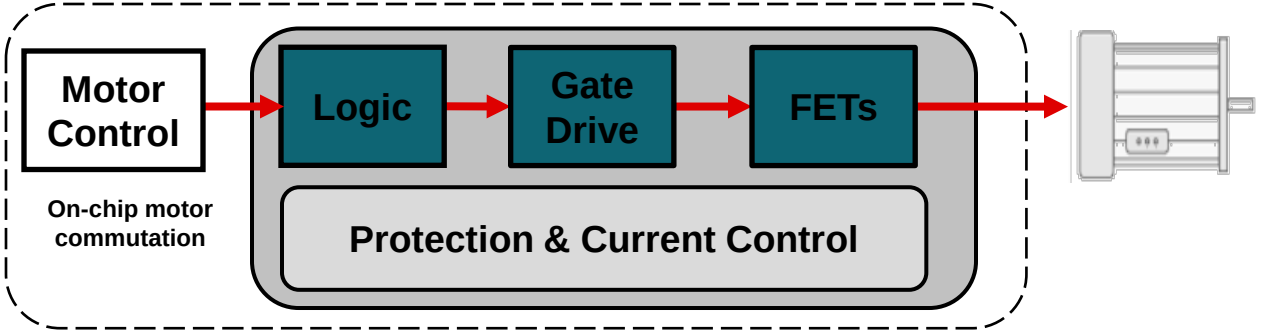
- Resonance
- Noise

[Brushed & Stepper] Image source: www.robot-and-machines-design.com

DRV integrated drivers & gate drivers

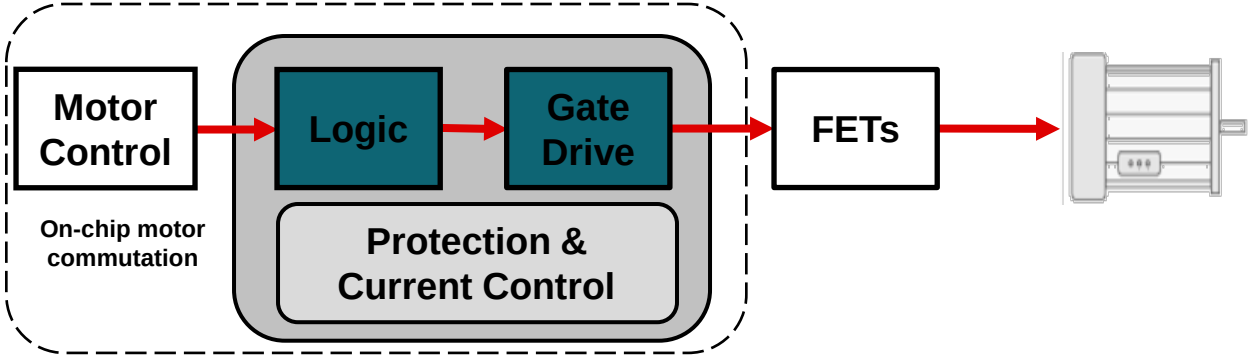
Integrated driver

- Smallest board space
- Easy to design
- Excellent performance
- Fully protected

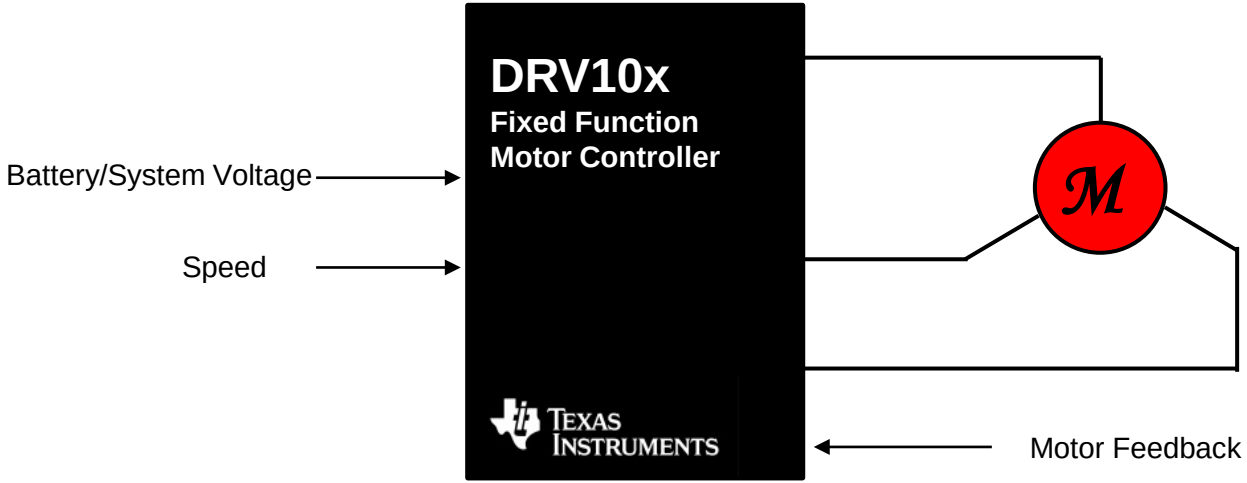


Gate driver

- Scalable / higher currents
- Better thermals
- Lower RDSON
- Reduced board space
- Fully protected



