



DRV8881 2.5A 双路 H 桥电机驱动器

1 特性

- 双路 H 桥电机驱动器
 - 双极步进电机驱动器
 - 单路或双路刷式直流电机驱动器
- 6.5V 至 45V 的工作电源电压范围
- 两个控制接口选项
 - PHASE/ENABLE (DRV8881E)
 - PWM (DRV8881P)
- 多种衰减模式，可为任何电机提供支持
 - AutoTune™ (仅限 DRV8881E)
 - 混合衰减
 - 慢速衰减
 - 快速衰减
- 平滑运动的自适应消隐时间
- 并行工作模式 (仅限 DRV8881P)
- 可配置关断时间脉宽调制 (PWM) 斩波
 - 10、20 或 30μs 关断时间
- 3.3V, 10mA 低压降 (LDO) 稳压器
- 低电流休眠模式 (28μA)
- 小型封装尺寸
 - 28 引脚散热薄型小外形尺寸 (HTSSOP) (PowerPAD) 封装
 - 28 引脚超薄型四方扁平无引线 (WQFN) (PowerPAD) 封装
- 保护特性
 - VM 欠压闭锁 (UVLO)
 - 电荷泵电压 (CPUV)
 - 过流保护 (OCP)
 - 自动过流保护 (OCP) 重试
 - 热关断 (TSD)
 - 故障条件指示引脚 (nFAULT)

2 应用

- 自动取款机和验钞机
- 视频安保摄像机
- 多功能打印机和文档扫描仪
- 工厂自动化和机器人
- 舞台照明设备

3 说明

DRV8881 是一款面向工业应用的双极步进或刷式直流电机驱动器。该器件的输出级由两个 N 沟道功率金属氧化物半导体场效应晶体管 (MOSFET) H 桥驱动器组成。DRV8881 的每个 H 桥能够驱动高达 2.5A 的峰值电流或 1.4A 均方根 (rms) 电流 (采用适当的印刷电路板 (PCB) 接地层进行散热, 电压为 24V, $T_A = 25^\circ\text{C}$)。

AutoTune™ 可自动调整电机以实现最佳电流调节性能, 并且能够对电机变化和老化问题进行补偿。

DRV8881E 上提供 AutoTune 功能。此外, 该器件还提供慢速、快速和混合三种衰减模式。

该器件可通过 PH/EN (DRV8881E) 或 PWM (DRV8881P) 引脚提供一个简单的控制接口。内置的感测放大器能够实现可调节的电流控制。凭借专用的 nSLEEP 引脚, 该器件可提供一种低功耗的休眠模式, 从而实现超低静态电流待机。

该器件内置以下保护功能: 欠压、电荷泵故障、过流、短路以及过热保护。故障条件通过 nFAULT 引脚指示。

器件信息⁽¹⁾

| 器件型号 | 封装 | 封装尺寸 (标称值) |
|---------|-------------|-----------------|
| DRV8881 | HTSSOP (28) | 9.70mm × 6.40mm |
| | WQFN (28) | 5.50mm × 3.50mm |

(1) 要了解所有可用封装, 请见数据表末尾的可订购产品附录。

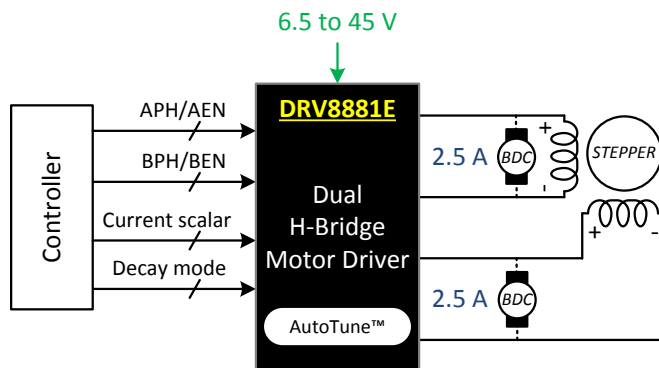


DRV8881

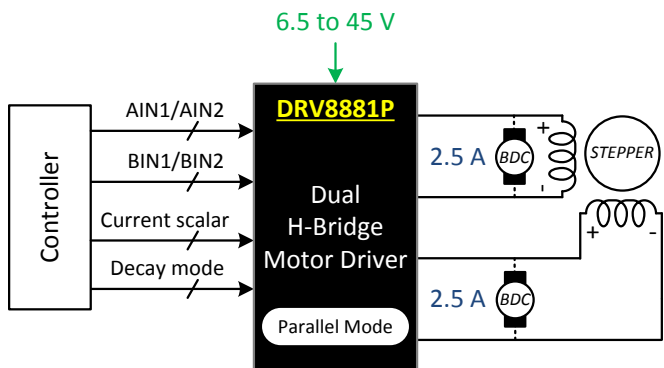
ZHCSDY9A–JUNE 2015–REVISED JULY 2015

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DRV8881E 简化系统图



DRV8881P 简化系统图



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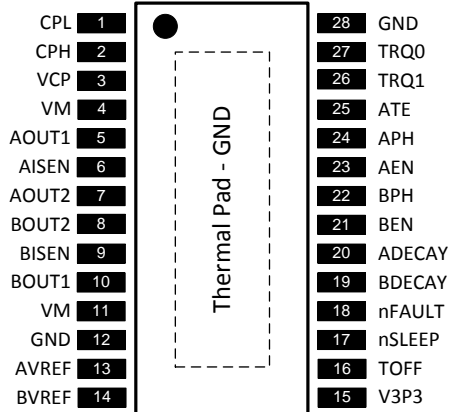
4 修订历史记录

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

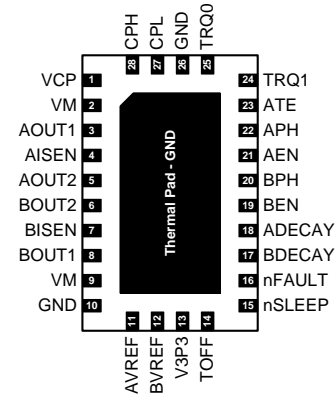
| Changes from Original (June 2015) to Revision A | Page |
|---|------|
| • 已将器件状态更新为量产数据 | 1 |
| • Updated from "PowerPAD" to "thermal pad" | 5 |
| • Corrected ATE pin number for RHR package to 23..... | 5 |

5 Pin Configuration and Functions

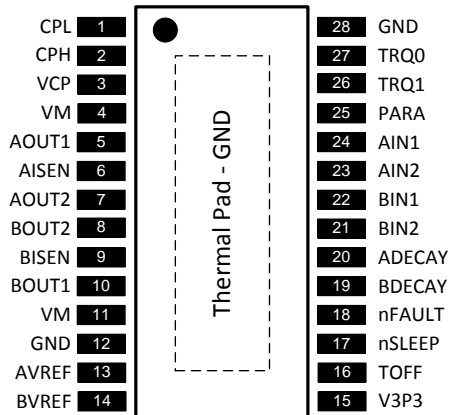
**PWP Package
28-Pin HTSSOP
Top View DRV8881E**



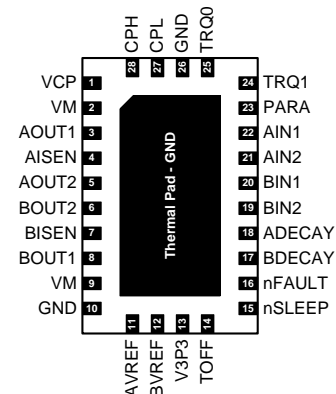
**RHR Package
28-Pin WQFN
Top View DRV8881E**



**PWP Package
28-Pin HTSSOP
Top View DRV8881P**



**RHR Package
28-Pin WQFN
Top View DRV8881P**



Pin Functions

| PIN | | | TYPE | DESCRIPTION | |
|-------|--------|--------|------|--------------------|--|
| NAME | PWP | RHR | | | |
| CPL | 1 | 27 | PWR | Charge pump output | Connect a VM rated, 0.1-μF ceramic capacitor between CPH and CPL |
| CPH | 2 | 28 | | | |
| VCP | 3 | 1 | O | Charge pump output | Connect a 16-V, 0.47-μF ceramic capacitor to VM |
| VM | 4, 11 | 2, 9 | PWR | Power supply | Connect to motor supply voltage; bypass to GND with two 0.1 μF (for each pin) plus one bulk capacitor rated for VM |
| AOUT1 | 5 | 3 | O | Winding A output | H-bridge outputs, drives one winding of a stepper motor |
| AOUT2 | 7 | 5 | | | |
| AISEN | 6 | 4 | O | Winding A sense | Requires sense resistor to GND; value sets peak current in winding A |
| BOUT2 | 8 | 6 | O | Winding B output | H-bridge outputs, drives one winding of a stepper motor |
| BOUT1 | 10 | 8 | | | |
| BISEN | 9 | 7 | O | Winding B sense | Requires sense resistor to GND; value sets peak current in winding B |
| GND | 12, 28 | 10, 26 | PWR | Device ground | Must be connected to ground |

Pin Functions (continued)

| PIN | | | TYPE | DESCRIPTION | |
|--------|-----|-----|------|---------------------------|---|
| NAME | PWP | RHR | | | |
| AVREF | 13 | 11 | I | Reference voltage input | Voltage on this pin sets the full scale chopping current in H-bridge A |
| BVREF | 14 | 12 | | | Voltage on this pin sets the full scale chopping current in H-bridge B |
| V3P3 | 15 | 13 | — | Internal regulator | Internal supply voltage; bypass to GND with a 6.3-V, 0.47-μF ceramic capacitor; up to 10-mA external load |
| TOFF | 16 | 14 | I | Decay mode off time set | Sets the off-time during current chopping; tri-level pin |
| nSLEEP | 17 | 15 | I | Sleep mode input | Logic high to enable device; logic low to enter low-power sleep mode; internal pulldown |
| nFAULT | 18 | 16 | O | Fault indication pin | Pulled logic low with fault condition; open-drain output requires an external pullup |
| BDECAY | 19 | 17 | I | Decay mode setting pins | Set the decay mode for bridge B; see Decay Modes ; tri-level pin |
| ADECAY | 20 | 18 | | | Set the decay mode for bridge A; see Decay Modes ; tri-level pin |
| TRQ1 | 26 | 24 | I | Torque DAC current scalar | Scales the current by 100%, 75%, 50%, or 25%; internal pulldown |
| TRQ0 | 27 | 25 | | | |
| PAD | PAD | PAD | PWR | Thermal pad | Must be connected to ground |

DRV8881E PH/EN Pin Functions

| PIN | | | TYPE | DESCRIPTION | |
|------|-----|-----|------|-----------------------|--|
| NAME | PWP | RHR | | | |
| BEN | 21 | 19 | I | Bridge B enable input | Logic high enables bridge B; logic low disables the bridge Hi-Z |
| BPH | 22 | 20 | I | Bridge B phase input | Logic high drives current from BOUT1 → BOUT2 |
| AEN | 23 | 21 | I | Bridge A enable input | Logic high enables bridge A; logic low disables the bridge Hi-Z |
| APH | 24 | 22 | I | Bridge A phase input | Logic high drives current from AOUT1 → AOUT2 |
| ATE | 25 | 23 | I | AutoTune enable pin | Logic high enables AutoTune operation; when logic low, the decay mode is set through the DECAYx pins; AutoTune must be pulled high prior to power-up or coming out of sleep, or else tied to V3P3 in order to enable AutoTune; internal pulldown; see AutoTune |

