



# TI Motor Driver – Safer, Greener, Smarter 德儀馬達驅動器 – 更安全，更環保，更智能

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Texas Instruments / 德州儀器

Sept 2012 / 二零一二年九月

## TI Spins Motors



Smarter. Safer. Greener.

# What's required to spin a motor nowadays? 現在對馬達驅動有哪些新要求？

**Safer**  
更安全

Stable operation and low failure rate  
運行穩定，故障率低

**Greener**  
更環保

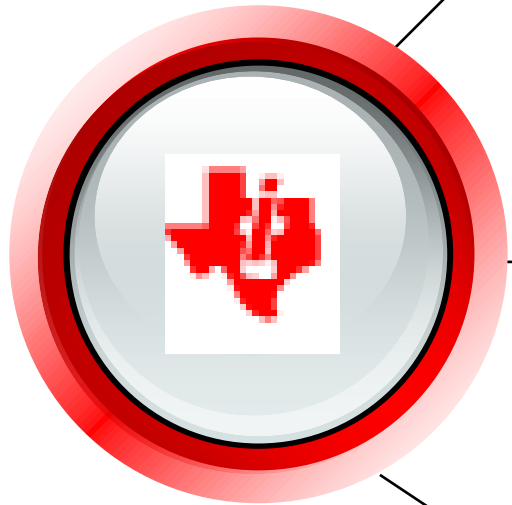
Improved efficiency and low power consumption  
高效率，低功耗

**Smarter**  
更智能

Advanced algorithm, easy to use  
算法先進，易於使用

# What's good about TI's motor drivers?

## TI的馬達驅動產品有哪些優勢？



Fully experienced and highly reliable  
豐富經驗，高度可靠

Advanced technology and low power  
dissipation  
先進工藝與低功耗

Advanced algorithm and fully supported  
先進算法，支持完善

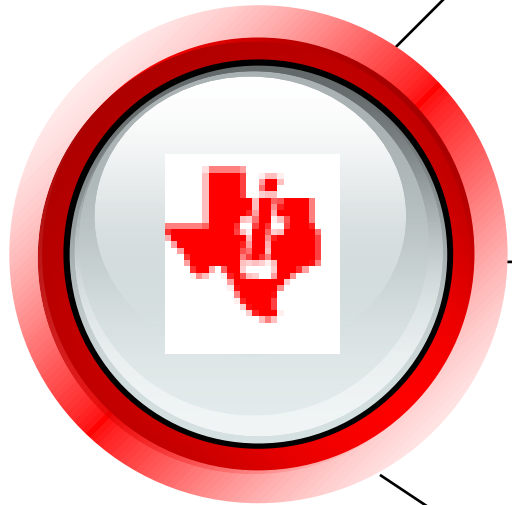
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更安全

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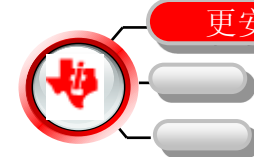
**Greener**  
更環保

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**Smarter**  
更智能

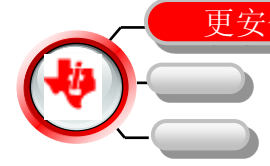
# Fully experienced/豐富經驗

更安全



## Genesis of TI motor driver offerings/德儀馬達驅動器產品簡介

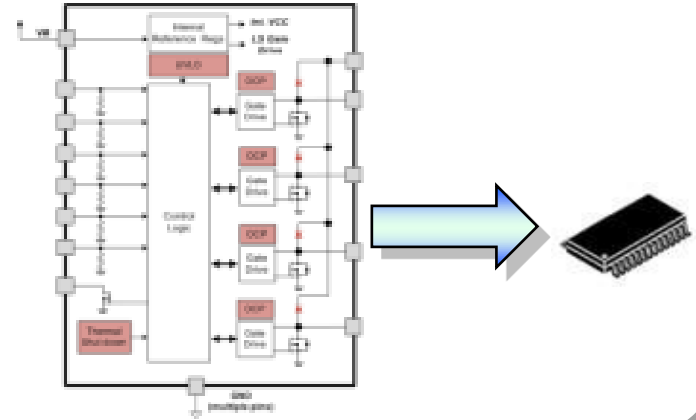
- TI in motor driver market for **>15 years**/持續銷售**超過15年**
- **>1Bu** motor driver shipped/累計產品銷售**超過10億顆**
- Widely used (in the form of custom engagements) in **HDD, ODD, Inkjet printers, Digital still cameras, & Automotives**/以客戶定制的形式廣泛應用於**硬碟、光驅、噴墨打印機、數位相機、汽車工業**等行業中
- TI entered **mass market** in 2010 with the formation of **Motor Drive Business Unit (MDBU)**/德儀在2010年成立了**馬達驅動事業部(MDBU)**，開始進軍**大眾市場**



# Highly reliable/高度可靠

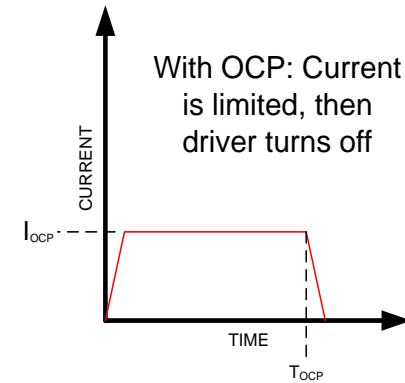
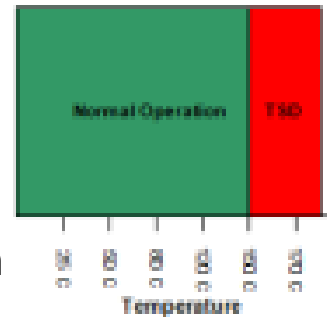
**Fully integrated solutions**  
高度整合的解決方案

- Reduced PCB space/BOM  
減小PCB尺寸，縮減BOM
- Improved reliability  
可靠性提升
- No discrete design required  
無需分立方案設計



**Robust & fully protected**  
萬全保護

- Over current / short protection  
過流 / 短路保護
- Thermal protection  
過熱保護
- Under voltage lock-out  
欠壓閉鎖
- Shoot-through protection  
擊穿保護

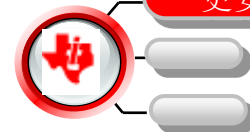




But I've got discrete solution already?

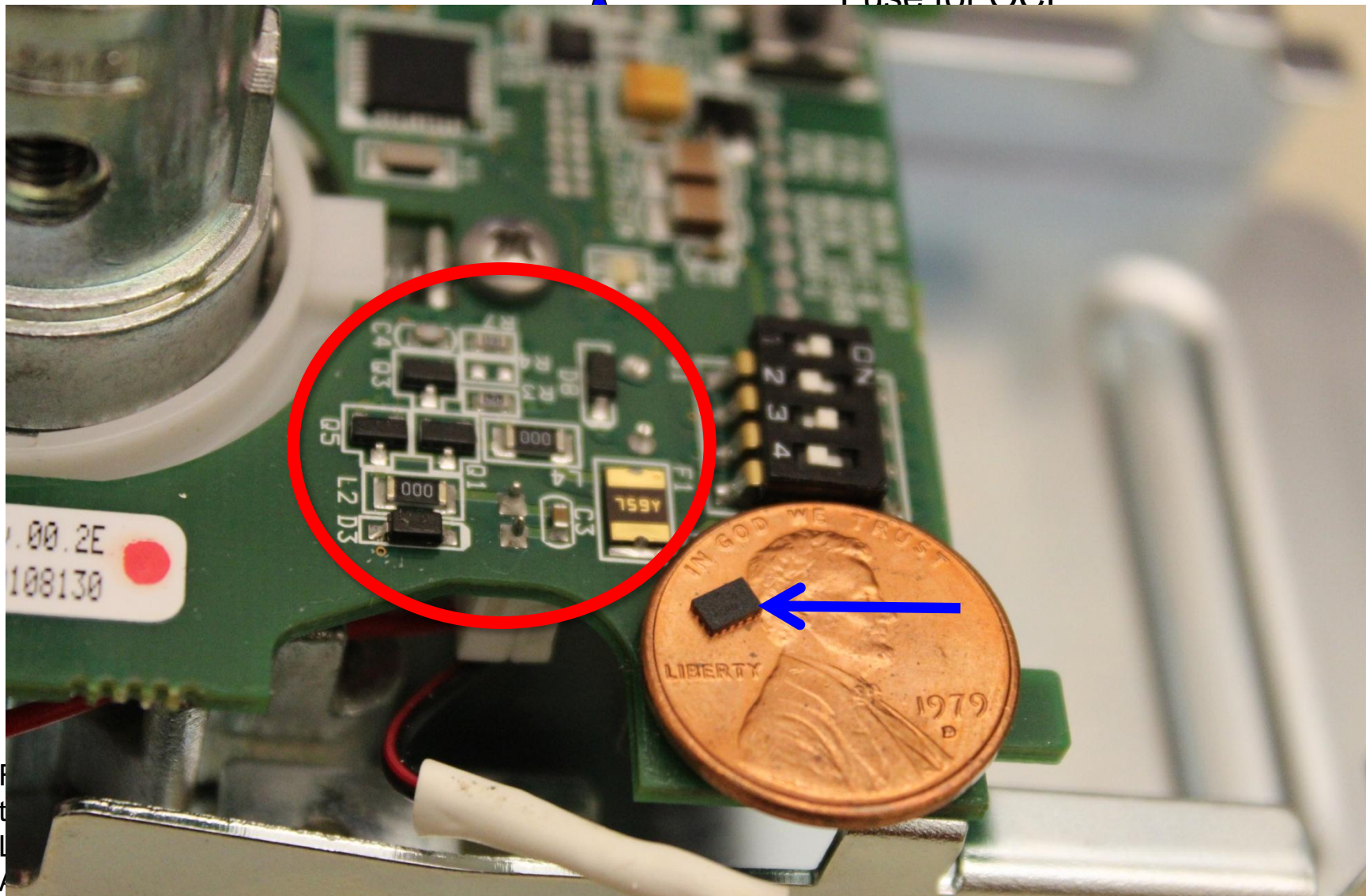
可是我已經有離散解決方案了呀？

更安全



VM  
▲

Fuse for OCP

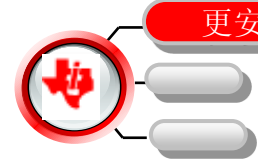


Selective Disclosure

 TEXAS  
INSTRUMENTS

# DRV8837:1.8A Low Voltage Brushed DC Motor Driver

## DRV8837: 1.8A低電壓直流有刷馬達驅動器



### Features

- Single H-Bridge motor driver
  - Dual supplies:  $V_m = 1.8$  to  $11V$   
 $V_{cc} = 1.8$  to  $7.0V$
  - Output current:  $1.8A$  cont /  $1.8A$  peak
  - RDSON :  $280m\Omega$  (LS + HS)
- PWM control interface (IN/IN)
- Brake support
- Sleep mode operation (35nA @ 5V)
- Tiny 2 x 2mm package
- Integrated protection features including over-current, thermal, shoot-through and UVLO protection