Integrated Motor Controller overview

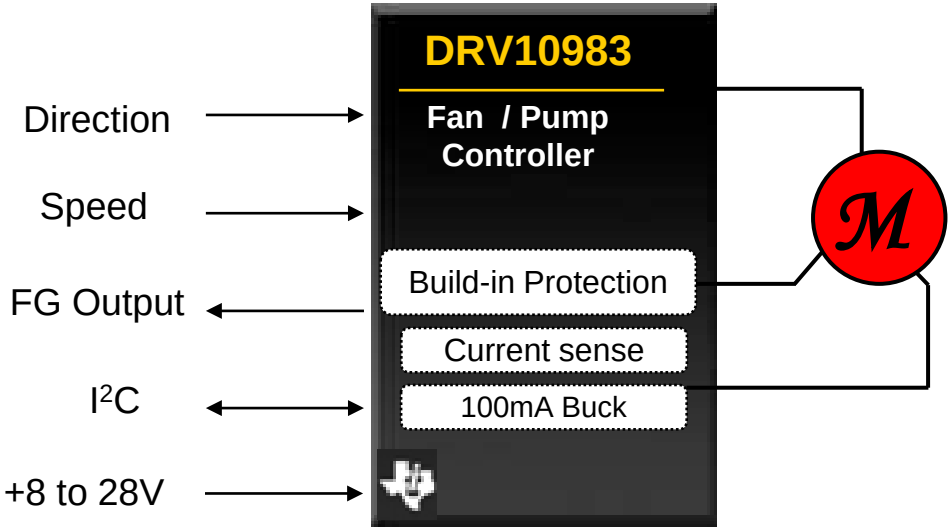


Customer benefits

- Optimal **efficiency**, ultra-low acoustic noise, minimal vibration to provide excellent system performance and reliability
- **Code-free** tunability provides minimum design efforts and use of the device
- **Small board** space usage and **BOM count** to save customer overall system cost

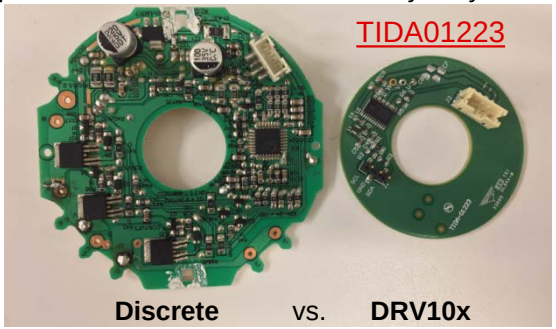
Motor Driver Device: DRV10983

+24V, 3-phase Sensorless BLDC Motor Driver



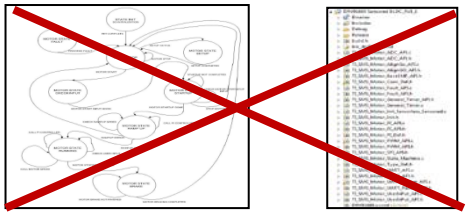
✓ **More compact board space**

Single chip solution vs. discrete enables >50% form factor saving



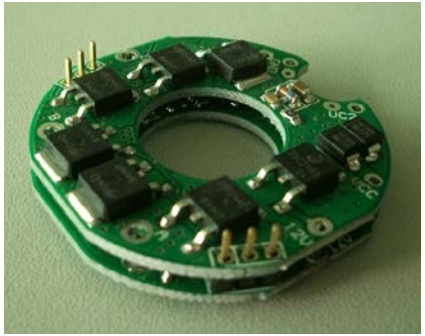
✓ **High performance BLDC control algorithm**