DRV8881P PWM Pin Functions

| PIN | | | TYPE | DESCRIPTION | |
|------|-----|-----|------|---------------------|---|
| NAME | PWP | RHR | | | |
| BIN2 | 21 | 19 | I | Bridge B PWM input | Logic controls the state of H-bridge B; internal pulldown |
| BIN1 | 22 | 20 | | | |
| AIN2 | 23 | 21 | I | Bridge A PWM input | Logic controls the state of H-bridge A; internal pulldown |
| AIN1 | 24 | 22 | | | |
| PARA | 25 | 23 | I | Parallel mode input | Logic high enables parallel mode |

External Components

| COMPONENT | PIN 1 | PIN 2 | RECOMMENDED |
|---------------------|---------------------------------|--------|--|
| CVM1 | VM | GND | 0.1-μF ceramic capacitor rated for VM per VM pin |
| CVM1 | VM | GND | Bulk electrolytic capacitor rated for VM, recommended value is 100 μF, see Bulk Capacitance Sizing |
| CVCP | VCP | VM | 16 V, 0.47 μF ceramic capacitor |
| CSW | CPH | CPL | 0.1-μF X7R capacitor rated for VM |
| CV3P3 | V3P3 | GND | 6.3 V, 0.47-μF ceramic capacitor |
| R _{nFAULT} | V _{MCU} ⁽¹⁾ | nFAULT | > 5 kΩ |
| R _{AISEN} | AISEN | GND | Optional sense resistor, see Sense Resistor |
| R _{BISEN} | BISEN | GND | |

- (1) V_{MCU} is not a pin on the DRV8881, but a supply voltage pullup is required for open-drain output nFAULT; nFAULT may be pulled up to V3P3

6 Specifications

6.1 Absolute Maximum Ratings

over operating free-air temperature range referenced with respect to GND (unless otherwise noted) ⁽¹⁾

| | MIN | MAX | UNIT |
|---|--------------------|------------|------|
| Power supply voltage (VM) | −0.3 | 50 | V |
| Power supply voltage ramp rate (VM) | 0 | 2 | V/μs |
| Charge pump voltage (VCP, CPH) | −0.3 | VM + 12 | V |
| Charge pump negative switching pin (CPL) | −0.3 | VM | V |
| Internal regulator voltage (V3P3) | −0.3 | 3.8 | V |
| Internal regulator current output (V3P3) | 0 | 10 | mA |
| Control pin voltage (APH, AEN, BPH, BEN, AIN1, AIN2, BIN1, BIN2, nSLEEP, nFAULT, ADECA, BDECA, TRQ0, TRQ1, ATE, PARA) | −0.3 | 7.0 | V |
| Open drain output current (nFAULT) | 0 | 10 | mA |
| Reference input pin voltage (AVREF, BVREF) | −0.3 | V3P3 + 0.5 | V |
| Continuous phase node pin voltage (AOUT1, AOUT2, BOUT1, BOUT2) | −0.7 | VM + 0.7 | V |
| Continuous shunt amplifier input pin voltage (AISEN, BISEN) ⁽²⁾ | −0.55 | 0.55 | V |
| Peak drive current (AOUT1, AOUT2, BOUT1, BOUT2, AISEN, BISEN) | Internally limited | | A |
| Operating junction temperature, T _J | −40 | 150 | °C |
| Storage temperature, T _{stg} | −65 | 150 | °C |

- (1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
- (2) Transients of ±1 V for less than 25 ns are acceptable

6.2 ESD Ratings

| | | VALUE | UNIT |
|--|--|-------|------|
| V _(ESD) Electrostatic discharge | Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001 ⁽¹⁾ | ±4000 | V |
| | Charged-device model (CDM), per JEDEC specification JESD22-C101 ⁽²⁾ | ±1000 | |

- (1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
- (2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

6.3 Recommended Operating Conditions

over operating free-air temperature range (unless otherwise noted)

| | | MIN | MAX | UNIT |
|-------------------|---|--------------------|-------------------|------|
| VM | Power supply voltage range | 6.5 | 45 | V |
| V _{IN} | Digital pin voltage range | 0 | 5.3 | V |
| VREF | Reference rms voltage range (AVREF, BVREF) | 0.3 ⁽¹⁾ | V3P3 | V |
| f _{PWM} | Applied PWM signal (APH, AEN, BPH, BEN, AIN1, AIN2, BIN1, BIN2) | 0 | 100 | kHz |
| I _{V3P3} | V3P3 external load current | 0 | 10 ⁽²⁾ | mA |
| I _{rms} | Motor rms current per H-bridge | 0 | 1.4 | A |
| T _A | Operating ambient temperature | –40 | 125 | °C |

(1) Operational at VREF ≈ 0 to 0.3 V, but accuracy is degraded

(2) Power dissipation and thermal limits must be observed

6.4 Thermal Information

| THERMAL METRIC ⁽¹⁾ | | DRV8881 | | UNIT |
|-------------------------------|--|--------------|------------|------|
| | | PWP (HTSSOP) | RHR (WQFN) | |
| | | 28 PINS | 28 PINS | |
| R _{θJA} | Junction-to-ambient thermal resistance | 33.1 | 37.5 | °C/W |
| R _{θJC(top)} | Junction-to-case (top) thermal resistance | 16.6 | 23.0 | °C/W |
| R _{θJB} | Junction-to-board thermal resistance | 14.4 | 8.0 | °C/W |
| ψ _{JT} | Junction-to-top characterization parameter | 0.4 | 0.2 | °C/W |
| ψ _{JB} | Junction-to-board characterization parameter | 14.2 | 7.8 | °C/W |
| R _{θJC(bot)} | Junction-to-case (bottom) thermal resistance | 1.3 | 1.7 | °C/W |

(1) For more information about traditional and new thermal metrics, see the *Semiconductor and IC Package Thermal Metrics* application report, [SPRA953](#).

6.5 Electrical Characteristics

over operating free-air temperature range (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|--|------------------------------------|--|-----|------------|-----|------|
| POWER SUPPLIES (VM, V3P3) | | | | | | |
| VM | VM operating voltage | | 6.5 | | 45 | V |
| I _{VM} | VM operating supply current | nSLEEP high; ENABLE high; no motor load; VM = 24 V | | 8 | 18 | mA |
| I _{VMQ} | VM sleep mode supply current | nSLEEP low; VM = 24 V; T _A = 25°C | | 28 | | μA |
| | | nSLEEP low; VM = 24 V; T _A = 125°C ⁽¹⁾ | | | 77 | |
| t _{SLEEP} | Sleep time | nSLEEP low to sleep mode | | | 100 | μs |
| t _{WAKE} | Wake-up time | nSLEEP high to output transition | | | 1.5 | ms |
| t _{ON} | Turn-on time | VM > V _{UVLO} to output transition | | | 1.5 | ms |
| V3P3 | Internal regulator voltage | External load 0 to 10 mA | 2.9 | 3.3 | 3.6 | V |
| CHARGE PUMP (VCP, CPH, CPL) | | | | | | |
| V _{CP} | VCP operating voltage | VM > 12 V | | VM + 11.5 | | V |
| | | V _{UVLO} < VM < 12 V | | 2xVM – 1.5 | | |
| f _{VCP} ⁽¹⁾ | Charge pump switching frequency | VM > V _{UVLO} | 175 | | 715 | kHz |
| LOGIC-LEVEL INPUTS (APH, AEN, BPH, BEN, AIN1, AIN2, BIN1, BIN2, nSLEEP, TRQ0, TRQ1, PARA) | | | | | | |
| V _{IL} | Input logic low voltage | | 0 | | 0.6 | V |
| V _{IH} | Input logic high voltage | | 1.6 | | 5.3 | V |
| V _{HYS} | Input logic hysteresis | | 100 | | | mV |
| I _{IL} | Input logic low current | V _{IN} = 0 V | –1 | | 1 | μA |
| I _{IH} | Input logic high current | V _{IN} = 5.0 V | | 50 | 100 | μA |
| R _{PD} | Pulldown resistance | Measured between the pin and GND | | 100 | | kΩ |
| t _{PD} | Propagation delay | xPH, xEN, xINx input to current change | | 450 | | ns |
| TRI-LEVEL INPUTS (ADELAY, BDEAY, TOFF) | | | | | | |
| V _{IL} | Tri-level input logic low voltage | | 0 | | 0.6 | V |
| V _{IZ} | Tri-level input Hi-Z voltage | | | 1.1 | | V |
| V _{IH} | Tri-level input logic high voltage | | 1.6 | | 5.3 | V |
| V _{HYS} | Tri-level input hysteresis | | 100 | | | mV |
| I _{IL} | Tri-level input logic low current | V _{IN} = 0 V | –55 | | –35 | μA |
| I _{IZ} | Tri-level input Hi-Z current | V _{IN} = 1.3 V | | 15 | | μA |
| I _{IH} | Tri-level input logic high current | V _{IN} = 3.3 V | | 85 | | μA |
| R _{PD} | Tri-level pulldown resistance | Measured between the pin and GND | | 40 | | kΩ |
| R _{PU} | Tri-level pullup resistance | Measured between V3P3 and the pin | | 45 | | kΩ |
| CONTROL OUTPUTS (nFAULT) | | | | | | |
| V _{OL} | Output logic low voltage | I _O = 4 mA | | | 0.5 | V |
| I _{OH} | Output logic high leakage | External pullup resistor to 3.3 V | –1 | | 1 | μA |
| MOTOR DRIVER OUTPUTS (AOUT1, AOUT2, BOUT1, BOUT2) | | | | | | |
| R _{DS(ON)} | High-side FET on resistance | VM = 24 V, I = 1 A, T _A = 25°C | | 330 | | mΩ |
| | | VM = 24 V, I = 1 A, T _A = 125°C ⁽¹⁾ | | 400 | 440 | |
| | | VM = 6.5 V, I = 1 A, T _A = 25°C | | 430 | | |
| | | VM = 6.5 V, I = 1 A, T _A = 125°C ⁽¹⁾ | | 500 | 560 | |
| R _{DS(ON)} | Low-side FET on resistance | VM = 24 V, I = 1 A, T _A = 25°C | | 300 | | mΩ |
| | | VM = 24 V, I = 1 A, T _A = 125°C ⁽¹⁾ | | 370 | 400 | |
| | | VM = 6.5 V, I = 1 A, T _A = 25°C | | 370 | | |
| | | VM = 6.5 V, I = 1 A, T _A = 125°C ⁽¹⁾ | | 450 | 490 | |