### Applications/應用範圍

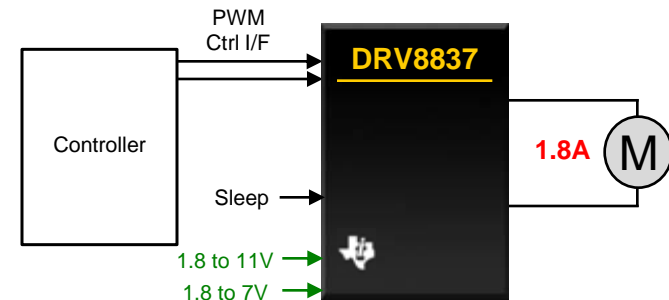
- Battery-powered consumer products/電池供電類消費電子
- Low voltage solenoids& relays/低壓螺線管&繼電器
- Portable medical devices/可攜式醫療設備
- Toys/玩具
- E-locks/電子鎖



2.0 x 2mm, 8-pin  
WSON package  
2.0 x 2mm, 8管腳  
WSON封裝

### 特性

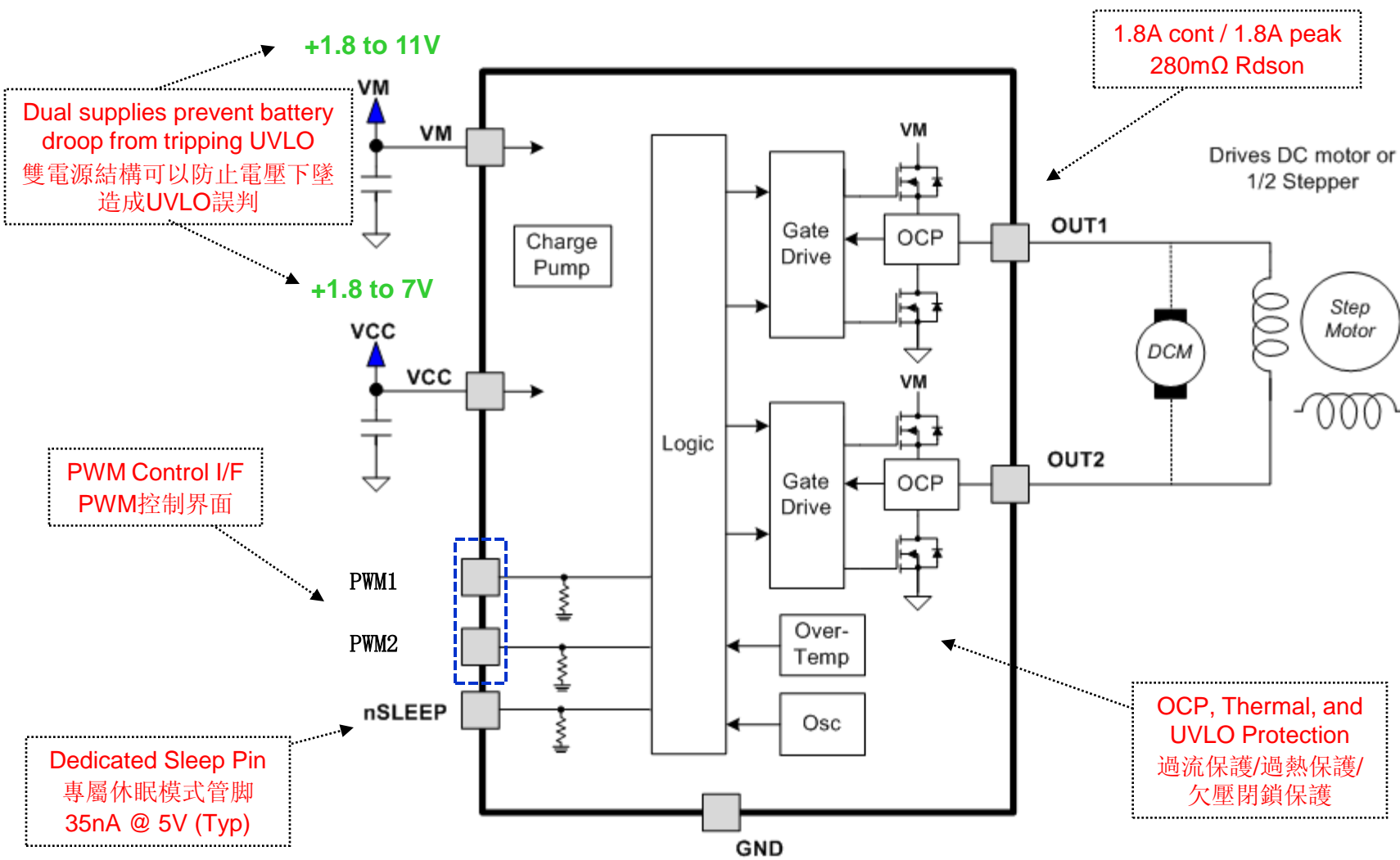
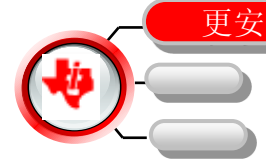
- 單H橋接驅動器
  - 馬達/邏輯雙電源:  $V_m = 1.8\sim 11V$   
 $V_{cc} = 1.8\sim 7.0V$
  - 輸出電流:  $1.8A$  cont /  $1.8A$  peak
  - RDSON:  $280m\Omega$  (LS + HS)
- PWM型控制接口 (IN/IN)
- 支馬達制動
- 支持休眠模式 (35nA @ 5V)
- 2 x 2mm封裝
- 整合過流保護、過壓保護、直通保護、欠壓鎖定等等保護機制





# DRV8837 Functional Block Diagram

## DRV8837原理圖





# DRV8837

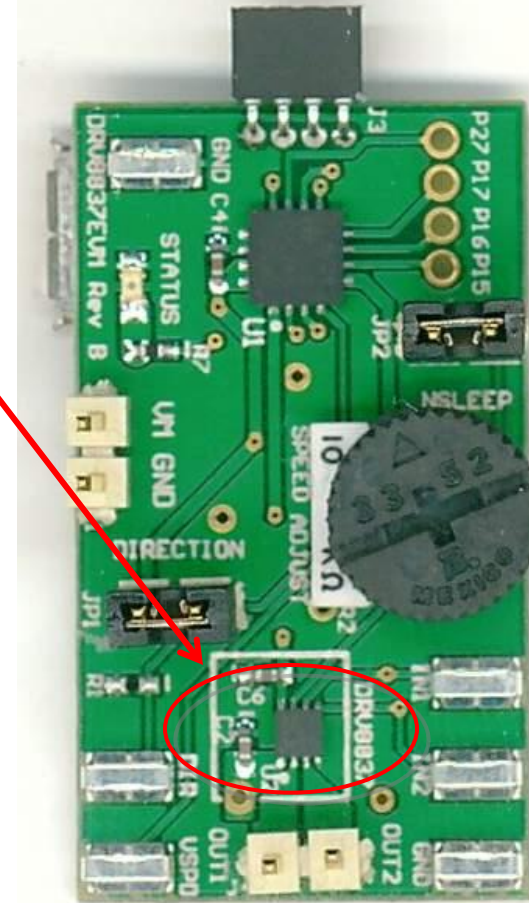
1.8A Low Voltage Brushed DC Motor Driver/1.8A低電壓直流有刷馬達驅動器

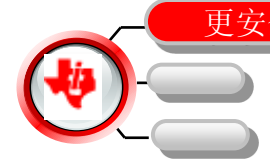
**Worlds smallest 1.8A Motor Driver (2 x 2 mm)**  
世界上最小的1.8A馬達驅動器 (2×2mm)

**Ultra low RDSON (140mR per FET)**  
超低的RDSON (140mR per FET)

**Ultra low sleep current (35nA)**  
超低的休眠電流 (35nA)

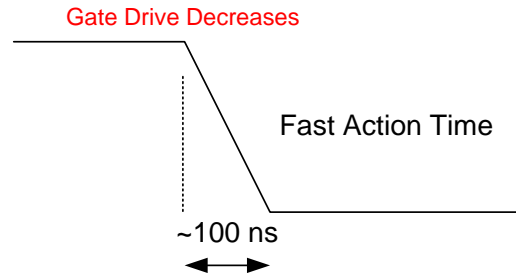
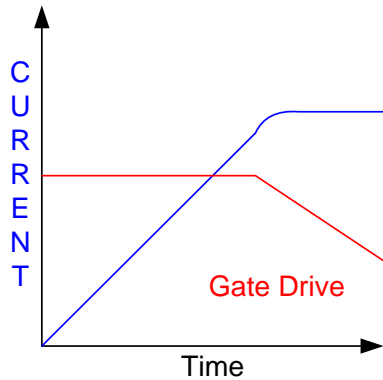
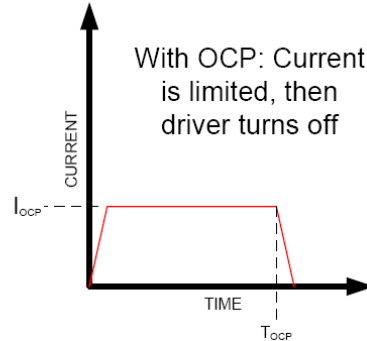
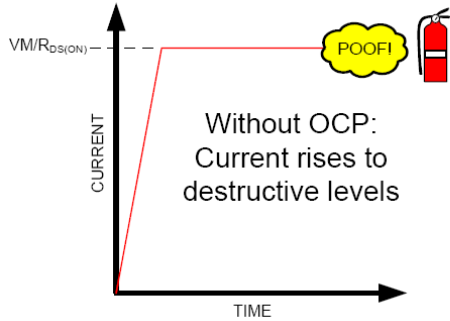
**Fully Protected**  
**全面保護**