Code-free for high efficiency & low acoustics, fast time to market

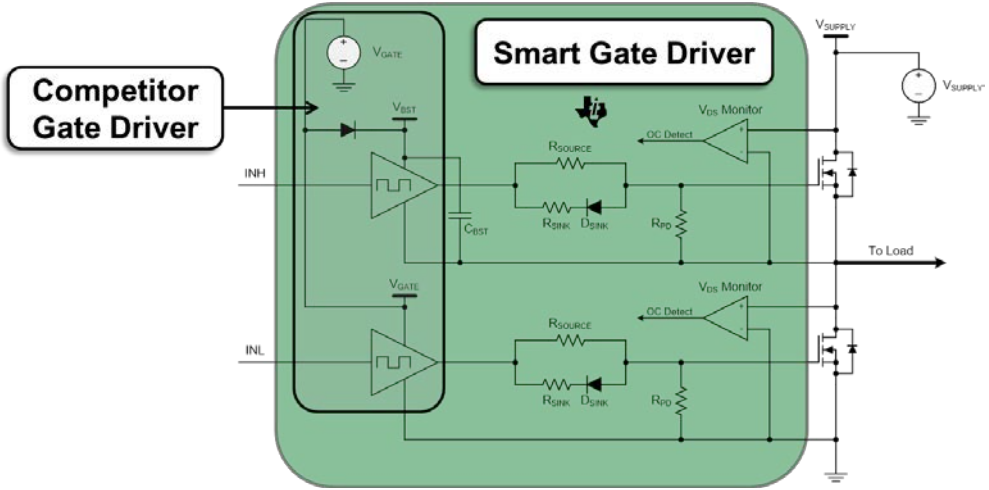


Smart gate drive technology

Challenge:



Solution: Integrated, adjustable, and protected gate driver



Benefits:

- High gate drive current and minimized dead time **(efficiency)**
- Easy, adjustable slew rate control **(flexibility)**
- Gate driver short and dV/dt protection **(robustness)**
- Removes external gate drive components **(cost)**

Smart Gate Driver

Motor Driver device: DRV832x family

65-V 3-Phase BLDC Smart Gate Driver

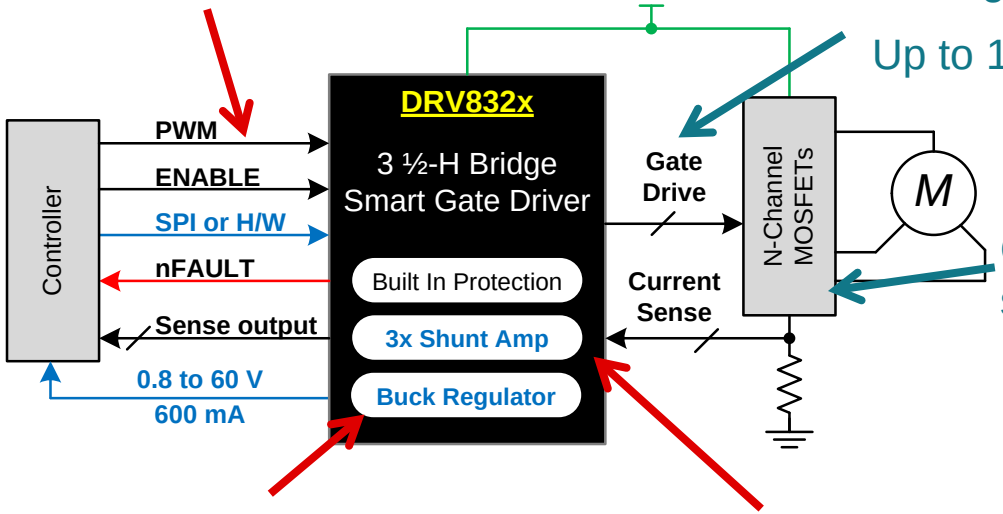
New!

12, 24, 36 V batteries or regulated supplies

H/W for simple operation,
SPI for more configuration

Smart Gate Drive, no gate drive resistors, gate current is adjustable

Up to 1A source, 2A sink



Can drive >300 nC FETs sinusoidal @ 25 kHz

Optional 600 mA buck regulator

Optional triple current shunt amplifiers

The DRV832x family:
DRV8320R
DRV8320
DRV8323R
DRV8323

Broad portfolio of Motor Drivers

Brushed-DC

Supply voltage support:

Low voltage, 12, 24, 36, 48 V

Technologies:

Integrated Current Sensing,

Smart Gate Drive

Differentiation:

Small footprint & high efficiency

Inrush current protection

Low-cost

Hero devices:

DRV8837

DRV8870/8871

DRV8701

Stepper

Supply voltage support:

Low voltage, 12, 24, 36, 48 V

Technologies:

Integrated Current Sensing,

AutoTune, & Smart Gate Drive

Differentiation:

Automatic decay selection

Indexers & precision microsteps

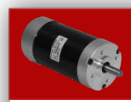
Passive component integration

Hero devices:

DRV8833

DRV8886AT

DRV8880



Brushless-DC

Supply voltage support:

Low voltage, 12, 24, 36, 48 V

Technologies:

Integrated state machine control

Low voltage support (start-stop)

Smart Gate Drive

Differentiation:

Sensorless & sensored support

Integrated shunt amplifiers

Integrated power management

SafeTI™ ASILB, D

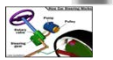
Hero devices:

DRV832x

DRV8305-Q1

DRV10983/10970

DRV3205



TIDesigns

Comprehensive designs:

Schematic or block diagram

Test data

Bill of materials and design files that explain the circuit's function and performance

Benefits:

Expedites grounds-up designs

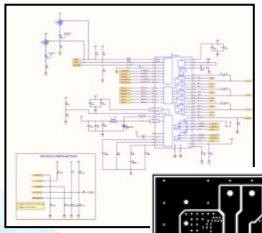
Saves on development cost

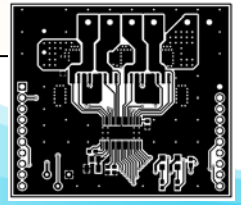
Key Motor Designs:

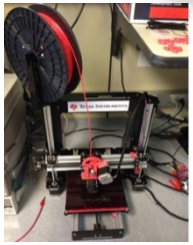
- Sunroof
- Power Tools
- HVAC Damper
- Pump
- Drones
- 3D printer

http://www.ti.com/lsds/ti/analog/motordrivers/overview.page

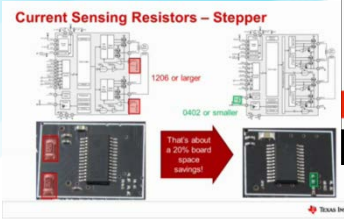
Motor Driver Design Support

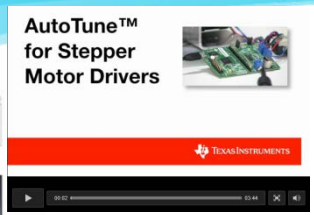


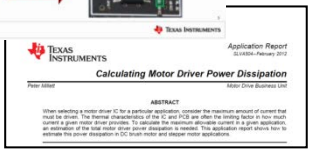


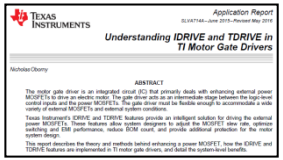


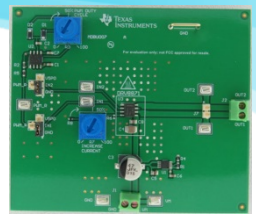
Support	TI Designs
TI E2E™ Community	TIDesigns
App Notes Guides Videos	EVMs

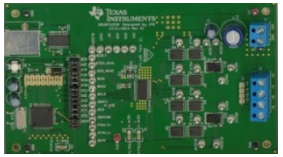








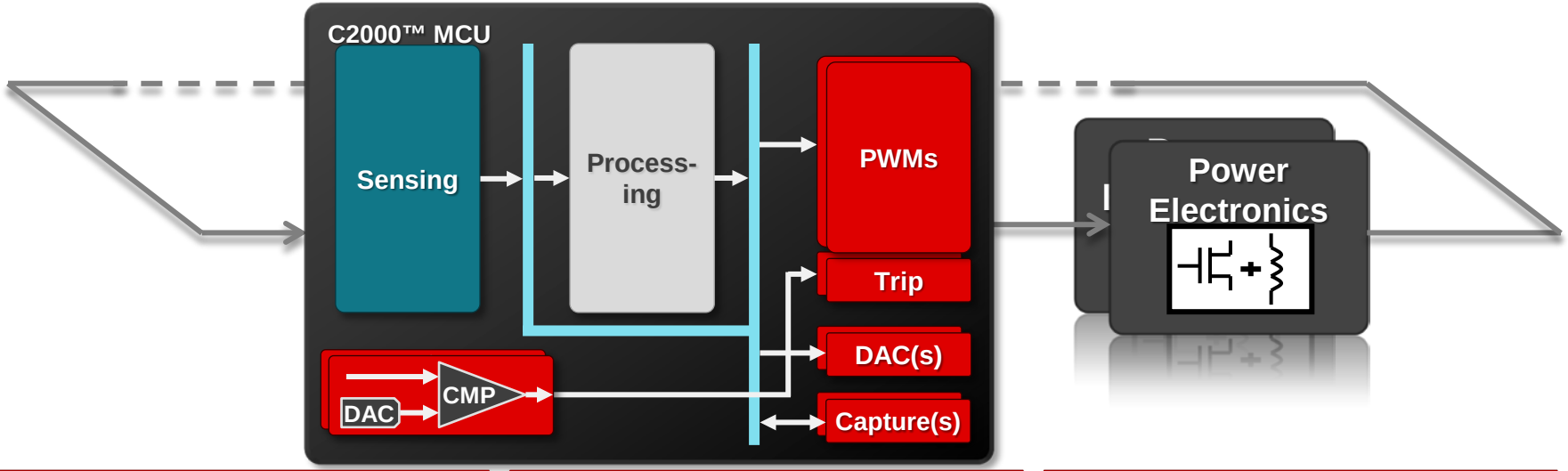




Enabling advanced motor control designs

Chris Clearman
Product marketing engineer, C2000™ microcontrollers, Motor control

C2000™ 32-bit MCU for Real Time Control



Precision Control	Flexible Interfacing	Advanced Protection
• High resolution PWM duty cycle • High resolution PWM period • High resolution PWM phase control • High resolution PWM dead-band • Advanced time synchronization between PWMs	• Advanced inter-PWM and ADC synchronization • Variety of timer count modes • Customizable triggering • External DACs for reference bias waveform generation	• Directly trip PWMs without CPU intervention, nor clocking • Supports PWM shutdown or cycle-by-cycle PWM modification • Peak current mode control support