(1) Specified by design and characterization data

Electrical Characteristics (continued)

over operating free-air temperature range (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|--|---|---|------|----------|------|------|
| t _{RISE} | Output rise time | VM = 24 V, 50 Ω load from xOUTx to GND | | 70 | | ns |
| t _{FALL} | Output fall time | VM = 24 V, 50 Ω load from VM to xOUTx | | 70 | | ns |
| t _{DEAD} | Output dead time ⁽²⁾ | | | 200 | | ns |
| V _d | Body diode forward voltage | I _{OUT} = 0.5 A | | 0.7 | 1 | V |
| PWM CURRENT CONTROL (VREF, AISEN, BISEN) | | | | | | |
| V _{TRIP} | xISENSE trip voltage, full scale current step | TRQ at 100%, VREF = 3.3 V | | 500 | | mV |
| | | TRQ at 75%, VREF = 3.3 V | | 375 | | |
| | | TRQ at 50%, VREF = 3.3 V | | 250 | | |
| | | TRQ at 25%, VREF = 3.3 V | | 125 | | |
| A _V | Amplifier attenuation | Torque = 100% (TRQ0 = 0, TRQ1 = 0) | 6.25 | 6.58 | 6.91 | V/V |
| | | Torque = 75% (TRQ0 = 1, TRQ1 = 0) | 6.2 | 6.56 | 6.92 | |
| | | Torque = 50% (TRQ0 = 0, TRQ1 = 1) | 6.09 | 6.51 | 6.94 | |
| | | Torque = 25% (TRQ0 = 1, TRQ1 = 1) | 5.83 | 6.38 | 6.93 | |
| t _{OFF} | PWM off-time | TOFF logic low | | 20 | | μs |
| | | TOFF logic high | | 30 | | |
| | | TOFF Hi-Z | | 10 | | |
| t _{BLANK} | PWM blanking time | See Table 6 for details | | 1.8 | | μs |
| | | | | 1.5 | | |
| | | | | 1.2 | | |
| | | | | 0.9 | | |
| PROTECTION CIRCUITS | | | | | | |
| V _{UVLO} | VM undervoltage lockout | VM falling; UVLO report | | 5.8 | 6.4 | V |
| | | VM rising; UVLO recovery | | 6.1 | 6.5 | |
| V _{UVLO,HYS} | Undervoltage hysteresis | Rising to falling threshold | 100 | | | mV |
| V _{CPUV} | Charge pump undervoltage | VCP falling; CPUV report | | VM + 1.8 | | V |
| | | VCP rising; CPUV recovery | | VM + 1.9 | | |
| V _{CPUV,HYS} | CP undervoltage hysteresis | Rising to falling threshold | 50 | | | mV |
| I _{OCP} | Overcurrent protection trip level | Current through any FET | 2.5 | 3.6 | | A |
| V _{OCP} | Sense pin overcurrent trip level | Voltage at AISEN or BISEN | 0.9 | 1.25 | | V |
| t _{OCP} | Overcurrent deglitch time | | | 2 | | μs |
| t _{RETRY} | Overcurrent retry time | | 0.5 | | 2 | ms |
| T _{TSD} ⁽²⁾ | Thermal shutdown temperature | Die temperature T _J | 150 | | | °C |
| T _{HYS} ⁽²⁾ | Thermal shutdown hysteresis | Die temperature T _J | | 35 | | °C |

(2) Specified by design and characterization data

6.6 Typical Characteristics

Over recommended operating conditions (unless otherwise noted)

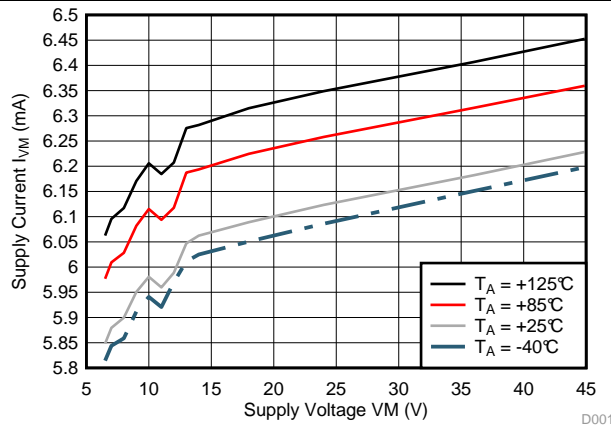


Figure 1. Supply Current over VM

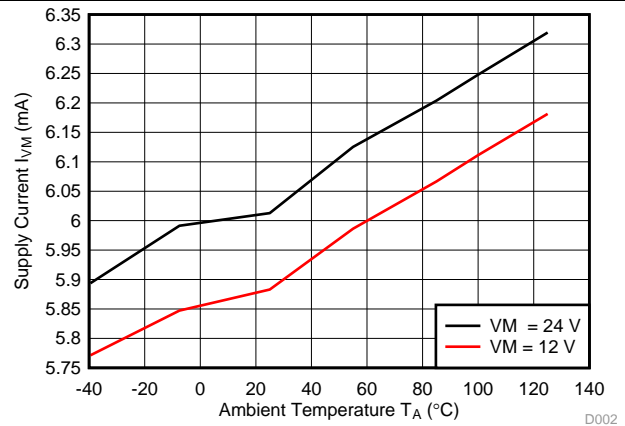


Figure 2. Supply Current over Temperature

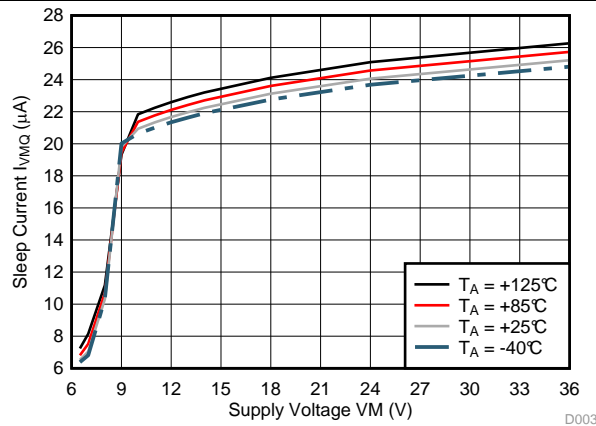


Figure 3. Sleep Current over VM

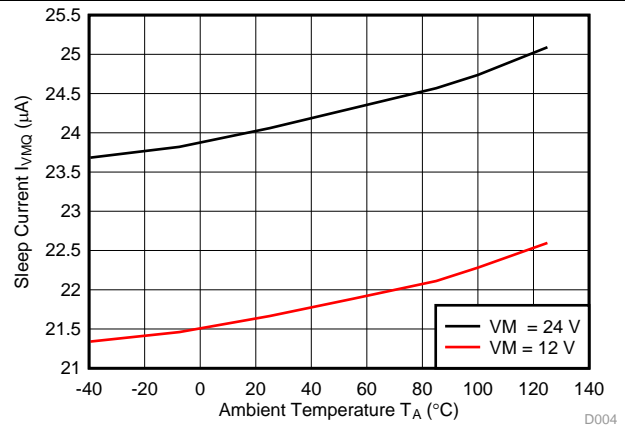


Figure 4. Sleep Current over Temperature

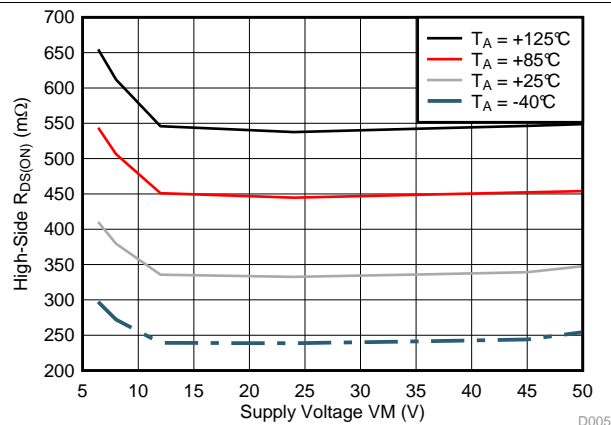


Figure 5. High-Side $R_{DS(ON)}$ over VM

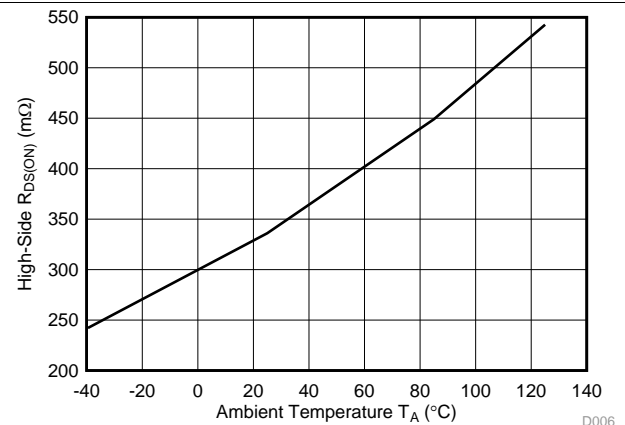


Figure 6. High-Side $R_{DS(ON)}$ over Temperature (VM = 12 V)

Typical Characteristics (continued)

Over recommended operating conditions (unless otherwise noted)

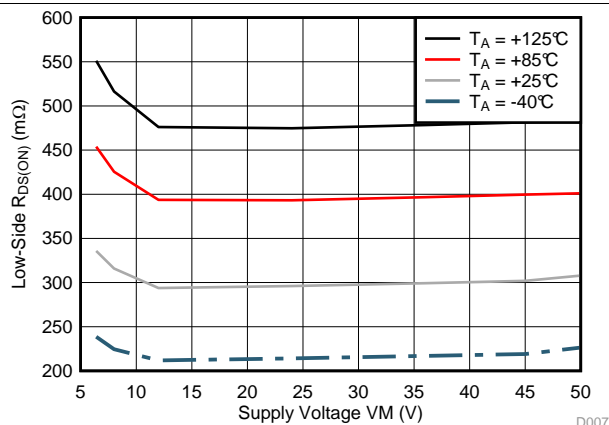


Figure 7. Low-Side $R_{DS(ON)}$ over VM

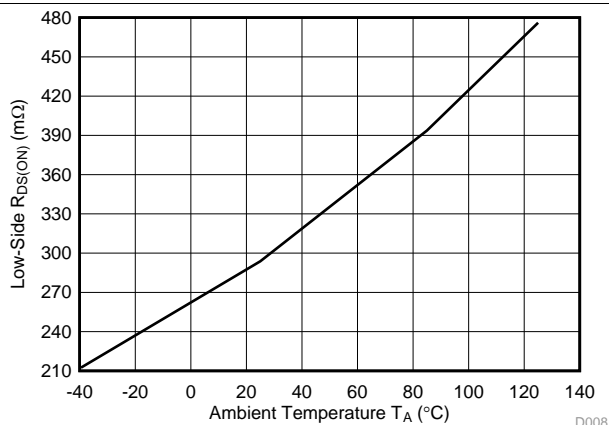


Figure 8. Low-Side $R_{DS(ON)}$ over Temperature (VM = 12 V)

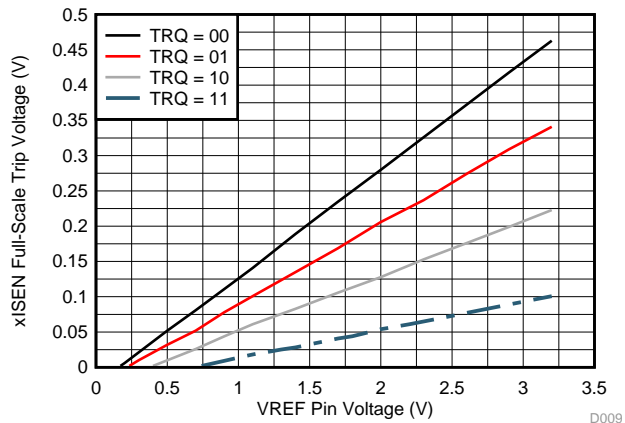


Figure 9. xISEN Trip Voltage over VREF Input

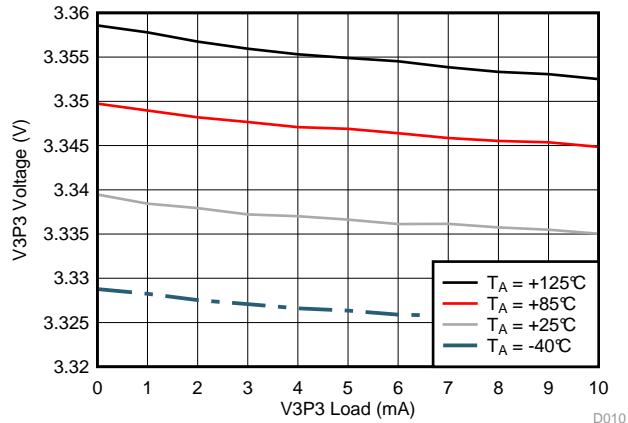


Figure 10. V3P3 Regulator over Load (VM = 24 V)

7 Detailed Description

7.1 Overview

The DRV8881 is an integrated motor driver solution for bipolar stepper motors or single/dual brushed-DC motors. The device integrates two NMOS H-bridges and current regulation circuitry. The DRV8881 can be powered with a supply voltage between 6.5 and 45 V, and is capable of providing an output current up to 2.5 A peak or 1.4 A rms per H-bridge. Actual operable rms current will depend on ambient temperature, supply voltage, and PCB ground plane size.