# Over Current Protection

## 過電流保護

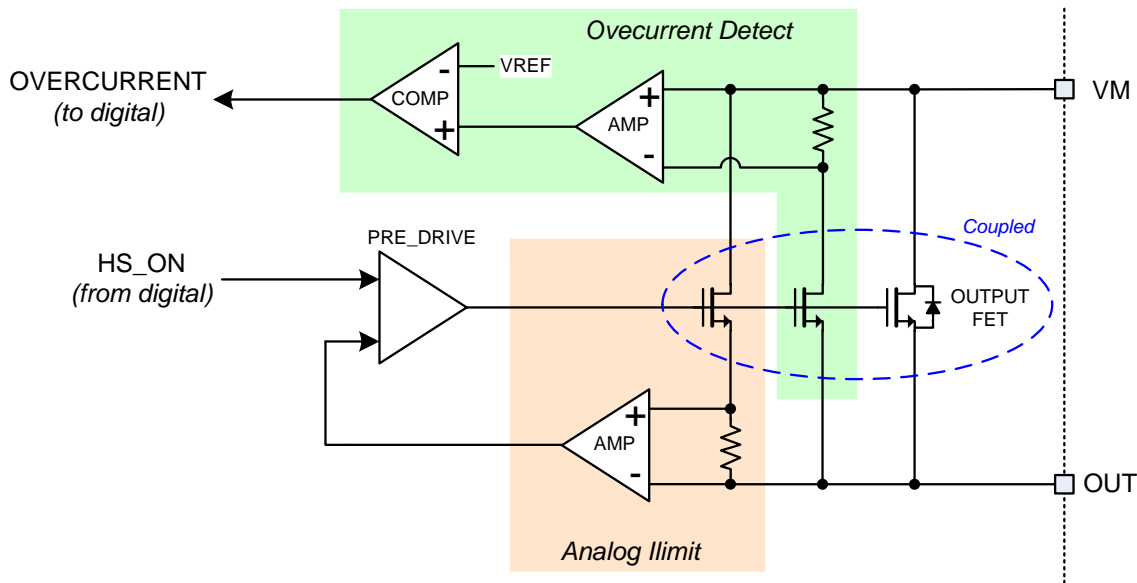


- Need to protect from damage caused by motor fault condition, e.g. short to GND, supply or across motor winding.  
與地、電源或線圈之間的短路等情況都需要過流保護。
- On Top of current regulation circuit, TI devices contain an extra protection called  $I_{LIMIT}$ .  
不同於電流調節電路，TI的產品一般都包括另外一個保護電路“ $I_{LIMIT}$ ”。
- By decreasing FET gate drive, the FET DS resistance increases and current is limited.  
通過減小功率管的門極電壓，其源漏極電阻會增加，限制通過的電流。
- Each FET is protected individually and need to react fast enough without false-triggering.  
每個功率管都需要單獨的保護機制，同時需要能迅速對過流情況進行反應，又不能有誤判。



# OCP realization (DRV88xx)

## 過流保護的實現 (DRV88xx)



**Key points/關鍵點:** Analog OCP implementation (high side shown)

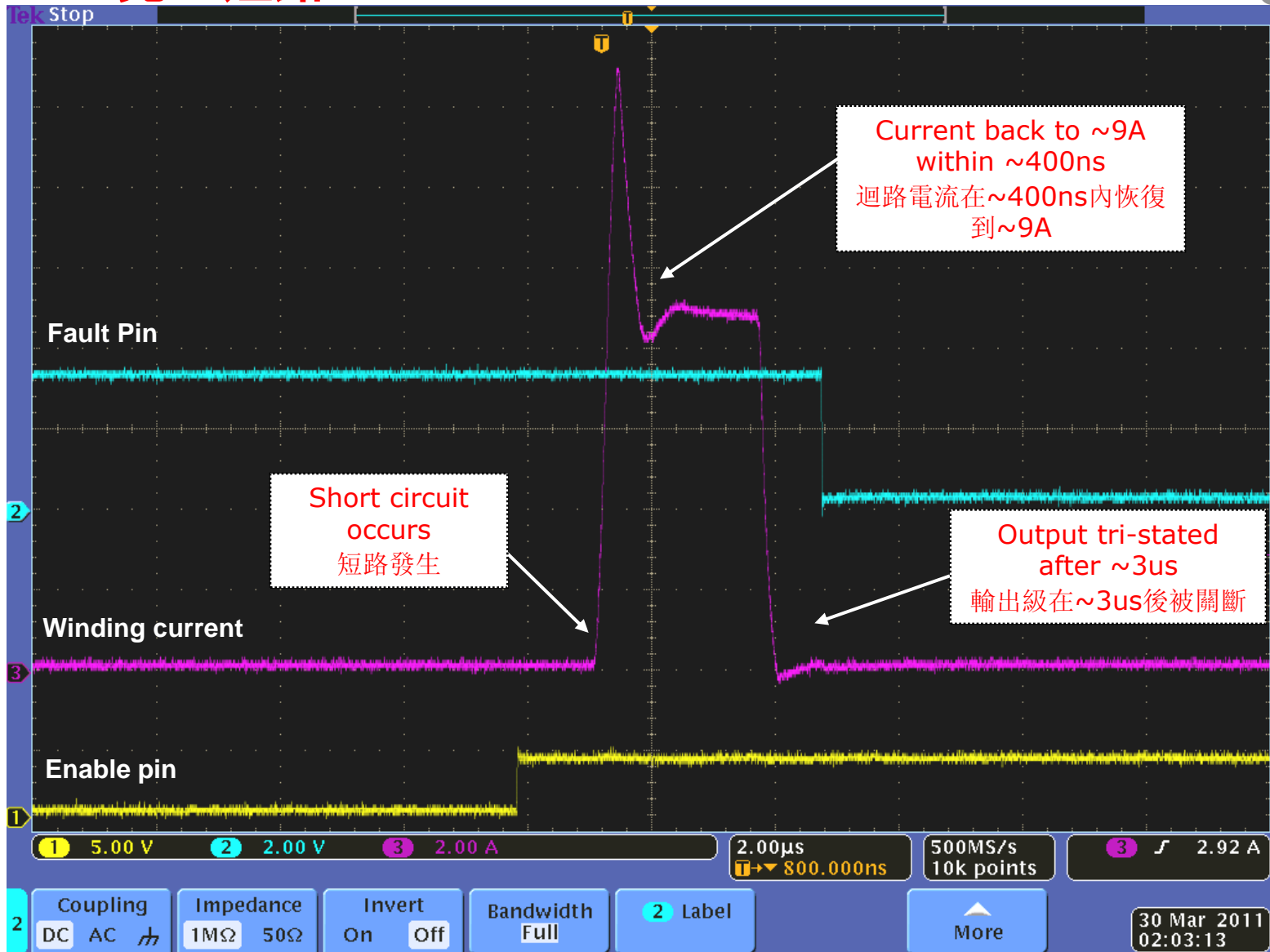
Analog OCP consists of two portions/類比OCP包括兩部分:

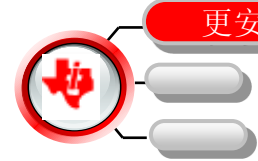
- An analog current limit removes gate drive  
限流迴路移除門極驅動
- An over-current detection circuit monitors current and provides OC signal to digital core  
過流檢測迴路檢測電流並為數位控制核心提供過流訊號

# Dead short on DRV88xx

## DRV88xx完全短路

更安全



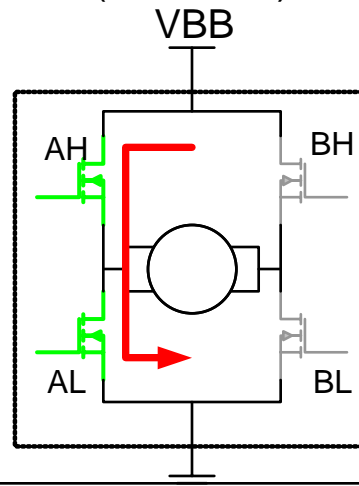


# UVLO/Shoot-through Protection

## 欠壓閉鎖/擊穿保護

- UVLO protection/欠壓閉鎖
  - Supply voltage level is constantly monitored and the device is tri-stated when the voltage level is too low to ensure proper control over the H-Bridge  
晶片自行持續監測供電電壓值，當電壓過低時輸出端被設置成高阻抗狀態，確保H橋接在正常運作狀態。
- Shoot-through Protection/擊穿保護
  - High side and low side on the same half bridge are never allowed to turn on at the same time. A small amount of delay (dead time) is inserted between high-side turning-off and low-side turning-on. The longer the dead time, the safer the operation but the worse the linearity and efficiency.

同一個半橋的上低側決不允許同時打開！為了避免此現象的發生，高側關斷和低側導通之間人為的增加一段延時（停滯時間）。停滯時間越長H橋接的運作越安全，但同時線性度和效率也越差。



**Shoot-through!!**



# Thermal Shutdown

## 熱關斷

- Excessive power dissipation, insufficient heat-sinking or a too high ambient temperature can lead to hazardous temp level.