30 years of C2000 Real-time Control

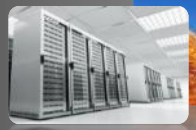
Energy Delivery

Solar Power

Charging Infrastructure

Wind Power

Digital Power



Telecom / Server
AC/DC Rectifiers

Uninterruptable
Power Supplies

DC/DC
Converters

Motor Control

Appliance

Drones

E-bike

Pumps

Industrial Drives

Robotics

Automation

Servo Drive

AC Drives

Sensors

C2000™
32-bit MCUs
Texas Instruments

Automotive & EV/HEV

On-Board Charging
(OBC)

EV-HEV
Auxiliary Motors

DC-DC

EV Traction

Electric Power
Steering

24 GHz Radar
Collision Avoidance

C2000 3-ph Motor Control Applications

PUMPS

Automotive	Industrial/Consumer
•Transmission •Brake/Boost •Oil •Turbo •Fuel/Water	•Constant pressure •Water/Waste/Chemical •Spa/pool pump •Geothermal pump •Dishwashers

COMPRESSORS

Automotive	Industrial/Consumer
•Refrigeration	•Air/Con •Refrigeration

LAUNDRY

•Washers
•Dryers

BLOWERS/FANS

Automotive	Industrial/Consumer
•Air/Con Blowers •Cooling Fan	•Respiratory •Vacuum •Fans •Air/Con Blowers •Exhaust

HIGH TORQUE

Transit	Conveyors
•Traction •eBike/Moped/Scooter •Off-highway Vehicles •Carts, Transport •Fork lifts •Wheel chairs	•Escalators •Elevators •Treadmill •Tools •AC Drive / Inverter •Assembly Line

Two Development Paths

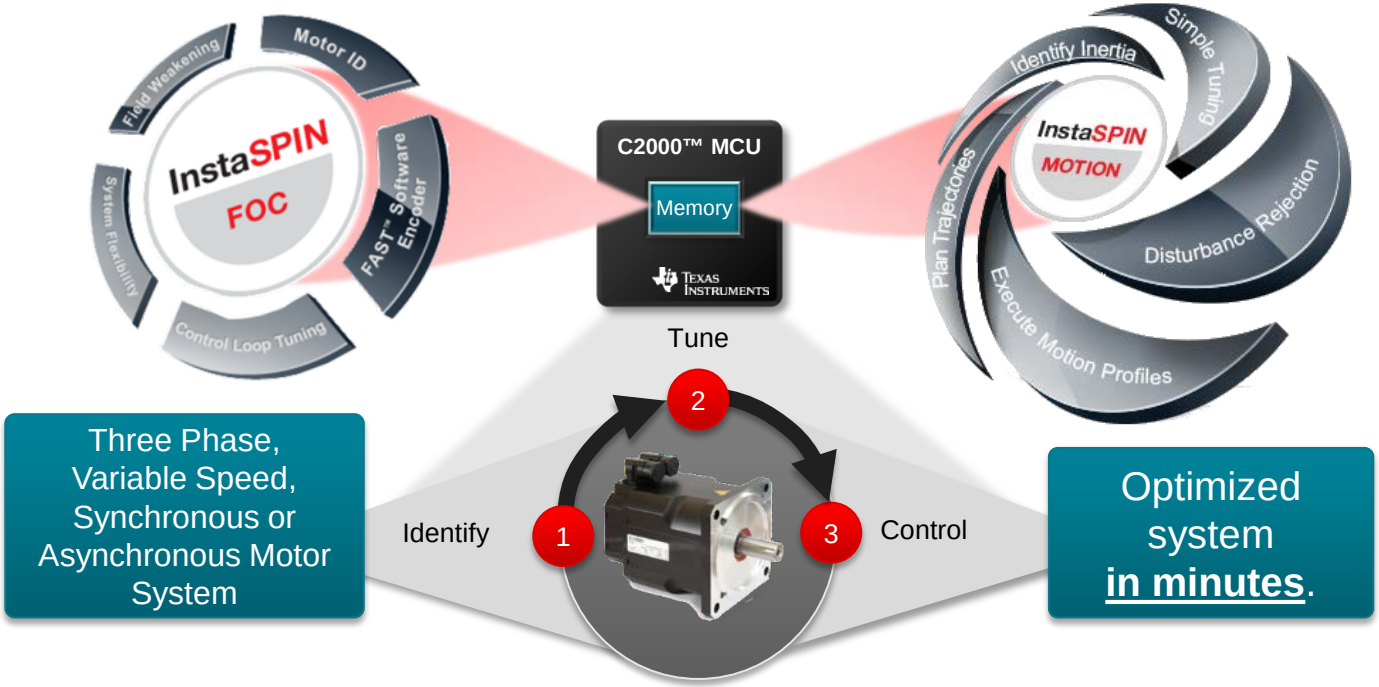
Expertise Included **MotorWare** **InstaSPIN solutions**	*Customer Provides Expertise* **controlSUITE** **motor_control library**
Specific Piccolo devices	Any C2000 device
On-chip ROM libraries and source code	Source code modules
Motor & Inertia Identification	No motor commissioning
Unified sensorless observer	Multiple observers for different motors
Automatically tuned sensorless observer	User tuned sensorless observers
Automatically tuned current controller	User tuned; servo fast current loop option
Single variable high performance velocity/position controller (IS-MOTION)	User tuned standard PID controllers
Motion trajectory generation and state machine framework (IS-MOTION)	No advanced motion trajectory provided