A simple PH/EN (DRV8881E) or PWM (DRV8881P) interface allows easy interfacing to the controller circuit.

The current regulation is highly configurable, with several decay modes of operation. The decay mode can be selected as a fixed slow, mixed, or fast decay.

In addition, an AutoTune mode can be used which automatically adjusts the decay setting to minimize current ripple while still reacting quickly to step changes. This feature greatly simplifies stepper driver integration into a motor drive system. AutoTune is only available on the DRV8881E.

The PWM off-time, t_{OFF} , can be adjusted to 10, 20, or 30 μ s.

An adaptive blanking time feature automatically scales the minimum drive time with output current. This helps alleviate current waveform distortion by limiting the drive time at low-currents.

A torque DAC feature allows the controller to scale the output current without needing to scale the analog reference voltage inputs AVREF and BVREF. The torque DAC is accessed using digital input pins. This allows the controller to save power by decreasing the current consumption when not required.

In the DRV8881P, a parallel mode allows the user to parallel the two H-bridge outputs in order to double the current capacity.

A low-power sleep mode is included which allows the system to save power when not driving the motor.

7.2 Functional Block Diagrams

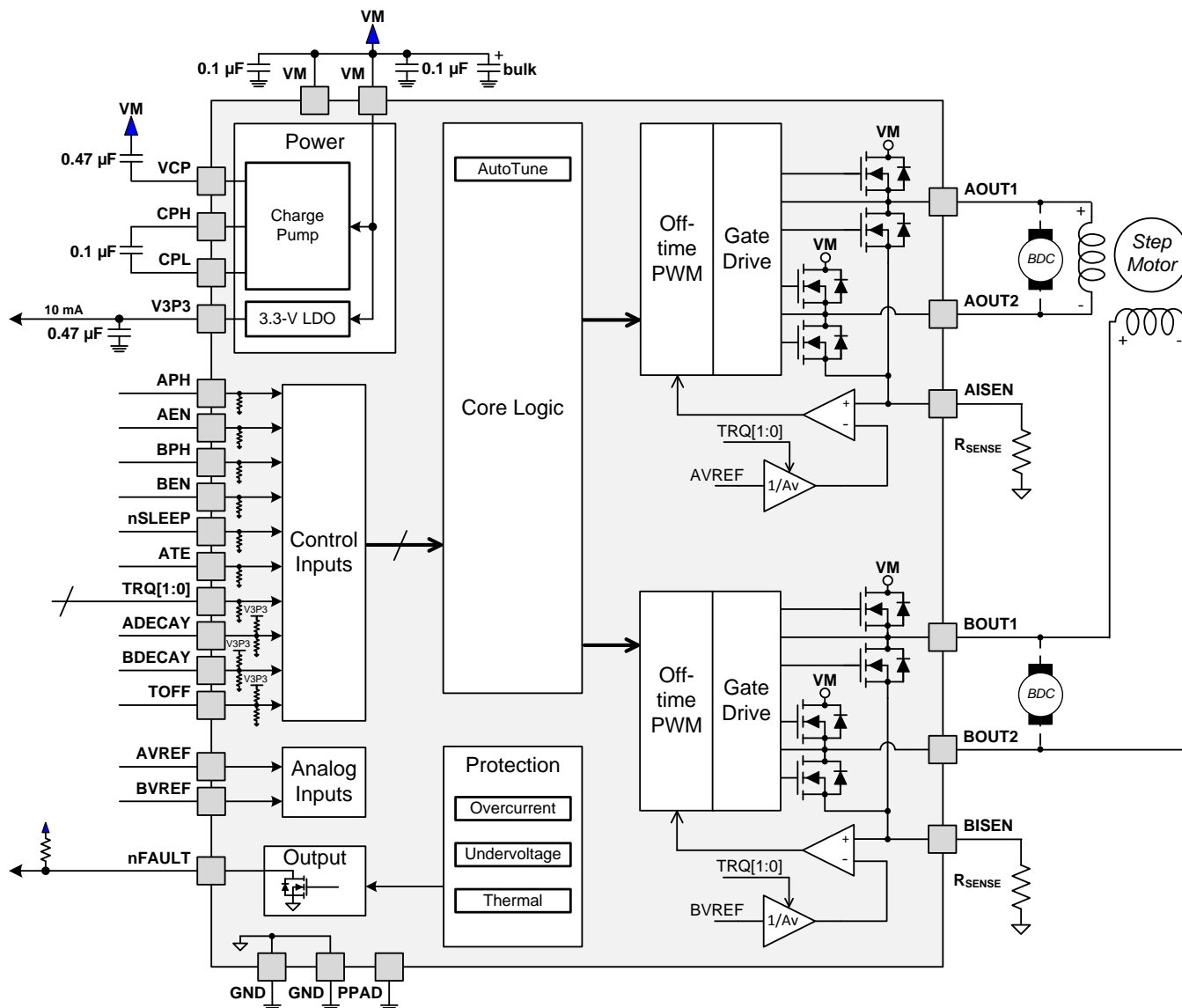
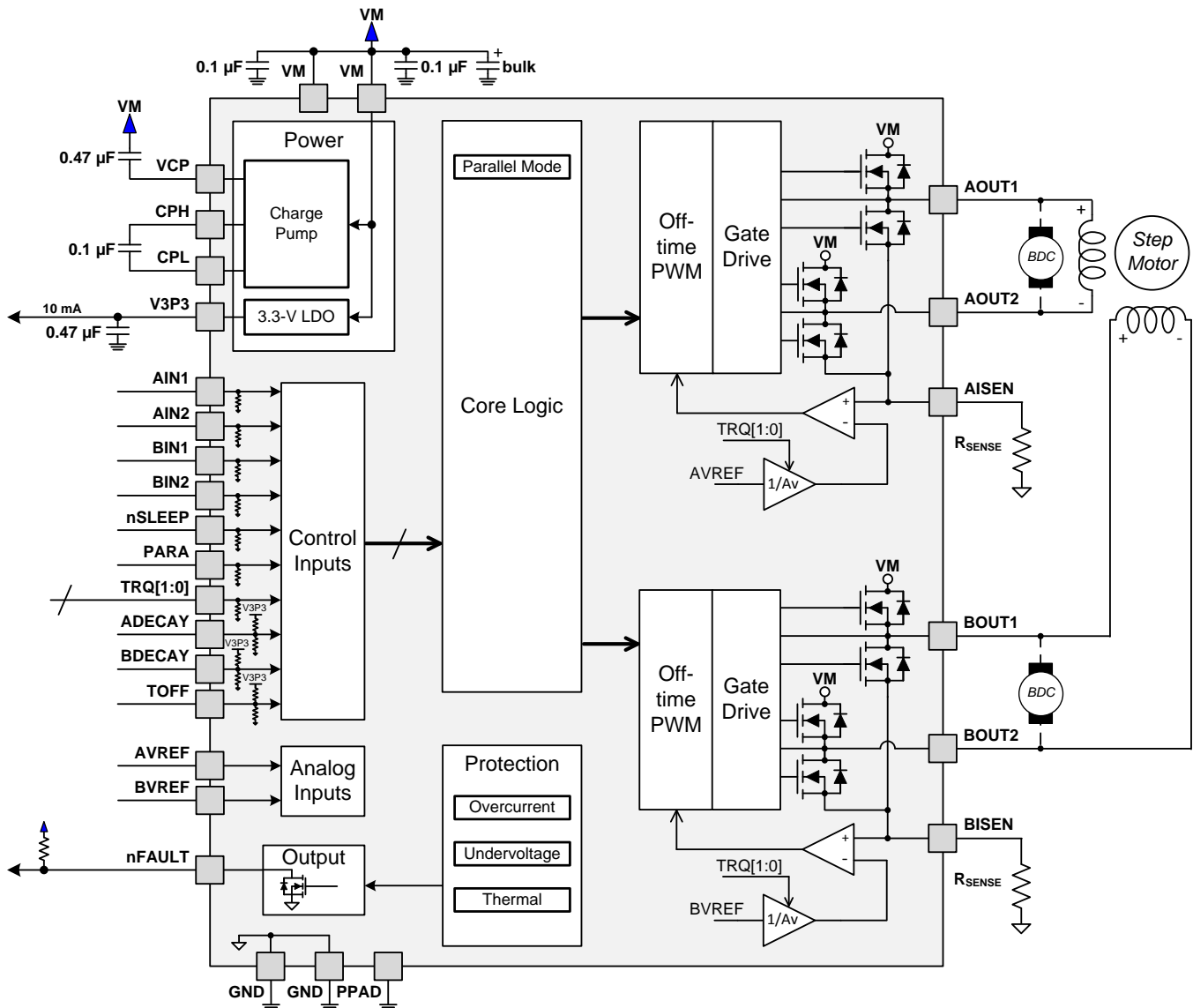


Figure 11. DRV8881E Block Diagram

Functional Block Diagrams (continued)

Figure 12. DRV8881P Block Diagram

7.3 Feature Description

7.3.1 Motor Driver Current Ratings

Brushed motor drivers can be classified using two different numbers to describe the output current: peak and rms. Stepper motor drivers can be described with three numbers: peak, rms, and full-scale.

7.3.1.1 Peak Current Rating

The peak current in a motor driver is limited by the overcurrent protection trip threshold I_{OCP} . The peak current describes any transient duration current pulse, for example when charging capacitance, when the overall duty cycle is very low. In general the minimum value of I_{OCP} specifies the peak current rating of the motor driver. For the DRV8881, the peak current rating is 2.5 A per bridge.

7.3.1.2 RMS Current Rating

The rms (average) current is determined by the thermal considerations of the IC. The rms current is calculated based on the $R_{DS(ON)}$, rise and fall time, PWM frequency, device quiescent current, and package thermal performance in a typical system at 25°C. The real operating rms current may be higher or lower depending on heatsinking and ambient temperature. For the DRV8881, the rms current rating is 1.4 A per bridge. In parallel mode, the DRV8881P is capable of double the rms output current, or 2.8 A.