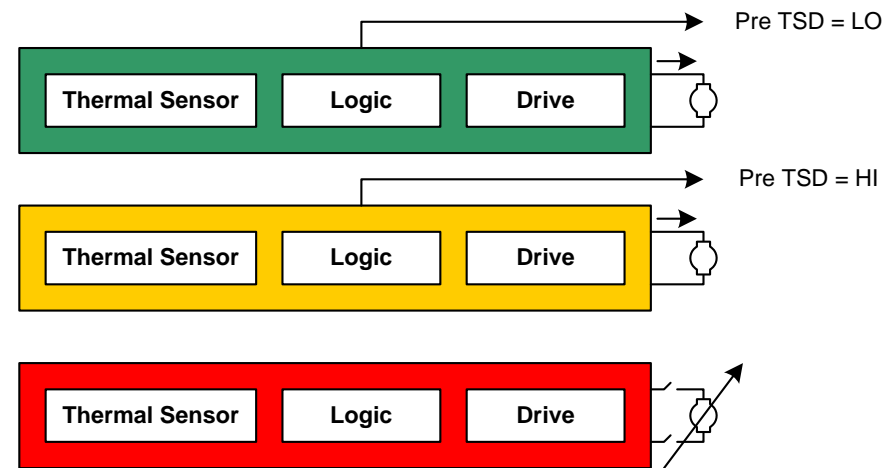
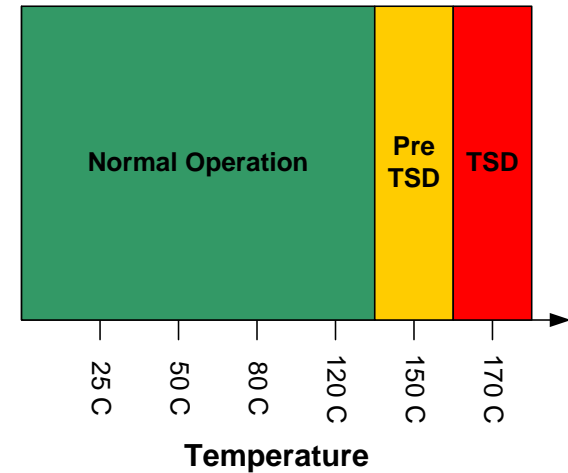
過度發熱、熱沉不足、環境溫度過高等都可能對晶片造成損害。

- Multiple thermal sensors are placed across the die, continuously monitoring temperature. When temperature reaches over-temp threshold, the H-bridge is tri-stated and indexer is reset, and a Thermal ShutDown (TSD) event occurs.

晶片內部放置了多個熱感應器來持續監控溫度。當芯片溫度上升到過熱的閾值時，H橋接將被設置成高阻，微步進細分也被重置—熱關斷。

- Some devices offer a warning signal called Pre-TSD. A Pre-TSD event occurs at the TSD-XC temperature, where XC is a temperature offset such as 20C or 30C.

有些產品在熱關斷之前可以先進行預判，預判溫度一般比熱關斷閾值低20~30C°。

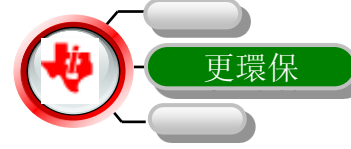


# What's good about TI's motor drivers?

## TI的馬達驅動產品有哪些優勢？

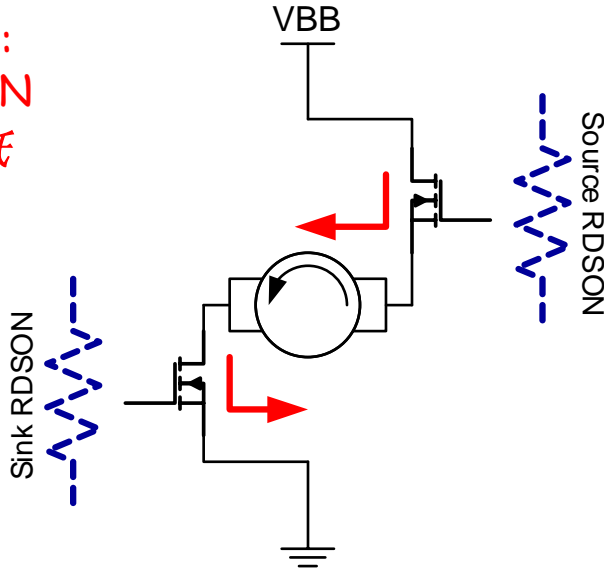


# Advanced technology & low power dissipation 先進工藝 & 低功耗

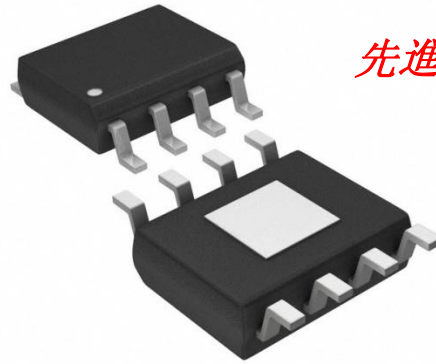


Advanced tech:  
ultra-low R<sub>DS(on)</sub>  
先進工藝之超低  
R<sub>DS(on)</sub>

- High efficiency  
高效率
- Good thermal performance  
優秀的散熱性能

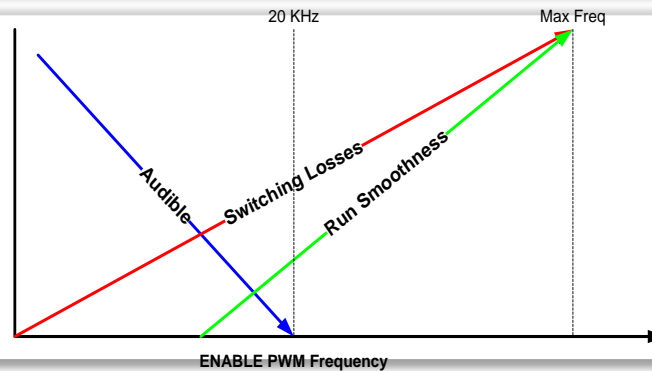


Advanced tech:  
thermal-efficient  
package  
先進工藝之有效的散  
熱封裝



PowerPAD™:  
Exposed pad to  
remove heat  
PowerPAD™:  
通過裸焊盤散熱

Low power:  
• R<sub>DS(on)</sub>  
• Sleep mode  
• Efficient PWM  
switching & dead time



低功耗:  
• R<sub>DS(on)</sub>  
• 休眠模式  
• 超高效的PWM和死  
區時間

# DRV8837

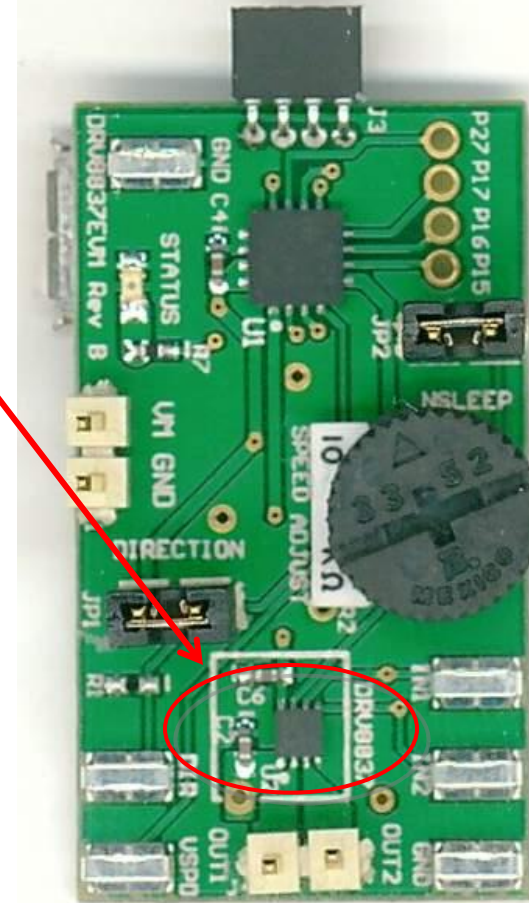
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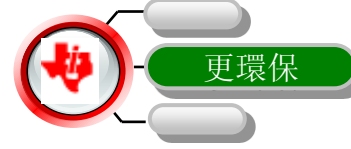
**Ultra low RDSON (140mR per FET)**  
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**Ultra low sleep current (35nA)**  
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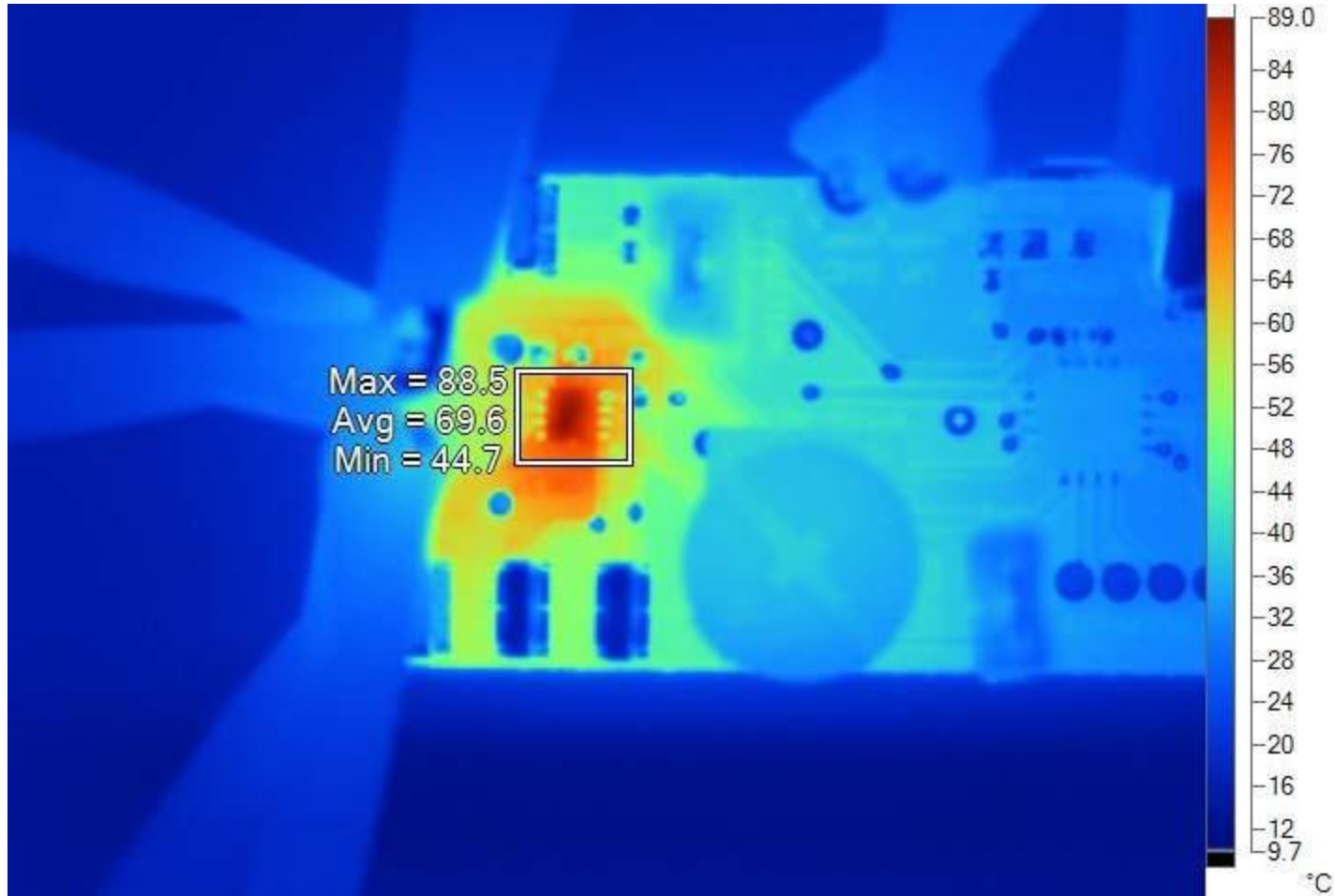
**Fully Protected**  
全面保護