InstaSPIN™ Microcontrollers

C2000™ microcontrollers with embedded InstaSPIN™ motion control software to identify, tune, and fully control three phase motors in minutes.

InstaSPIN™ 32-bit MCUs

Texas Instruments



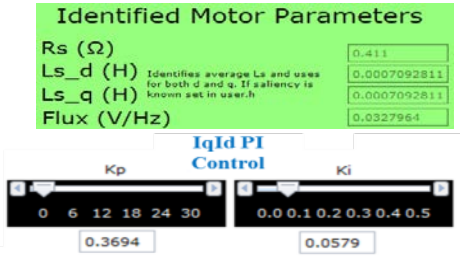
Challenges of Sensorless 3-ph Motor Control

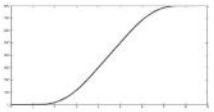
More details SPRUHI9

Customer Challenges	InstaSPIN Solutions
Sensorless observer relies on accurate knowledge of motor parameters	Off-line and Run-time motor parameter identification feature FAST observer relies on fewer parameters
Tuning observer is extremely challenging, multiple tuning sets over operating range	FAST observer self-tunes and works over entire operating range
Observers are not high performance	FAST observer reliable at much lower frequency, under dynamic transients, can recover from stalls, and can track an already moving motor even with inverter un-powered (flying-start)
Start-up from zero speed and transitions through zero speed are extremely challenging	Start-up from zero speed with 100% torque capability, angle convergence within 1 electrical cycle, stable through zero speed during CW/CCW movements
Tuning torque/current controllers challenging, especially when unsure of observer tuning	Torque/current controllers automatically set to stable values, user adjustable after performance testing
Tuning velocity controller challenging for inexperienced	Simple step response how-to provided, or advanced single-variable tuning available
Low fidelity speed estimates based on estimated angle	High fidelity speed estimate calculated independent of angle, with high speed angle compensation feature and unique torque estimate
InstaSPIN-FOC: Identify, tune, and run best sensorless FOC in minutes	

Instantly Enabling Superior 3-phase Motor & Motion Solutions

www.ti.com/instaspin





Motor Parameter ID
Automatic FOC torque tuning
Robust software encoder

InstaSPIN™-FOC

+ best [sensorless]
+ sinewave [commutate]
+ ideal [torque]

Simplified speed tuning
Premium performance
Motion & Planning

InstaSPIN™-MOTION

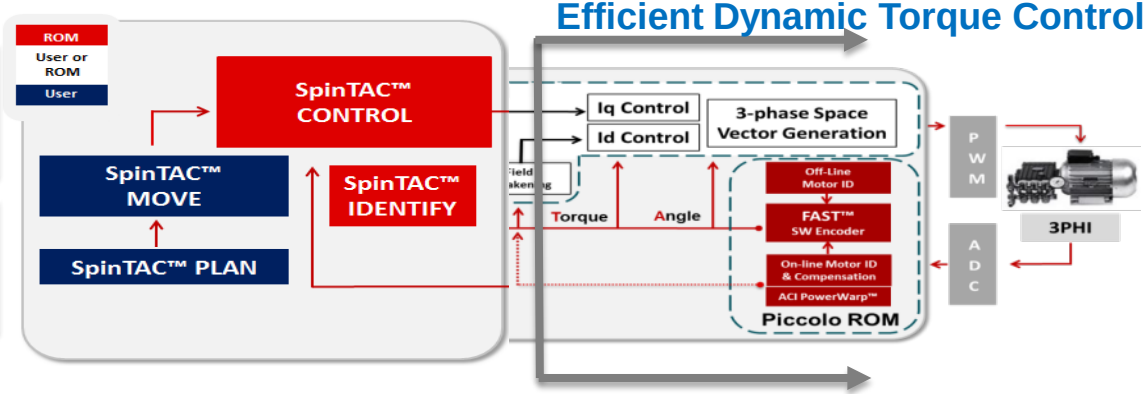
+ ideal [speed]
+ ideal [position]
+ on-chip [motion]
+ integrated [plan]