7.3.1.3 Full-Scale Current Rating

The full-scale current for a stepper motor describes the top of the sinusoid current waveform while stepping. Since the sinusoid amplitude is related to the rms current, the full-scale current is also determined by the thermal considerations of the IC. The full-scale current rating is approximately $\sqrt{2} \times I_{rms}$. The full-scale current is set by xVREF, the sense resistor, and Torque DAC when configuring the DRV8881. For the DRV8881, the full-scale current rating is 2.0 A per bridge.

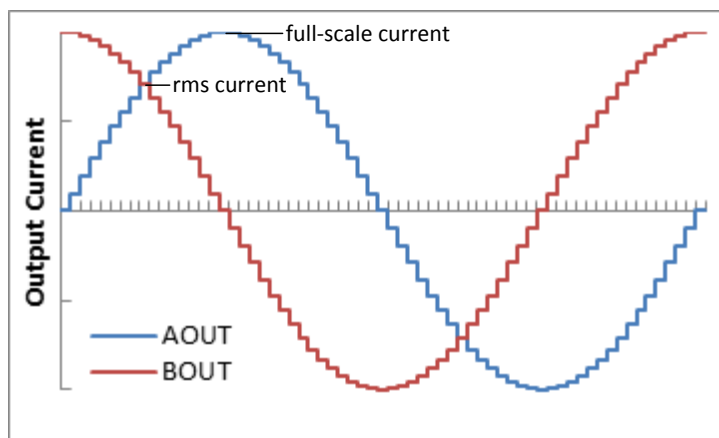


Figure 13. Full-Scale and rms Current

Feature Description (continued)

7.3.2 PWM Motor Drivers

The DRV8881 contains drivers for two full H-bridges. Figure 14 shows a block diagram of the circuitry.

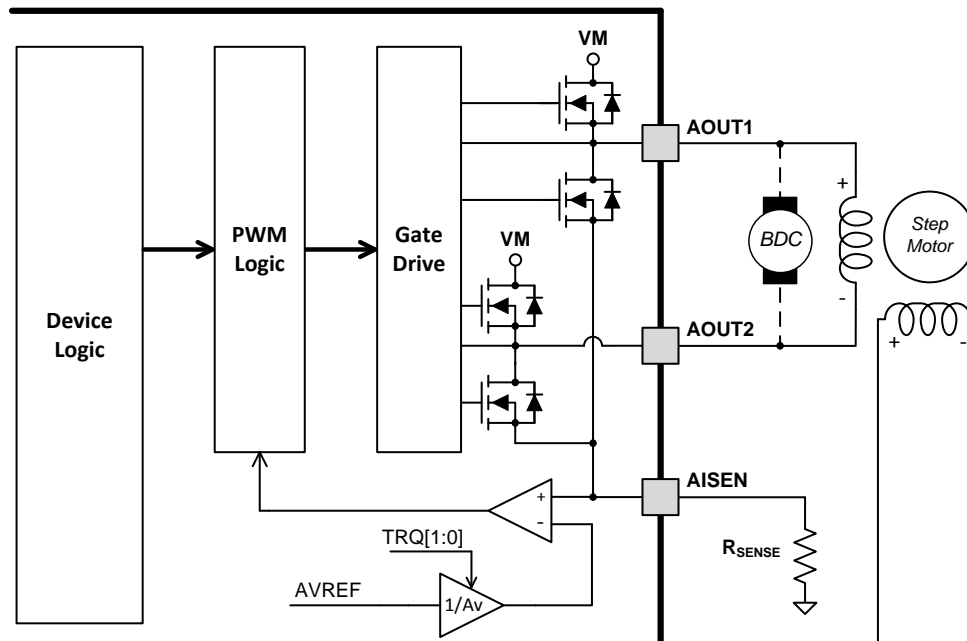


Figure 14. PWM Motor Driver Block Diagram

7.3.3 Bridge Control

The DRV8881E is controlled using a PH/EN interface. Table 1 gives the full H-bridge state. Note that this table does not take into account the current control built into the DRV8881E. Positive current is defined in the direction of xOUT1 → xOUT2.

Table 1. DRV8881E (PH/EN) Control Interface

| nSLEEP | ENx | PHx | xOUT1 | xOUT2 | V3P3 | DESCRIPTION |
|--------|-----|-----|-------|-------|----------|------------------------------------|
| 0 | X | X | Hi-Z | Hi-Z | Disabled | Sleep mode; H-bridge disabled Hi-Z |
| 1 | 0 | X | Hi-Z | Hi-Z | Enabled | H-bridge disabled Hi-Z |
| 1 | 1 | 0 | L | H | Enabled | Reverse (current xOUT2 → xOUT1) |
| 1 | 1 | 1 | H | L | Enabled | Forward (current xOUT1 → xOUT2) |

The DRV8881P is controlled using a PWM interface. Table 2 gives the full H-bridge state. Note that this table does not take into account the current control built into the DRV8881P. Positive current is defined in the direction of xOUT1 → xOUT2.

Table 2. DRV8881P (PWM) Control Interface

| nSLEEP | xIN1 | xIN2 | xOUT1 | xOUT2 | V3P3 | DESCRIPTION |
|--------|------|------|-------|-------|----------|------------------------------------|
| 0 | X | X | Hi-Z | Hi-Z | Disabled | Sleep mode; H-bridge disabled Hi-Z |
| 1 | 0 | 0 | Hi-Z | Hi-Z | Enabled | Coast; H-bridge disabled Hi-Z |
| 1 | 0 | 1 | L | H | Enabled | Reverse (current xOUT2 → xOUT1) |
| 1 | 1 | 0 | H | L | Enabled | Forward (current xOUT1 → xOUT2) |
| 1 | 1 | 1 | L | L | Enabled | Brake; low-side slow decay |

7.3.4 Current Regulation

The current through the motor windings is regulated by an adjustable fixed-off-time PWM current regulation circuit. When an H-bridge is enabled, current rises through the winding at a rate dependent on the DC voltage, inductance of the winding, and the magnitude of the back EMF present. Once the current hits the current chopping threshold, the bridge enters a decay mode for a fixed period of time to decrease the current, which is configurable between 10 and 30 μs through the tri-level input TOFF. After the off time expires, the bridge is re-enabled, starting another PWM cycle.

Table 3. Off-Time Settings

| TOFF | OFF-TIME t_{OFF} |
|------|---------------------------|
| 0 | 20 μs |
| 1 | 30 μs |
| Z | 10 μs |

The PWM chopping current is set by a comparator which compares the voltage across a current sense resistor connected to the xISEN pin with a reference voltage. To generate the reference voltage for the current chopping comparator, the xVREF input is attenuated by a factor of A_v . In addition, the TRQx pins further scale the reference.

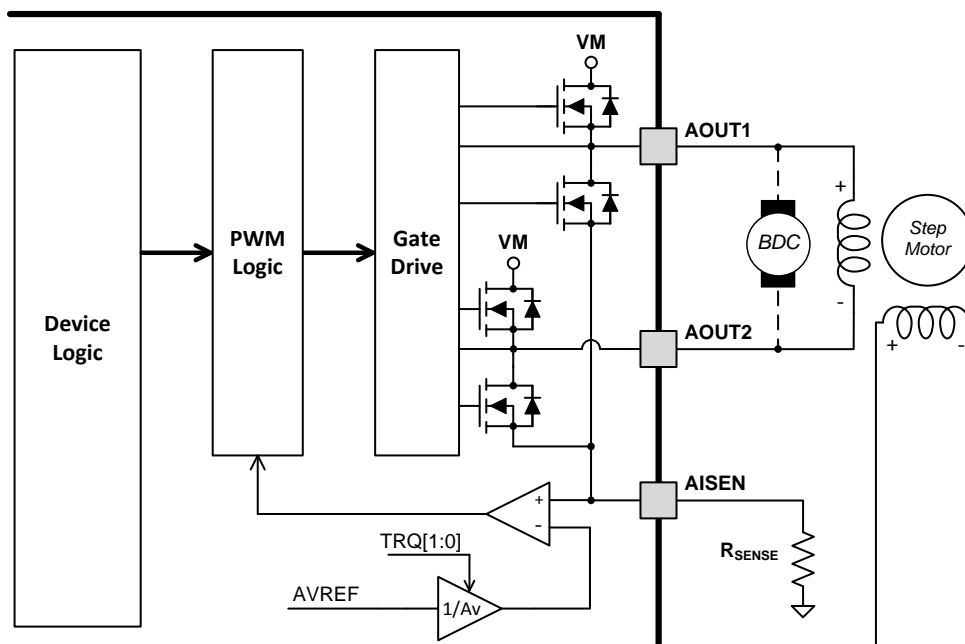


Figure 15. Current Regulation Block Diagram

The chopping current is calculated as follows:

$$I_{\text{TRIP}} (\text{A}) = \frac{V_{\text{REF}} (\text{V}) \times \text{TRQ} (\%) }{A_v \times R_{\text{SENSE}} (\Omega)} = \frac{V_{\text{REF}} (\text{V}) \times \text{TRQ} (\%) }{6.6 \times R_{\text{SENSE}} (\Omega)} \quad (1)$$

TRQ is a DAC used to scale the output current. The current scalar value for different inputs is shown in [Table 4](#).

Table 4. Torque DAC Settings

| TRQ1 | TRQ0 | CURRENT SCALAR (TRQ) | EFFECTIVE ATTENUATION |
|------|------|----------------------|-----------------------|
| 1 | 1 | 25% | 26.4 V/V |
| 1 | 0 | 50% | 13.2 V/V |
| 0 | 1 | 75% | 8.8 V/V |
| 0 | 0 | 100% | 6.6 V/V |

7.3.5 Decay Modes

A fixed decay mode is selected by setting the tri-level ADECAY and BDECAY pins as shown in [Table 5](#). Note that if the ATE pin is logic high, the ADECAY and BDECAY pins are ignored and AutoTune is used.

Table 5. Decay Mode Settings

| xDECAY | DECAY MODE |
|--------|-----------------------|
| 0 | Slow decay |
| Z | Fast decay |
| 1 | Mixed decay: 30% fast |

The ADECAY pin sets the decay mode for H-bridge A (AOUT1, AOUT2), and the BDECAY pin sets the decay mode for H-bridge B (BOUT1, BOUT2).

7.3.5.1 Mode 1: Slow Decay

To configure the DRV8881 into this mode, pull DECAY1 and DECAY0 logic low.