# DRV8837: Excellent Thermal Performance:



# DRV8837: 超好的散熱效能



Max case temp = 88.5°C @ 1.8A

# DRV8818 – 2.5A Stepper Motor Driver (with On-Chip 1/8 $\mu$ -Stepping Indexer)

## DRV8818 – 2.5A 步進馬達驅動器（內建整合 1/8 細分索引）

### Features

- Dual H-Bridge stepper motor driver
  - Supply voltage: 8~35V
  - Output current: 1.75A RMS / 2.5A peak per winding
- P2P upgrade to DRV8811 with lower R<sub>dson</sub> (0.37 $\Omega$  HS+LS)
- On-chip indexer supports up to 1/8 micro-stepping
- Programmable mixed (fast + slow) decay mode
- Integrated protection features including over-current, thermal, shoot-through and UVLO protection
- P2P replacement for competitors, and runs up to **30%** cooler.

### Applications/應用範圍

- Printer/印表機
- Scanner/掃描機
- Textile Machinery/紡織機械
- Positioning & Tracking/定位 & 追蹤
- Factory Automation/工廠自動化
- Robotics/機器人技術

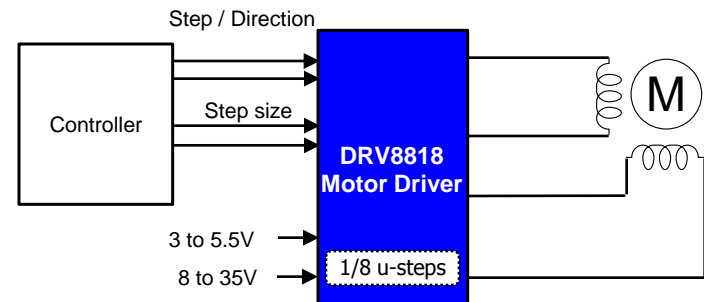


9.7 x 6.4mm, 28-pin  
HTSSOP package

9.7 x 6.4mm, 28腳  
HTSSOP封裝

### 特性

- 雙H 橋接步進電動驅動器
  - 供電電壓: 8~35V
  - 輸出電流: 每繞組 1.75A RMS / 2.5A 峰值
- DRV8811的接腳相容升級版，R<sub>dson</sub> 更低 (0.37 $\Omega$ HS+LS)
- 內建索引支援最高1/8細分
- 可程式的混合電流衰變（快速衰變+緩慢衰變）模式
- 包含過電流、過熱、擊穿與欠壓封鎖等整合保護特性
- 可接腳兼容代替其他公司的一些產品，同時運行溫度要低超過**30%**



1/8 Micro-Stepping  
1/8細分微步進驅動



# DRV8818 – The Coolest 2.5A $\mu$ Stepping Motor Driver

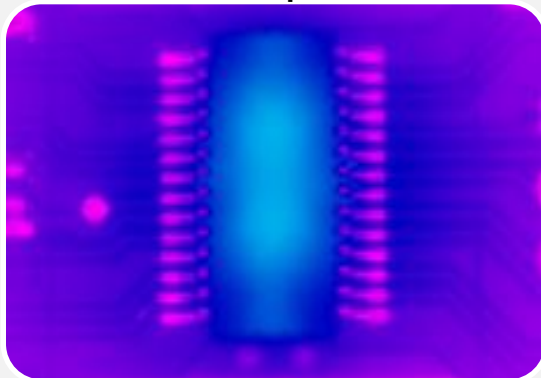
## DRV8818 – 溫度最低的細分步進馬達驅動器

*Greater than 30% temperature reduction*

*Pin to pin compatible drops into existing layout!*

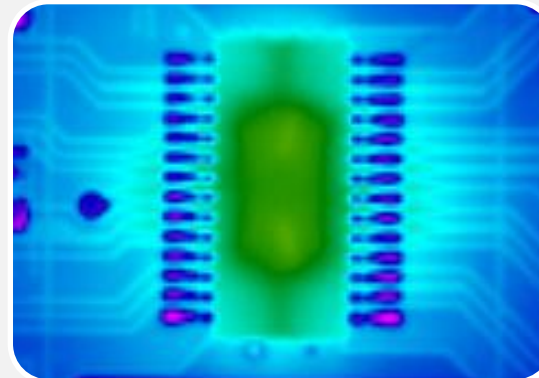
相比其他互相接腳兼容的產品，DRV8818的溫度要低過30%!

Max Temp 107°C



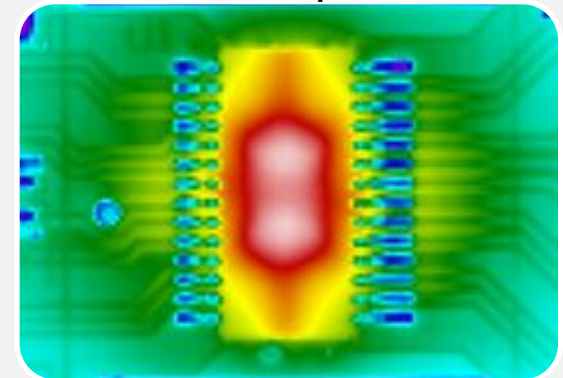
TI - DRV8818

Max Temp 130°C



Competitor 1

Max Temp 157°C



Competitor 2

2.5A sine wave peak, 1/8 micro-stepping, 2-layer board

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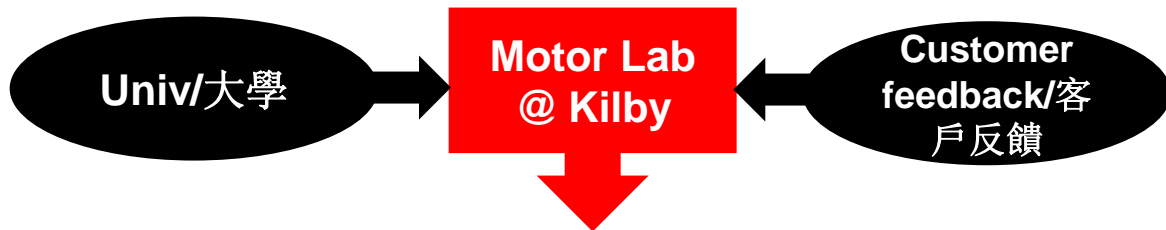
**Safer**  
更安全

**Greener**  
更環保

**Smarter**  
更智能

# Advanced algorithm: Motor Lab @ Kilby

## 先進算法: Kilby 馬達實驗室



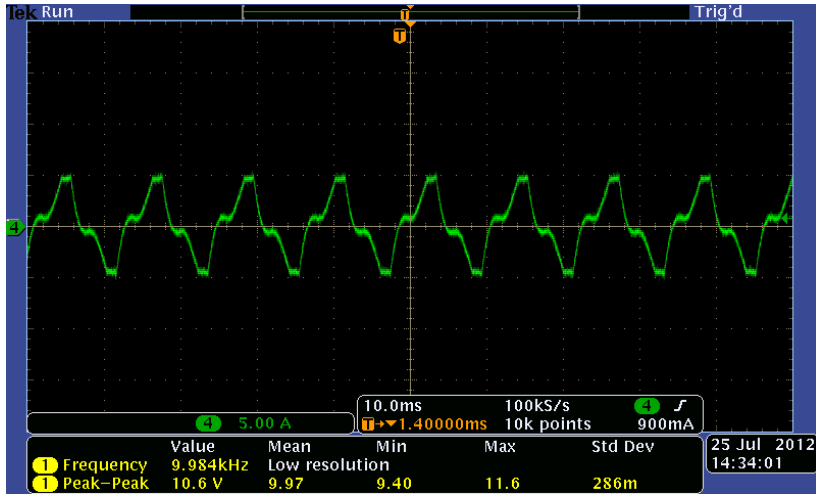
- ◆ New motor technology/algorithms  
新的馬達驅動算法
- ◆ Real world applications  
工業界的現實應用
- ◆ Working closely with Universities  
與大學緊密合作



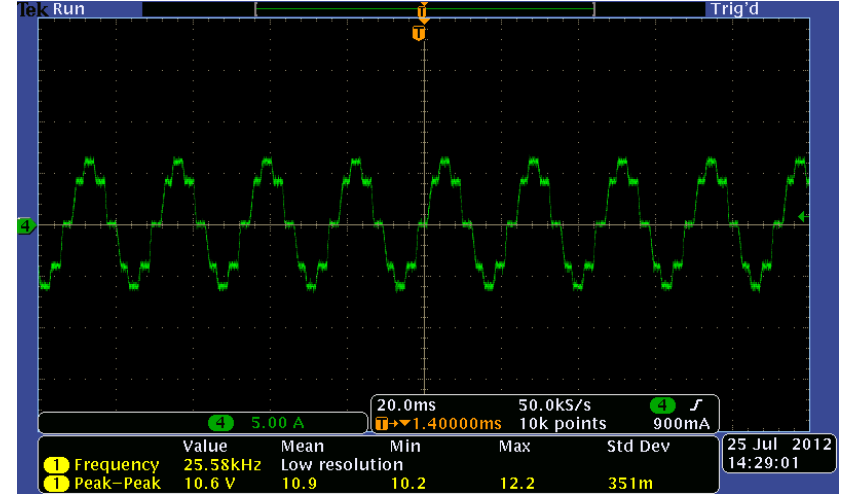
# DRV8818 $\mu$ Stepping Current Waveform Example