InstaSPIN-FOC to InstaSPIN-MOTION

Speed PI tuning
Complex
Inconsistent across use

Building Motions
Even more complex
Only as good as control

InstaSPIN-FOC provides
Efficient Dynamic Torque Control



InstaSPIN-MOTION

- Builds upon InstaSPIN-FOC (or use with sensors)
- SpinTAC™ Suite component for high performance motion control

InstaSPIN-FOC Speed Control

- Initial PI gains are just a first starting point
- Does not incorporate real inertia of system
- Control requires
  - Tuning of 2-variable PI controller
  - “gain staging”, different sets of tuning at various operating points
- Movements / Trajectories
  - Only offers constant fixed acceleration

SpinTAC™ Components

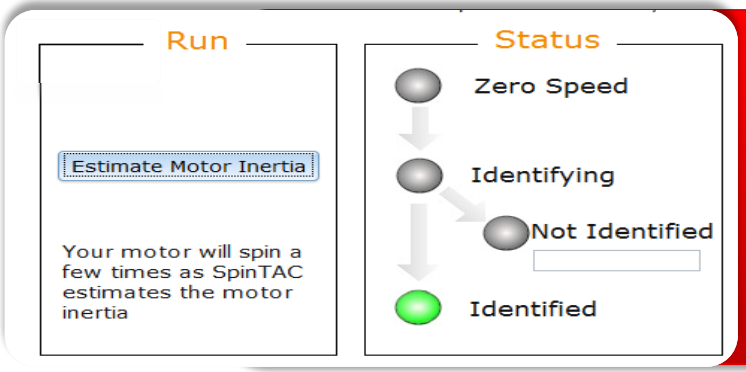
Account for mechanical inertia - Robust speed control - Simplified tuning

Identify:
Measure Inertia

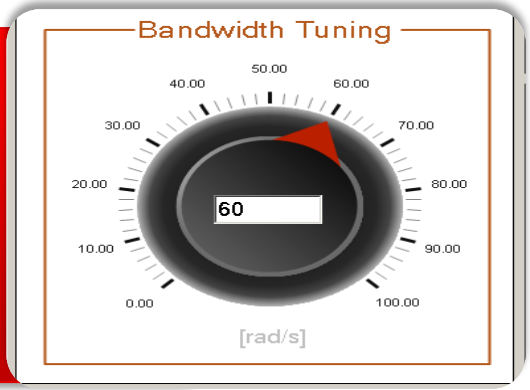
- Inertia is important for accurate control
- Short acceleration test to identify system inertia

Control:
Maximum control, minimum effort

- Disturbance-rejecting controller
- Single variable to tune response
- Typically effective across full variable speed and load range