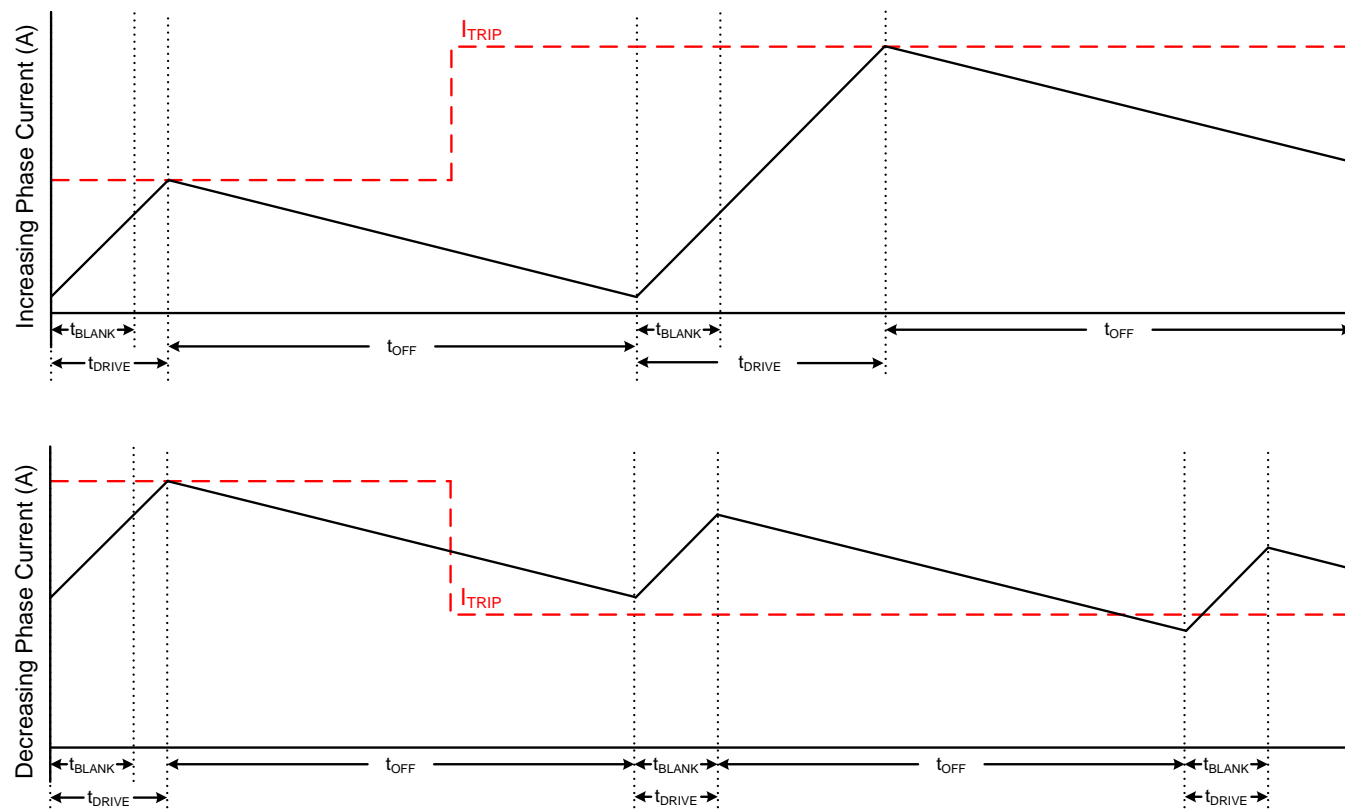


Figure 16. Slow Decay Mode

During slow decay, both of the low-side FETs of the H-bridge are turned on, allowing the current to be recirculated.

Slow decay exhibits the least current ripple of the decay modes for a given t_{OFF} . However, if the current trip level is decreasing, slow decay will take a long time to settle to the new I_{TRIP} level because the current decreases very slowly.

7.3.5.2 Mode 2: Fast Decay

To configure the DRV8881 into this mode, pull DECAY1 and DECAY0 logic high.

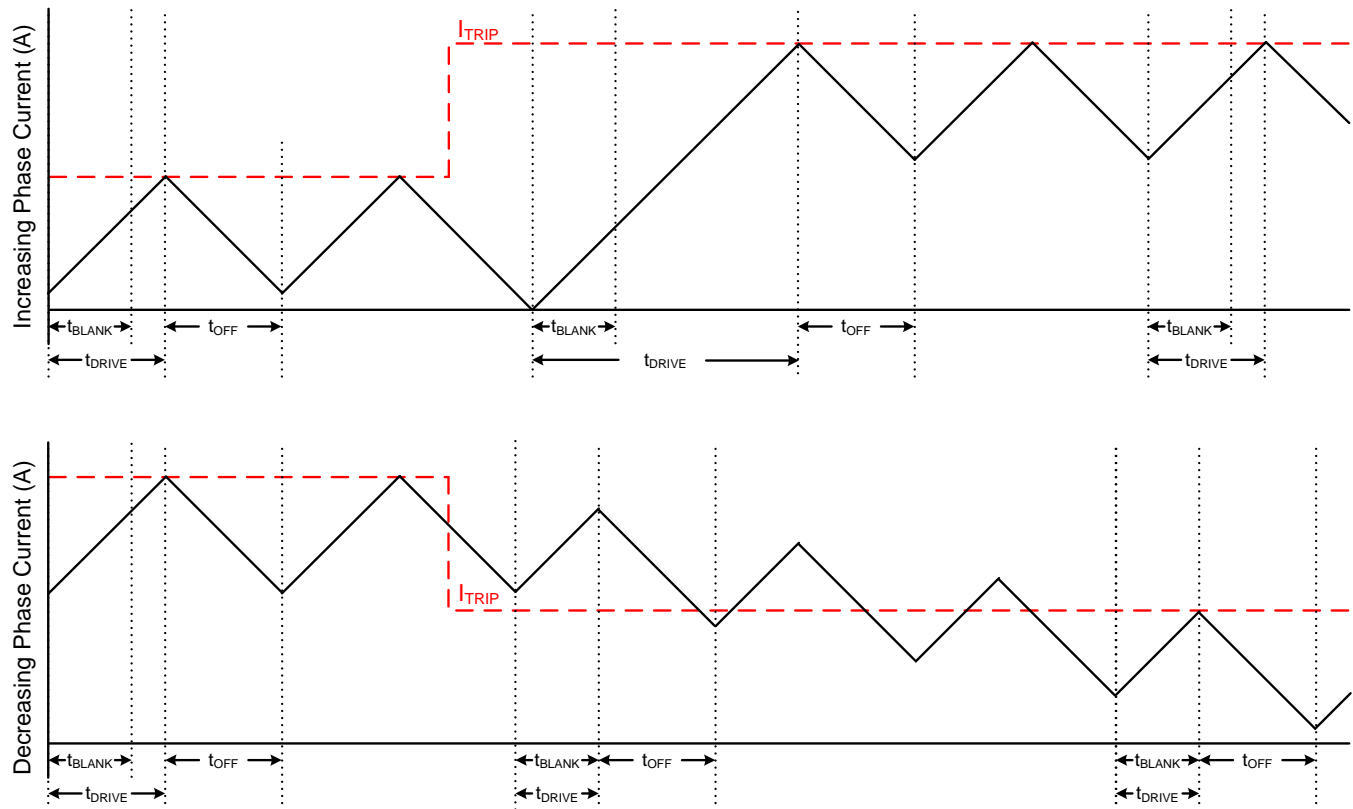


Figure 17. Fast Decay Mode

During fast decay, the polarity of the H-bridge is reversed. The H-bridge will be turned off as current approaches zero in order to prevent current flow in the reverse direction.

Fast decay exhibits the highest current ripple of the decay modes for a given t_{OFF} . Transition time on decreasing current is much faster than slow decay since the current is allowed to decrease much faster.

7.3.5.3 Mode 3: 30%/70% Mixed Decay

To configure the DRV8881 into this mode, pull DECAY1 logic high and pull DECAY0 logic low.

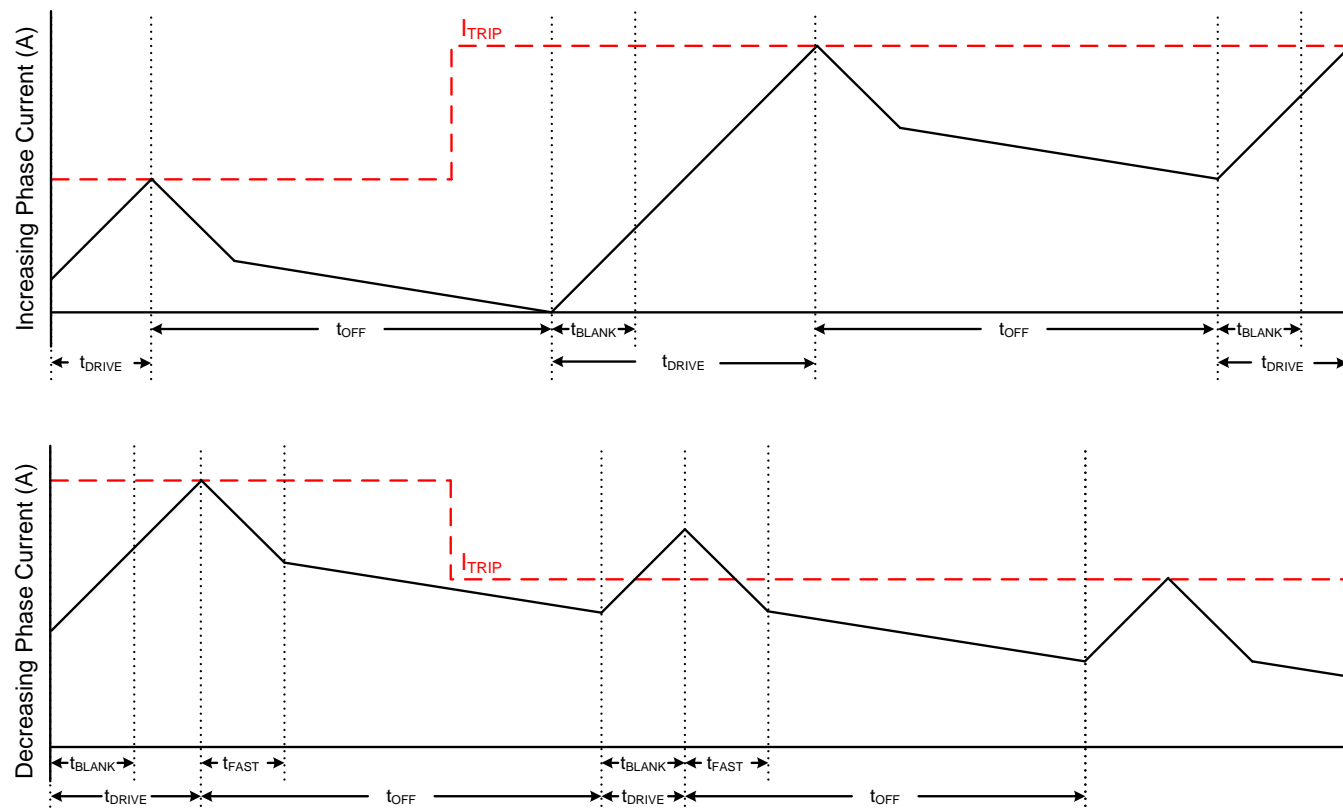


Figure 18. Mixed Decay Mode (30% Fast, 70% Slow)

Mixed decay begins as fast decay for 30% of t_{OFF} , followed by slow decay for the remainder of t_{OFF} . In this mode, mixed decay occurs for both increasing and decreasing current steps.

This mode exhibits ripple larger than slow decay, but smaller than fast decay. Mixed decay will settle to the new I_{TRIP} level faster than slow decay when dealing with decreasing current trip levels.

In cases where current is held for a long time or at very-low stepping speeds, slow decay may not properly regulate current because no back-EMF is present across the motor windings. In this state, motor current can rise very quickly, and requires an excessively large off-time. Increasing/decreasing mixed decay mode allows the current level to stay in regulation when no back-EMF is present across the motor windings.