## DRV8818 微步進細分電流波形範例

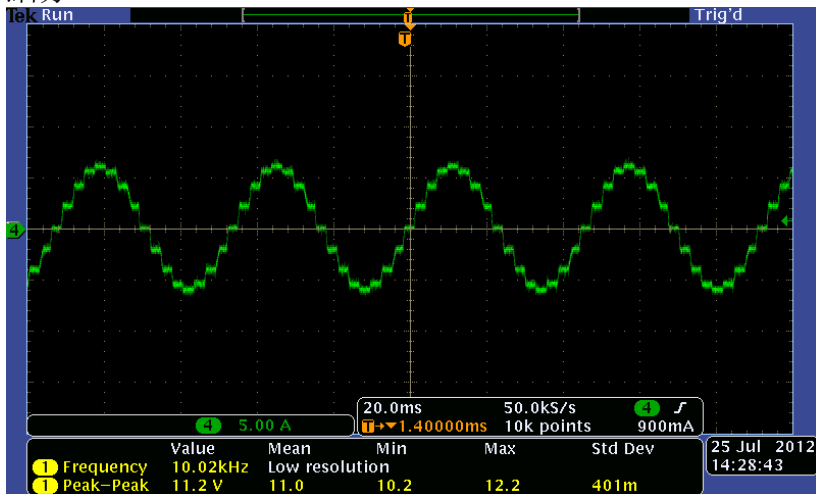
Full stepping  
全步步進



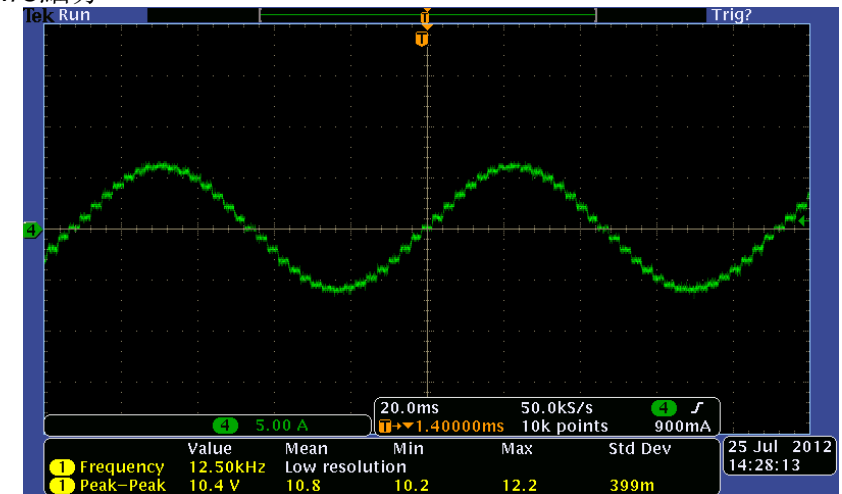
1/2  $\mu$ -stepping  
1/2細分



1/4  $\mu$ -stepping  
1/4細分

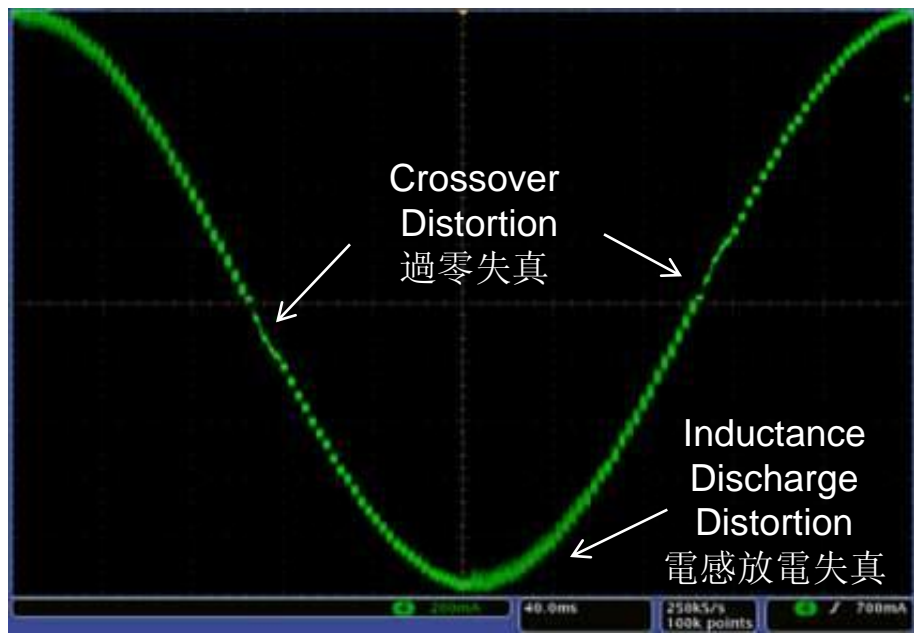


1/8  $\mu$ -stepping  
1/8細分





**Competitor: A**

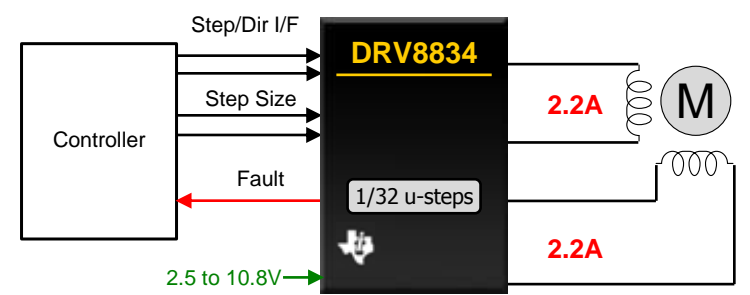


**DRV8834**



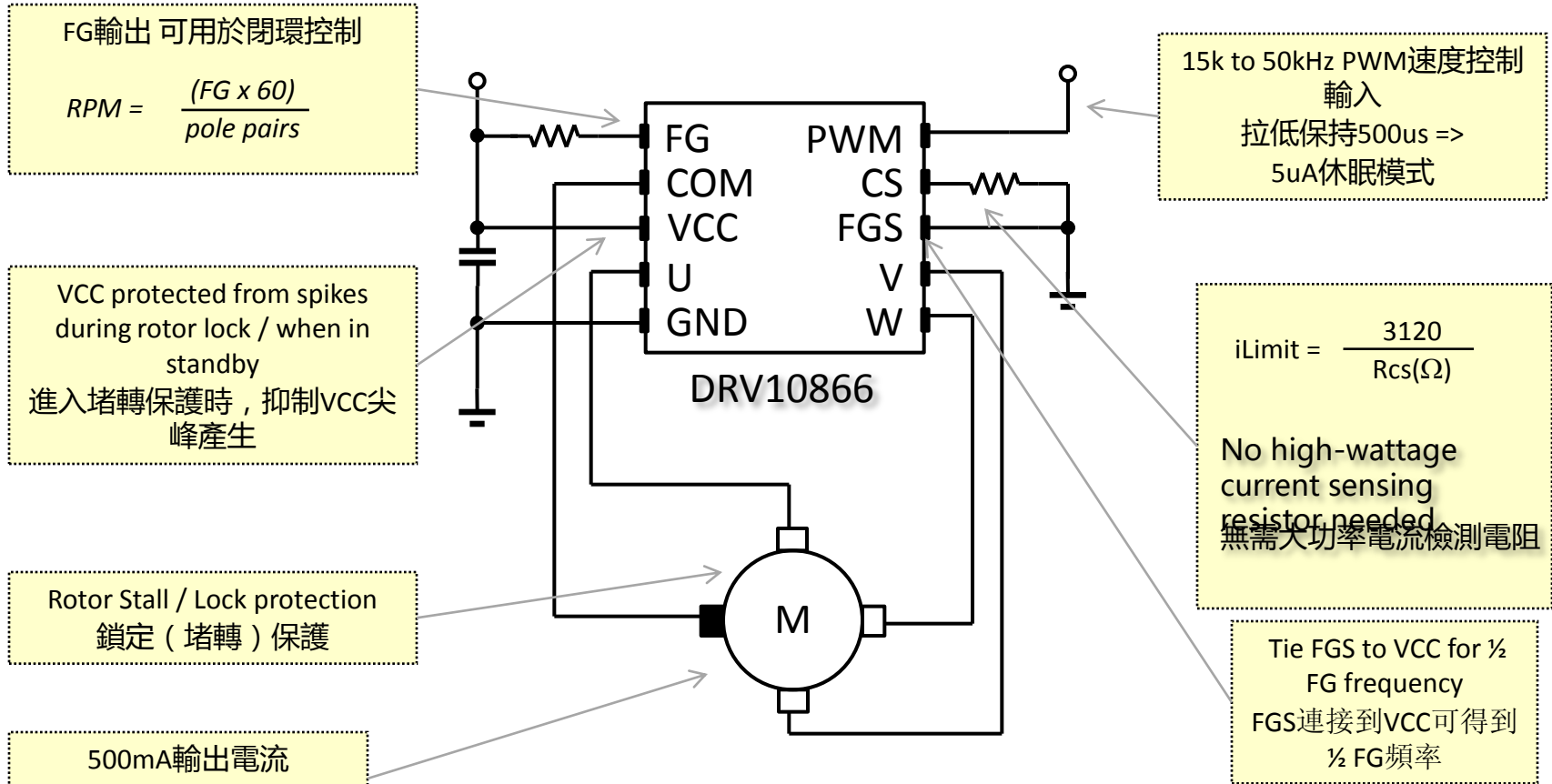
Less Distortion → Less Torque Ripple → Smoother Motion  
 更小的失真 → 更小的轉矩漣波 → 更平滑的馬達運轉

- Dynamic TBLANK minimizes crossover distortion
- 動態消隱時間最優化過零失真
- Variable Mixed Decay Ratio minimizes discharge distortion
- 可變混合電流衰減比例最優化放電失真