1. **Press button to measure inertia**
2. **Adjust knob to tune**

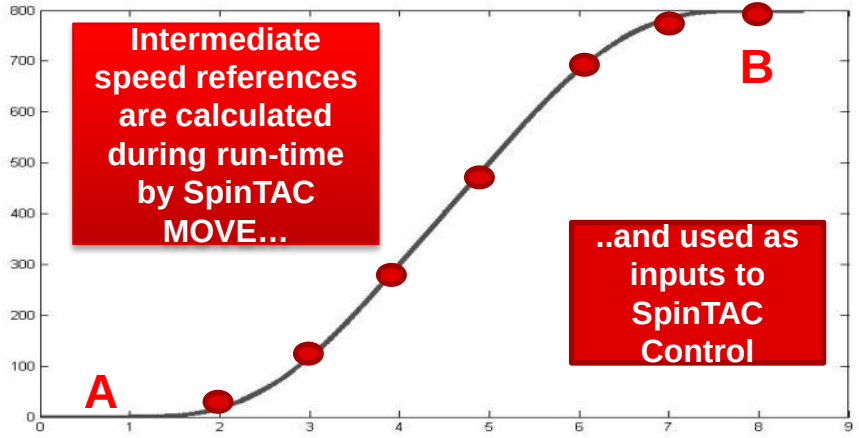


SpinTAC™ Components

Integrated Movement and Motion Design

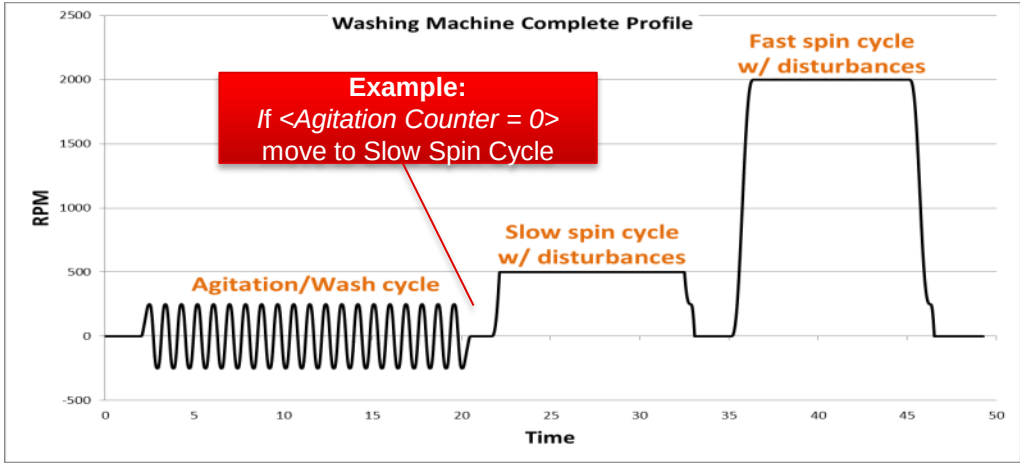
Move:
Build Trajectories

- Select Motion Type for Speed **A** to **B**
- Define constraints (accel, jerk)
- Move generates the ideal curve



Plan:
Design Motion Sequence

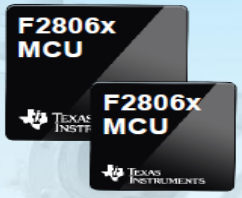
- Define operating states and transitions
- Connect logic-based Moves
- Execute the motion sequence



InstaSPIN™-enabled, real-time controllers

TI's InstaSPIN three-phase motor control solutions are enabled by special libraries in the read-only memory (ROM) of Piccolo microcontrollers (MCUs) that allow you to create products with improved efficiency, performance, and reliability, while reducing development time from months to minutes. TI's InstaSPIN-enabled MCUs provide expertise to designers of sensorless (velocity and torque) or sensored (position, velocity and torque) motor control applications.

16x16 mm



14x14 mm

14x14 mm

9x9 mm

Click a part number to learn more

	InstaSPIN Solution	MHz	FPU	CLA Co-Processor	Motors	Flash (KB)	12b ADC Chs	PGA	CAN	QEP	USB	SPI	UART	I2C	Pins	Temp
F28069M	-MOTION	90	Y	Y	1 or 2	256	16 or 12	--	1	1	1	2	2	1	100/80	-40 to 105° C
F28068M	-MOTION			--		256										
F28069F	-FOC			Y		256										
F28068F	-FOC			--		256										
F28062F	-FOC			--		128										
F28054M	-MOTION	60	--	--	1 or 2	128	16	4	1	1	--	1	3	1	80	-40 to 125° C Q100
F28054F	-FOC					128										
F28052M	-MOTION					64										
F28052F	-FOC					64										
F28027F	-FOC	60	--	--	1	64	13	--	--	--	--	1	1	1	48	
F28026F	-FOC					32										

InstaSPIN-FOC & -MOTION Evaluation

 $299	**DRV8312-69M-KIT** TMDSCNCD28069MISO and 24V BLDC motor can add TMDSCNCD28054MISO TMDSCND28027F + JTAG emulator	15-50V *24V supply included* 66.32V ADC Scale	3.5A continuous 6.5A peak 8.65A ADC Scale
$66+ 	**LAUNCHXL-F28027F or F28069M + BOOSTXL-DRV8301 or BOOSTXL-DRV8305EVM**	6-24V Input or 6-42V Input 26.3V or 44.3V ADC Scale	10A or 15A continuous 16A or 23.5A ADC Scale
 $299	**DRV8301-69M-KIT** TMDSCNCD28069MISO can add TMDSCNCD28054MISO TMDSCND28027F + JTAG emulator	8-60V Input 66.32V ADC Scale	~40A continuous 40A peak 41.25A ADC Scale
 $699	**TMDSHVMTRINSPIN** TMDSCNCD28069MISO and TMDSCNCD28027F can add TMDSCNCD28054MISO	50-350V Input *AC/DC supply included* 409.6 ADC Scale	8A continuous 9A peak 9.945A ADC Scale

FREE

InstaSPIN™ projects

MotorWare™ code infrastructure

C code projects & Lab Guide

- Labs teach how to use features

Object oriented APIs

- Intuitive drivers, modules & functions

Scalable support

- Projects easily scale across MCU family and inverter hardware
- Easy to add custom application code

CCSv5 Eclipse for code gen

Online forum support

InstaSPIN™ Resources

www.ti.com/instaspin

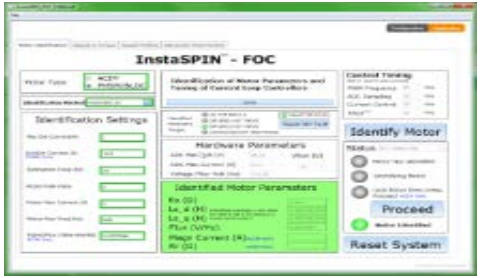
TI E2E™ Community

InstaSPIN™-FOC and –MOTION

- Thorough Reference Manuals and User's Guide
- MotorWare projects, detailed lab documentation, and code examples provided
- Includes API information
- GUI and CCS

Training

- MotorWare projects offer self paced workshop style sessions



Thank you!