7.3.6 AutoTune

AutoTune is available on DRV8881E only.

To enable the AutoTune mode, pull the ATE pin logic high. Ensure the xDECAY pins are logic low. The AutoTune mode is registered internally when exiting from sleep mode or the power-up sequence. The ATE pin can be shorted to V3P3 to pull it logic high for this purpose.

AutoTune greatly simplifies the decay mode selection by automatically configuring the decay mode between slow, mixed, and fast decay. In mixed decay, AutoTune dynamically adjusts the fast decay percentage of the total mixed decay time. This feature eliminates motor tuning by automatically determining the best decay setting that results in the lowest ripple for the motor.

The decay mode setting is optimized iteratively each PWM cycle. If the motor current overshoots the target trip level, then the decay mode becomes more aggressive (add fast decay percentage) on the next cycle in order to prevent regulation loss. If there is a long drive time to reach the target trip level, the decay mode becomes less aggressive (remove fast decay percentage) on the next cycle in order to operate with less ripple and more efficiently.

AutoTune will automatically adjust the decay scheme based on operating factors like:

- Motor winding resistance and inductance
- Motor aging effects
- Motor dynamic speed and load
- Motor supply voltage variation
- Motor back-EMF difference on rising and falling steps
- Low-current vs. high-current di/dt

7.3.7 Adaptive Blanking Time

After the current is enabled in an H-bridge, the voltage on the xISEN pin is ignored for a period of time before enabling the current sense circuitry. Note that the blanking time also sets the minimum drive time of the PWM.

The time t_{BLANK} is determined by VREF and the torque DAC setting. The timing information for t_{BLANK} is given in [Table 6](#).

Table 6. Adaptive Blanking Time Settings over Torque DAC and xVREF Input Voltage

| xVREF | TORQUE DAC TRQ[1:0] SETTING | | | |
|-----------------|-----------------------------|--------------|--------------|--------------|
| | 00 - 100% | 01 - 75% | 10 - 50% | 11 - 25% |
| 2.475 → 3.300 V | 1.80 μ s | 1.50 μ s | 1.20 μ s | 0.90 μ s |
| 1.650 → 2.475 V | 1.50 μ s | 1.20 μ s | 0.90 μ s | 0.90 μ s |
| 0.825 → 1.650 V | 1.20 μ s | 0.90 μ s | 0.90 μ s | 0.90 μ s |
| 0.000 → 0.825 V | 0.90 μ s | 0.90 μ s | 0.90 μ s | 0.90 μ s |

7.3.8 Parallel Mode

To enter parallel mode on the DRV8881P, the PARA pin must be logic high during device power-up or when exiting the sleep mode. The PARA pin can be shorted to V3P3 to pull it logic high for this purpose.

In this mode, the AIN1 and AIN2 pins control the state of the outputs and the BIN1 and BIN2 pins are ignored. Similarly, the ADECAY pin controls the decay mode of the output and AVREF is used as the analog reference voltage. The BIN1, BIN2, BDECAY, and BVREF pins can be tied to GND or left Hi-Z.

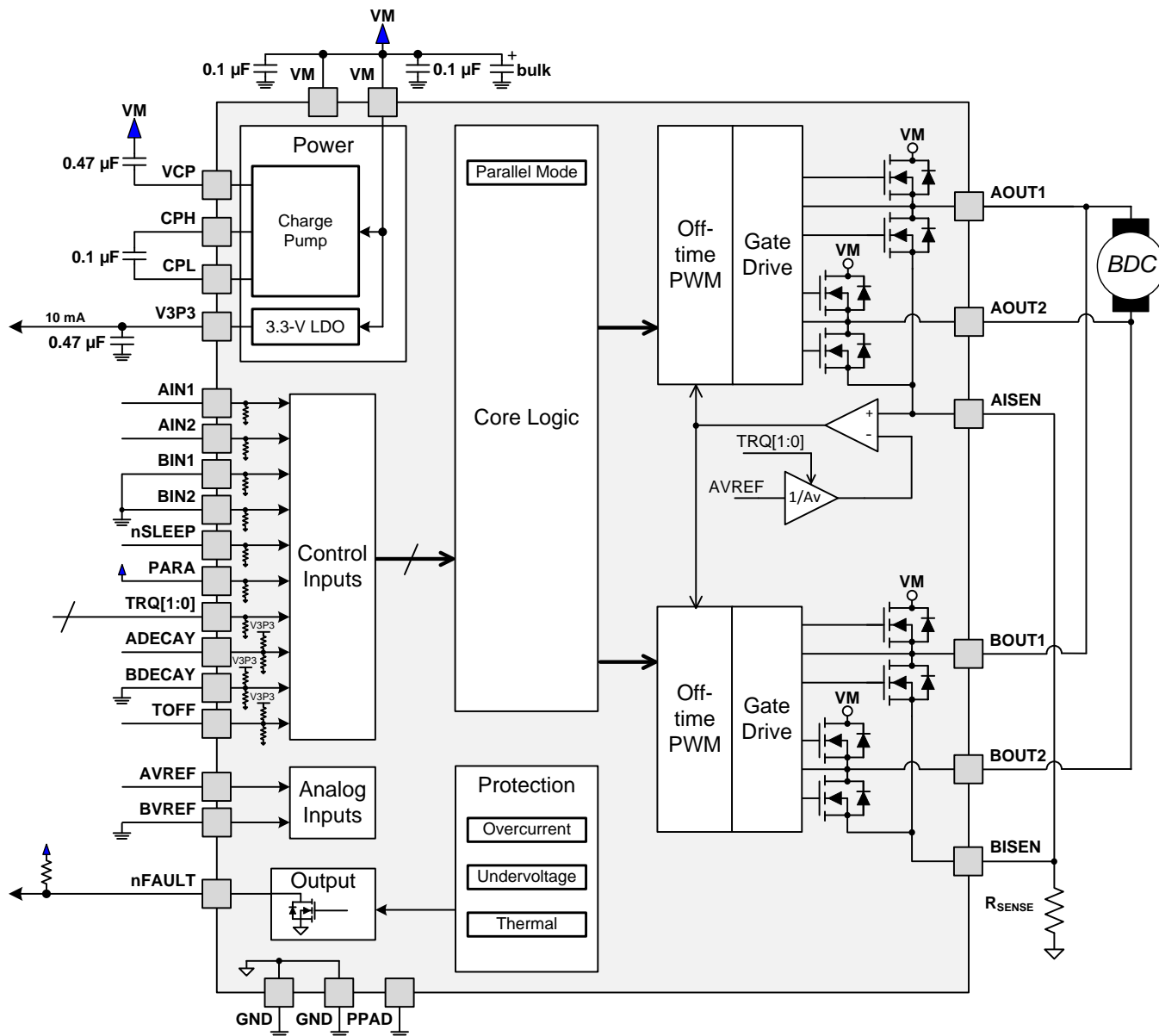


Figure 19. Parallel Mode Diagram

7.3.9 Charge Pump

A charge pump is integrated in order to supply a high-side NMOS gate drive voltage. The charge pump requires a capacitor between the VM and VCP pins. Additionally a low-ESR ceramic capacitor is required between pins CPH and CPL.

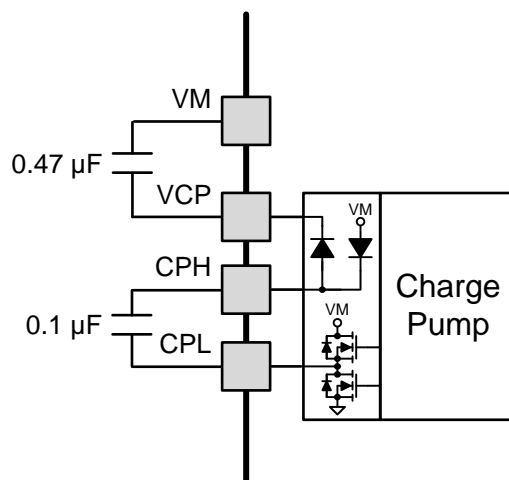


Figure 20. Charge Pump Diagram

7.3.10 LDO Voltage Regulator

An LDO regulator is integrated into the DRV8881. It can be used to provide the supply voltage for a low-power microcontroller or other low-current devices. For proper operation, bypass V3P3 to GND using a ceramic capacitor.

The V3P3 output is nominally 3.3 V. When the V3P3 LDO current load exceeds 10 mA, the LDO will behave like a constant current source. The output voltage will drop significantly with currents greater than 10 mA.

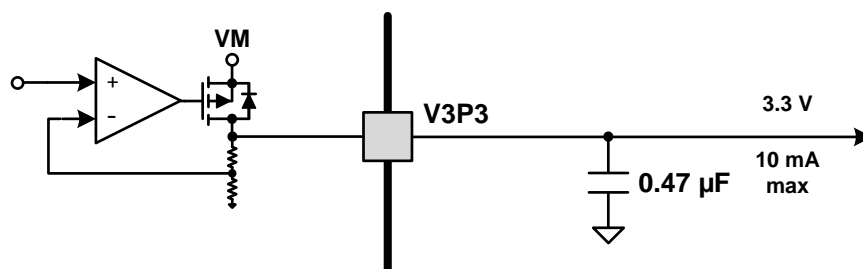


Figure 21. LDO Diagram

If a digital input needs to be tied permanently high (that is, TOFF or ADECAY), it is preferable to tie the input to V3P3 instead of an external regulator. This will save power when VM is not applied or in sleep mode: V3P3 is disabled and current will not be flowing through the input pulldown resistors. For reference, logic level inputs have a typical pulldown of 100 kΩ, and tri-level inputs have a typical pulldown of 40 kΩ.

7.3.11 Logic and Tri-Level Pin Diagrams

Figure 22 gives the input structure for logic-level pins APH/AIN1, AEN/AIN2, BPH/BIN1, BEN/BIN2, nSLEEP, ATE/PARA, TRQ0, TRQ1:

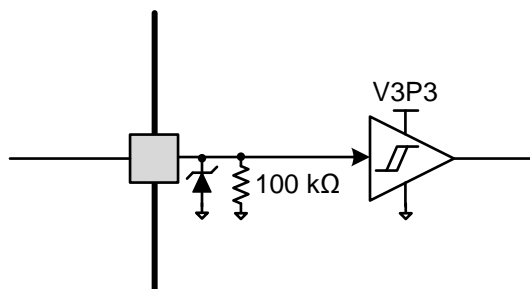


Figure 22. Logic-level Input Pin Diagram

Tri-level logic pins TOFF, ADECAY, and BDECAY have the following structure as shown in Figure 23.

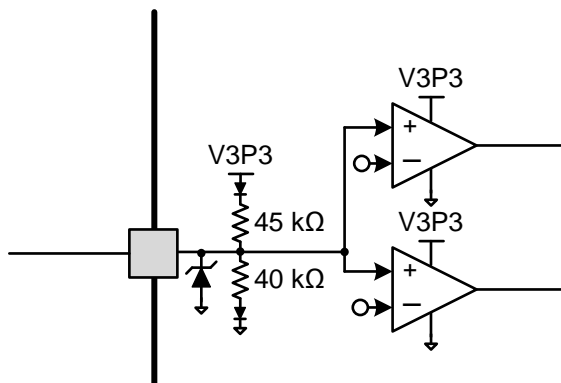


Figure 23. Tri-Level Input Pin Diagram

7.3.12 Protection Circuits

The DRV8881 is fully protected against VM undervoltage, charge pump undervoltage, overcurrent, and overtemperature events.