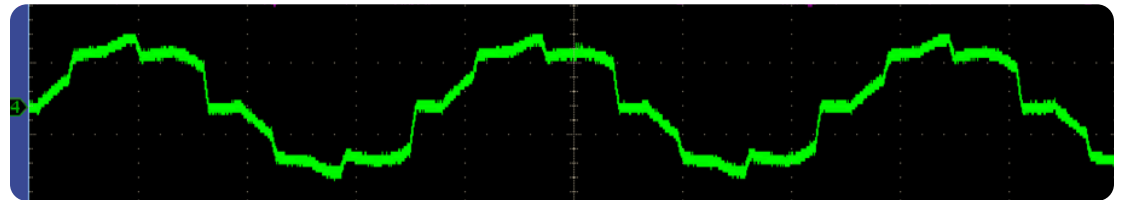


# DRV10866

## 5V 3-Phase Sensor-less BLDC Fan Driver 5V 3相 無刷 無感測器 集成馬達驅動器



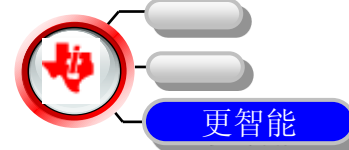
**150° Driving Phase current**  
驅動相電流波形





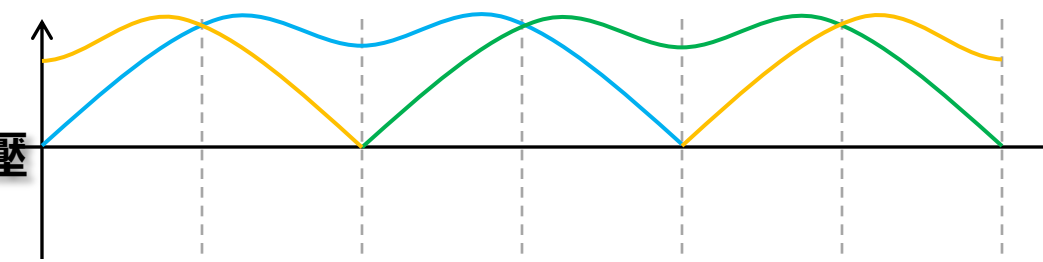
# 3-Phase BLDC Motor 180° Driving Technology

## 三相無刷直流馬達180°驅動技術

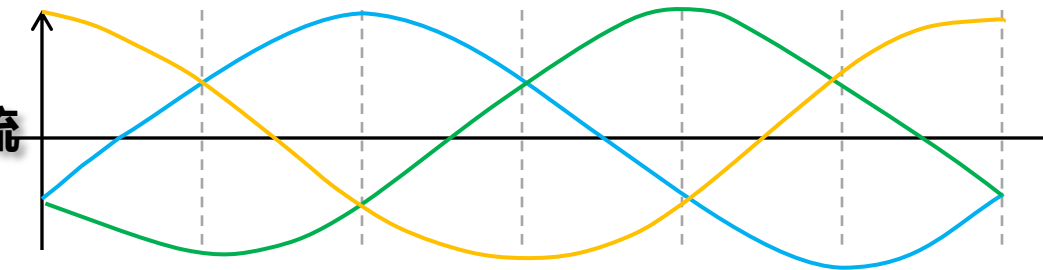


180° 驅動

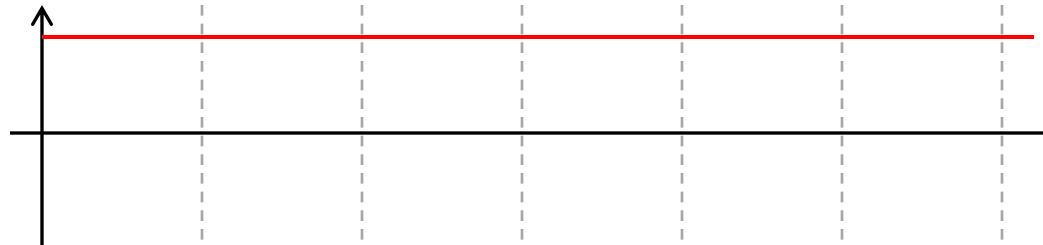
Phase V 相電壓



Phase I 相電流

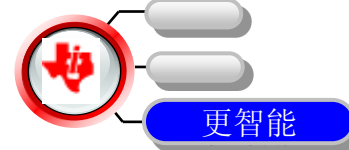


Torque 轉矩



# Quicker Time to Spin!

## DRV8312-C2-KIT 3-Phase Brushless Motor Drive and Control



### Features:

- Software Support:
  - Field Oriented Control (sensorless)
  - Trapezoidal (sensored & sensorless)
  - InstaSPIN support
- Speed & torque control loops
- Piccolo + DRV8312 (3.5A RMS / 6.5A peak / 50V)
- Kit includes motor w/ hall sensors, power supply, and USB stick with Quick Start GUI and guide.

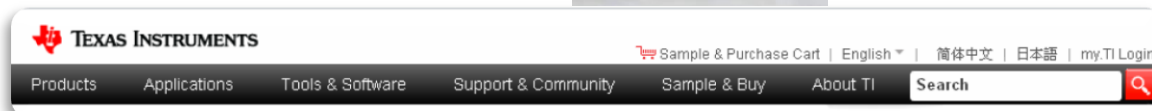


**In Stock / In Production  
Order Now!**

# Fully supported/支持完善

## Eval-kits 開發套件

- Total solution. Drop in and Spin.  
完備的解決方案，即插即轉。
- Fully open resources. Easy to apply.  
完全公開的檔案，易於申請。



## Online support 線上支持

- Website/官網: [www.ti.com/motors](http://www.ti.com/motors)
- Online community/線上社區: [e2e.ti.com](http://e2e.ti.com)

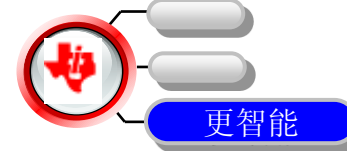


## Supporting team 技術支持團隊

- Taiwan FAE: Bruce LIU/劉俊男 (Taipei/台北)
- Motor Application Team: TANG Zhao/唐釗 (Beijing/北京)  
Wilson ZUO/左巍 (Beijing/北京)

# TI WW manufacturing footprint

## 持續供貨的保障：遍布全球的工廠



U.S., Asia and Europe

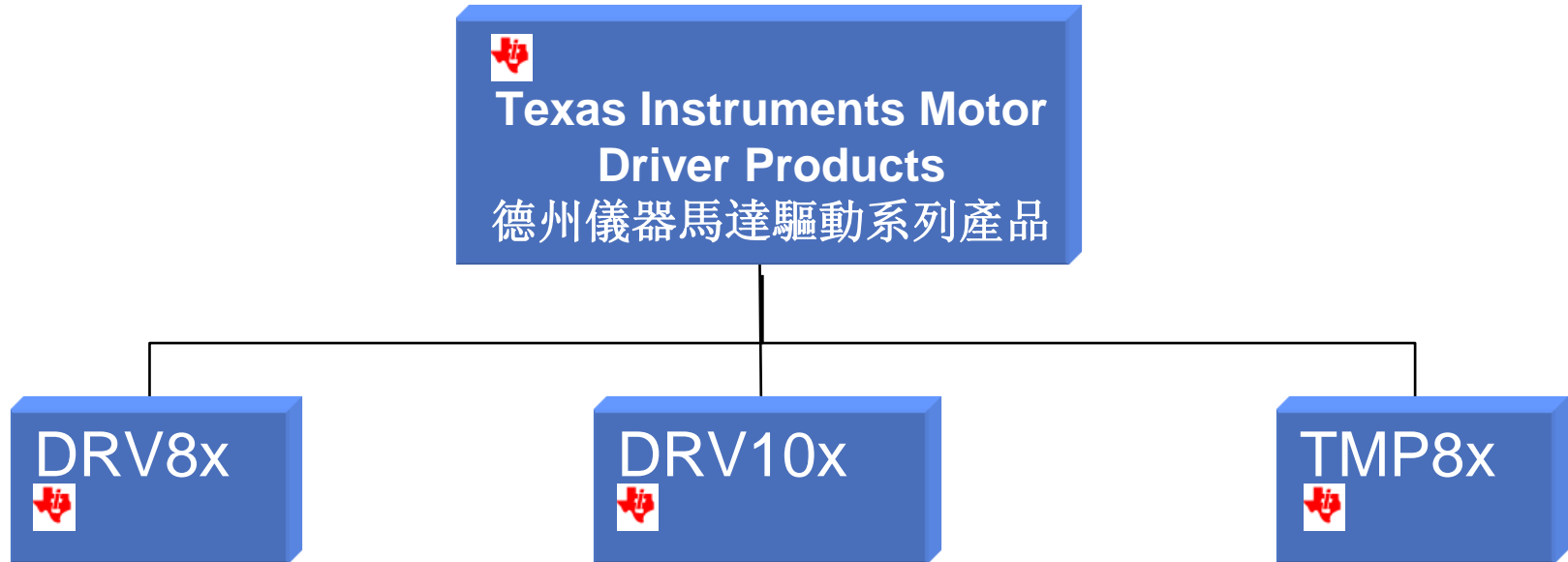


11 wafer fabs  
 7 assembly/test sites  
 3 bump facilities

Map shows internally owned capacity

# Complete Product Family

## 完整的產品陣容



Powerful, Highly Integrated Motor Driver  
功能強大的類整合馬達驅動器

# Analog Motor Driver: DRV8x

## 類比馬達驅動器: DRV8x系列

### Stepper Motor Drive

#### 步進馬達驅動

- 1.8V~60V; 0~12A
- High Count  $\mu$ -Stepping Indexer 高細分微步進索引
- Current Regulation / Control 電流調節/控制



Open Loop Control  
開放迴路控制

### Brushed DC

#### Motor Drive

#### 有刷 DC 馬達驅動

- 1.8V~60V; 0~24A
- Inrush Current / Stall protection 突波電流 / 停止保護



Simplicity & Low Cost  
易設計, 低成本

### 3-Phase BLDC Motor Drive 三相 BLDC 馬達 驅動

- 8V~60V; 0~13A
- Integrated current sense amps / buck 整合電流感應放大器 / 降壓
- Pre-drivers & drivers (w/ integrated FETs) 前置驅動器/ 整合 MOSFET

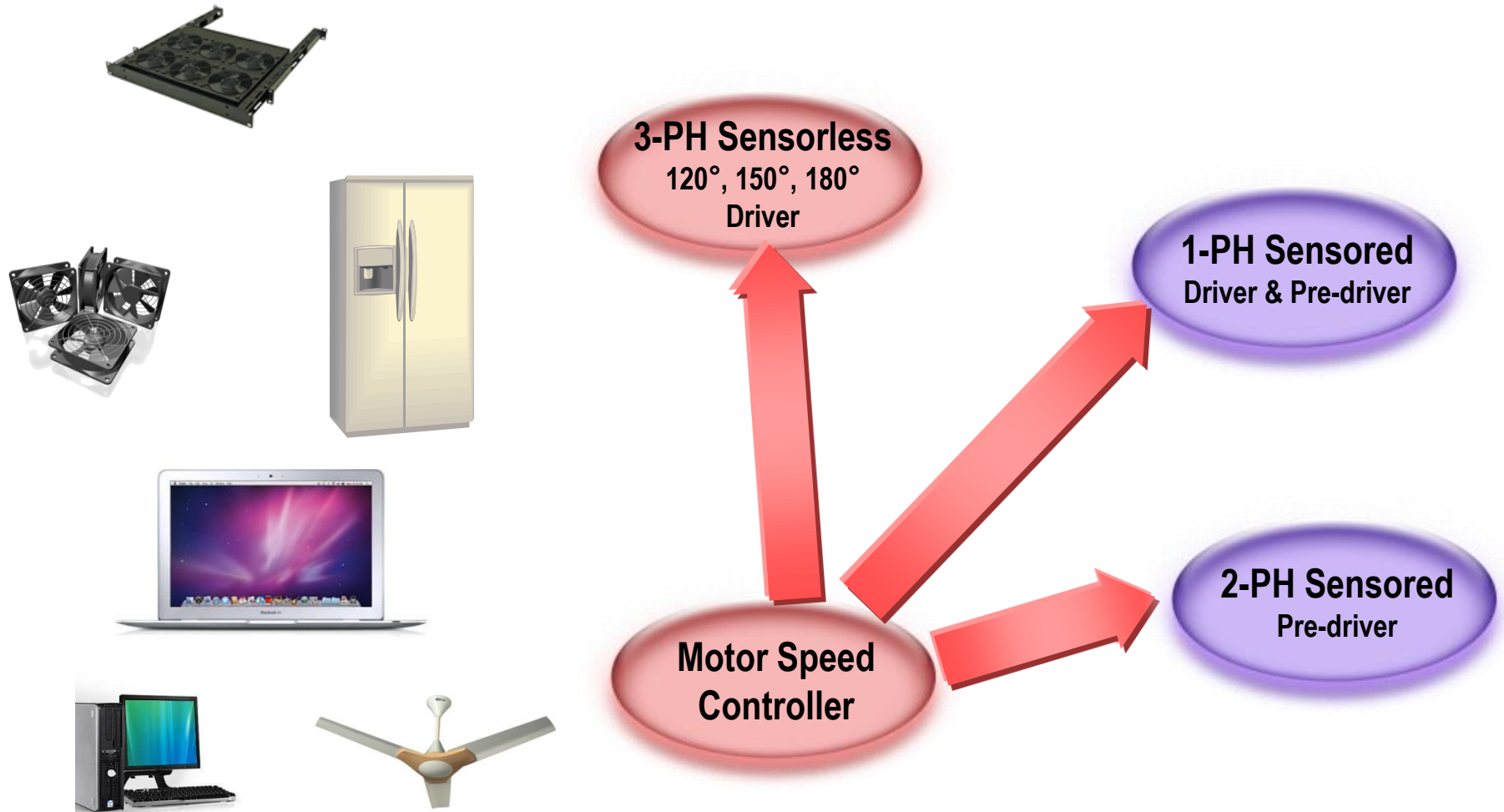


Reliability & Efficiency  
可靠、高效



# DRV10x/TMP8x Integrated BLDC Motor Driver (NDA Required)

## DRV10x/TMP8x系列整合無刷直流馬達驅動器 (需簽NDA)



# Success story/成功案例: 24V Motor Application



## Printers

STP: Sheet Feeder / Scanner

DCM: Paper Cutter, Stapler, Sheet Lifter



## ATM / Cash Resistor

STP: Bill / Receipt Sender, Receipt Printer Head

DCM: Paper Cutter, Cover Opener



## Sewing Machine

STP:

Textile Feeder

Thread / Needle



## Vending Machine

STP: Feeder (Ticket, Drink)

DCM: Feeder

(Bill Senders are supplied as a Module)



## Slot Machine

STP: Reel Rotator

DCM: Coin Hopper

(Bill Senders are supplied as a Module)



## Time Recorder

DCM: Card Feeder

Printer Head



## Automation

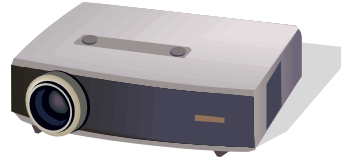
STP: Robot

# Success story/ 成功案例: 3 ~15V Motor Application



## Label Printer

STP: Paper Feeder  
DCM: Paper Cutter



## Projector

STP: Auto Focus  
Zoom, Iris, Lens shift



## Toy R/C, Toy Robot

STP: Joint Control  
DCM: Drive / Wheel Control



## Security Camera

STP: Lends AF, Zoom, Tilt



## Vacuum Cleaner

DCM: Auto Filter Cleaner



## Air Conditioner

STP: Auto Filter Cleaner



## Refrigerator

STP: Flow Adjuster  
DCM: Ice Maker



## POS / Card Terminal

STP: Paper Feeder  
DCM: Paper Cutter  
(Cash Drawers are supplied as a Module)

# For More Information:

## Motor Solutions Home Page: [www.ti.com/motor](http://www.ti.com/motor)



## Motor Solutions Guide

TI Spins Motors.



Motor Solutions Guide



[www.ti.com/motor](http://www.ti.com/motor)

04 2011

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### Motor Drive and Control

For various motor types, AC Induction (ACIM), Brushed DC, Brushless DC (BLDC), Permanent Magnet Synchronous and Stepper find the right analog and digital products, software and support to precisely control the position, velocity and torque


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**Motor Control**

Overview | By Motor Type | **By Product** | Tools & Software | Application Notes | Training & Support | Videos


**Search for Motor Drive and Control Solution Products**

**DRV8x Motor Drivers**




- Integrated Motor Drivers  
Integration of the Gate Driver, MOSFETs and protection circuitry inside a single IC provides the highest level of functionality at the lowest cost and physical size.
- Gate Drivers (MOSFET)  
The gate driver is a power amplifier designed to precisely control and drive the power stage section. It is designed to produce the high-current drive required to switch power MOSFETs and IGBTs.

**MCU - Microcontrollers**



- C2000™ 32-bit Real-time MCUs**
  - Up to 300MHz
  - Flash 16KB to 512KB, PWM, ADC, CAN, SPI, I<sup>2</sup>C, EMIF, QE1
  - Motor Control
- MSP430™ 16-bit Ultra-Low Power MCUs**
  - Up to 25MHz
  - Flash 0.5KB to 256KB, ADC, DAC, LCD, I<sup>2</sup>C, PWM, Op-Amp, SPI, I<sup>2</sup>C
  - Measurement, Metering, Sensing, General Purpose
- Stellaris® ARM® Cortex™-M3-based MCUs**
  - Up to 80MHz
  - Flash 5KB to 256KB, USB, ENET, NAC&PHY, CAN, ADC, PWM, SPI, QE1
  - Motor Control, Human Machine Interface (HMI), Industrial Automation
- TMS570 ARM® Cortex™-R4F-based MCUs**
  - Up to 160MHz
  - 1MB and 2MB Flash Devices, Flexray, CAN, ADC, PWM, SPI
  - Safe Motor Control, Transportation, and Industrial Automation

**Signal Chain**



- Industrial Communications**  
Complicated motor control applications often require communication buses in order to control and synchronize multiple motors with a main motion controller.
- Digital Isolation**  
Digital isolation is typically used in high voltage motor drives in between the control electronics and the high voltage gate drivers to protect the controller in case of mechanical or electrical faults in the power stage.
- Discrete Analog-to-Digital Converters (ADCs)**  
ADCs are often used in high voltage AC induction motor control where the on-chip ADC in the microcontroller does not offer enough performance or when using digital isolation to separate the sensitive control logic from high voltage power stage.
- Current Sense Amps**  
Electronic circuits that monitor the current flow by measuring the voltage drop across a resistor placed in the current path.

**By Motor Type**

- Motor Control: AC Induction
- Motor Control: Brushed DC
- Motor Control: Brushless DC
- Motor Control: Permanent Magnet
- Motor Control: Stepper Motor

**By Product: Integrated Drivers & Gate Drivers**

- Gate Drivers (MOSFET)
- Integrated Motor Drivers

**By Product: Signal Chain**

- Industrial Communication
- Digital Isolation
- Discrete Analog-to-Digital Converters
- Current Sense Amps

**By Product: Controllers (Microcontrollers/MCUs)**

- C2000™ 32-bit Real-Time Controllers
- MSP430™ 16-bit Ultra-Low Power MCUs
- Stellaris® ARM® Cortex™-M3
- TMS570 ARM® Cortex™-R4F-based MCUs

Motor News | Success Story

**Use TI's NEW Selection Tool to Find:**

- Brushless DC Driver
- Brushed DC Driver
- Stepper Driver
- Pre-Driver

**TI Spins Motors**  
Motor Solutions Guide

**New TI Motor Solutions Guide**

Selective Disclosure

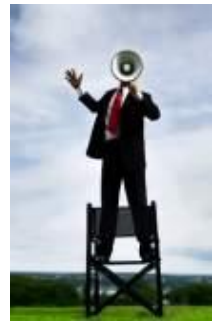
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<b>L293D vs. SN754410 protection requirements</b>	Latest post: <a href="#">By Jose Quinones</a> 19 May 2011 8:20 AM Posted in <a href="#">Motor Drivers Forum</a>	4	136
<b>PWM Motor Drivers - Full Bridge</b>	Latest post: <a href="#">By Jose Quinones</a> 19 May 2011 6:40 AM Posted in <a href="#">Motor Drivers Forum</a>	1	57
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**Thank You!!**  
**感謝大家!!**

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