7.3.12.1 VM Undervoltage Lockout (UVLO)

If at any time the voltage on the VM pin falls below the undervoltage lockout threshold voltage, all FETs in the H-bridge will be disabled, the charge pump will be disabled, and the nFAULT pin will be driven low. Operation will resume when VM rises above the UVLO threshold. The nFAULT pin will be released after operation has resumed.

7.3.12.2 VCP UVLO (CPUV)

If at any time the voltage on the VCP pin falls below the undervoltage lockout threshold voltage, all FETs in the H-bridge will be disabled and the nFAULT pin will be driven low. Operation will resume when VCP rises above the CPUV threshold. The nFAULT pin will be released after operation has resumed.

7.3.12.3 Overcurrent Protection (OCP)

An analog current limit circuit on each FET limits the current through the FET by removing the gate drive. If this analog current limit persists for longer than t_{OCP} , all FETs in the H-bridge will be disabled and nFAULT will be driven low. In addition to this FET current limit, an overcurrent condition is also detected if the voltage at xISEN exceeds V_{OCP} .

For the DRV8881E (PH/EN), both H-bridges are shut down when either bridge encounters an overcurrent fault. For the DRV8881P (PWM), only the H-bridge driver experiencing the overcurrent fault is shut down, and the other bridge will remain active.

The driver will be re-enabled after the OCP retry period (t_{RETRY}) has passed. nFAULT becomes high again after the retry time. If the fault condition is still present, the cycle repeats. If the fault is no longer present, normal operation resumes and nFAULT remains deasserted.

7.3.12.4 Thermal Shutdown (TSD)

If the die temperature exceeds safe limits, all FETs in the H-bridge will be disabled and the nFAULT pin will be driven low. After the die temperature has fallen to a safe level, operation will automatically resume. The nFAULT pin will be released after operation has resumed.

Table 7. Fault Condition Summary

| FAULT | CONDITION | ERROR REPORT | H-BRIDGE | CHARGE PUMP | V3P3 | RECOVERY |
|-------------------------|--|--------------|----------|-------------|-----------|--|
| VM undervoltage (UVLO) | $VM < V_{UVLO}$ (max 6.4 V) | nFAULT | Disabled | Disabled | Operating | $VM > V_{UVLO}$ (max 6.5 V) |
| VCP undervoltage (CPUV) | $VCP < V_{CPUV}$ (typ VM + 1.8 V) | nFAULT | Disabled | Operating | Operating | $VCP > V_{CPUV}$ (typ VM + 1.9 V) |
| Thermal shutdown (TSD) | $T_J > T_{TSD}$ (min 150°C) | nFAULT | Disabled | Operating | Operating | $T_J < T_{TSD} - T_{HYS}$ (T_{HYS} typ 35°C) |
| Overcurrent (OCP) | $I_{OUT} > I_{OCP}$ (min 2.5 A) $V_{xISEN} > V_{OCP}$ (min 0.9 V) | nFAULT | Disabled | Operating | Operating | t_{RETRY} |

7.4 Device Functional Modes

The DRV8881 is active unless the nSLEEP pin is brought logic low. In sleep mode the charge pump is disabled, the H-bridge FETs are disabled Hi-Z, and the V3P3 regulator is disabled. Note that t_{SLEEP} must elapse after a falling edge on the nSLEEP pin before the device is in sleep mode. The DRV8881 is brought out of sleep mode automatically if nSLEEP is brought logic high. Note that t_{WAKE} must elapse before the outputs change state after wake-up.

Table 8. Functional Modes Summary

| FAULT | CONDITION | H-BRIDGE | CHARGE PUMP | V3P3 |
|-------------------|--|-----------|-------------|-----------|
| Operating | $6.5\text{ V} < \text{VM} < 45\text{ V}$ nSLEEP pin = 1 | Operating | Operating | Operating |
| Sleep mode | $6.5\text{ V} < \text{VM} < 45\text{ V}$ nSLEEP pin = 0 | Disabled | Disabled | Disabled |
| Fault encountered | VM undervoltage (UVLO) | Disabled | Disabled | Operating |
| | VCP undervoltage (CPUV) | Disabled | Operating | Operating |
| | Overcurrent (OCP) | Disabled | Operating | Operating |
| | Thermal shutdown (TSD) | Disabled | Operating | Operating |

8 Application and Implementation

NOTE

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

8.1 Application Information

The DRV8881 is used in stepper or brushed motor control.

8.2 Typical Applications

8.2.1 DRV8881P Typical Application

The following design procedure can be used to configure the DRV8881. In this application, the DRV8881P will be used to drive a stepper motor.

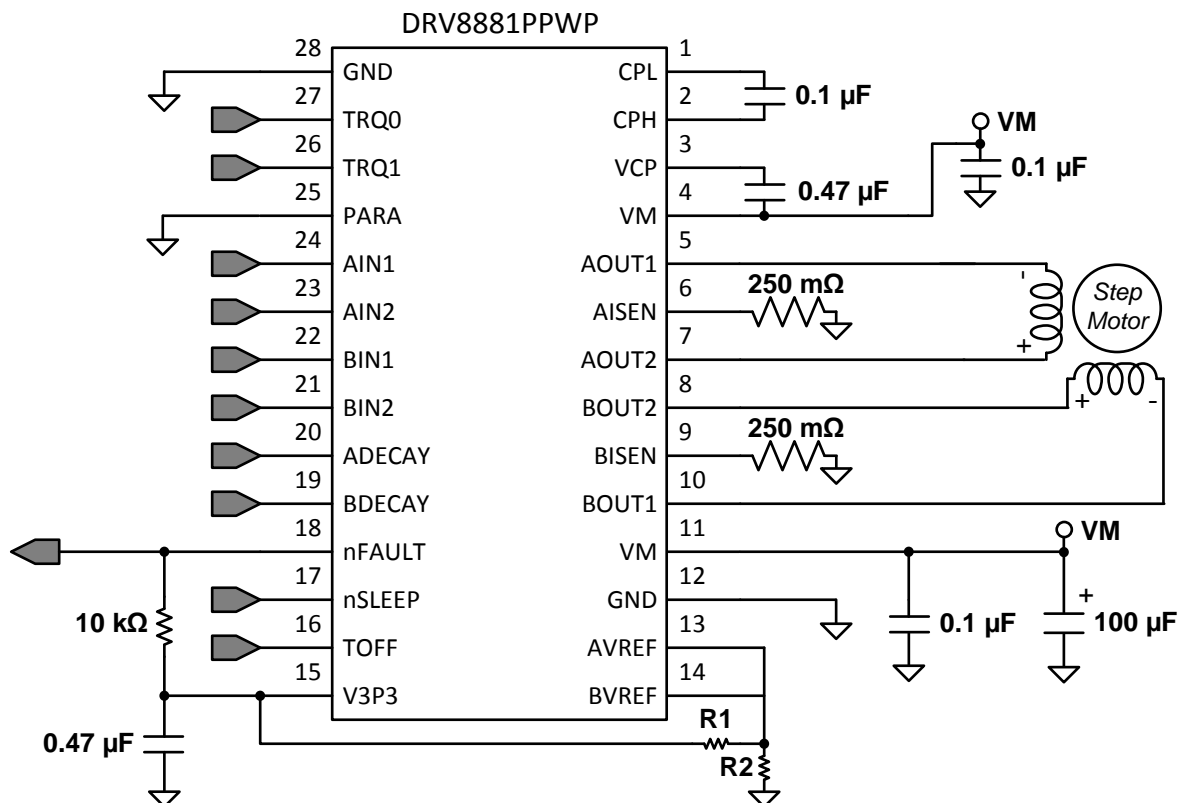


Figure 24. Typical Application Schematic

Typical Applications (continued)

8.2.1.1 Design Requirements

Table 9 gives design input parameters for system design.

Table 9. Design Parameters

| DESIGN PARAMETER | REFERENCE | EXAMPLE VALUE |
|----------------------------|-------------------|-----------------------|
| Supply voltage | VM | 24 V |
| Motor winding resistance | R _L | 4.5 Ω/phase |
| Motor winding inductance | L _L | 10.5 mH/phase |
| Motor full step angle | θ _{step} | 1.8°/step |
| Target microstepping level | n _m | Non-circular 1/2 step |
| Target motor speed | v | 120 rpm |
| Target full-scale current | I _{FS} | 800 mA |

8.2.1.2 Detailed Design Procedure

8.2.1.2.1 Current Regulation

In a stepper motor, the full-scale current (I_{FS}) is the maximum current driven through either winding. This quantity will depend on the TRQ pins, the xVREF analog voltage, and the sense resistor value (R_{SENSE}). AVREF and BVREF can be configured to drive different currents, but in this example the same full-scale current is used in both coils.

$$I_{FS} (A) = \frac{xVREF (V) \times TRQ (\%)}{A_v \times R_{SENSE} (\Omega)} = \frac{xVREF (V) \times TRQ (\%)}{6.6 \times R_{SENSE} (\Omega)} \quad (2)$$

TRQ is a DAC used to scale the output current. The current scalar value for different inputs is shown in Table 10.

Table 10. Torque DAC Settings

| TRQ1 | TRQ0 | CURRENT SCALAR (TRQ) |
|------|------|----------------------|
| 1 | 1 | 25% |
| 1 | 0 | 50% |
| 0 | 1 | 75% |
| 0 | 0 | 100% |

Example: If the desired full-scale current is 800 mA

Set R_{SENSE} = 250 mΩ, assume TRQ = 100%.

xVREF would have to be 1.32 V.

Create a resistor divider from V3P3 (3.3 V) to set AVREF and BVREF ≈ 1.32 V.

Set R2 = 10 kΩ, set R1 = 15 kΩ

Note that I_{FS} must also follow Equation 3 in order to avoid saturating the motor. VM is the motor supply voltage, and R_L is the motor winding resistance.

$$I_{FS} (A) < \frac{VM (V)}{R_L (\Omega) + 2 \times R_{DS(ON)} (\Omega) + R_{SENSE} (\Omega)} \quad (3)$$

8.2.1.2.2 Stepper Motor Speed

Next, the driving waveform needs to be planned. In order to command the correct speed, determine the frequency of the input waveform.

If the target motor speed is too high, the motor will not spin. Make sure that the motor can support the target speed.

For a desired motor speed (v), microstepping level (n_m), and motor full step angle (θ_{step}),

$$f_{\text{step}} \text{ (steps / s)} = \frac{v \text{ (rpm)} \times 360 \text{ (}^\circ \text{ / rot)}}{\theta_{\text{step}} \text{ (}^\circ \text{ / step)} \times n_m \text{ (steps / microstep)} \times 60 \text{ (s / min)}} \quad (4)$$

θ_{step} can be found in the stepper motor data sheet or written on the motor itself.

The frequency f_{step} gives the frequency of input change on the DRV8881P. $1/f_{\text{step}} = t_{\text{STEP}}$ on the diagram below.

$$f_{\text{step}} \text{ (steps / s)} = \frac{120 \text{ rpm} \times 360^\circ \text{ / rot}}{1.8^\circ \text{ / step} \times 1/2 \text{ steps / microstep} \times 60 \text{ s / min}} = 800\text{Hz} \quad (5)$$

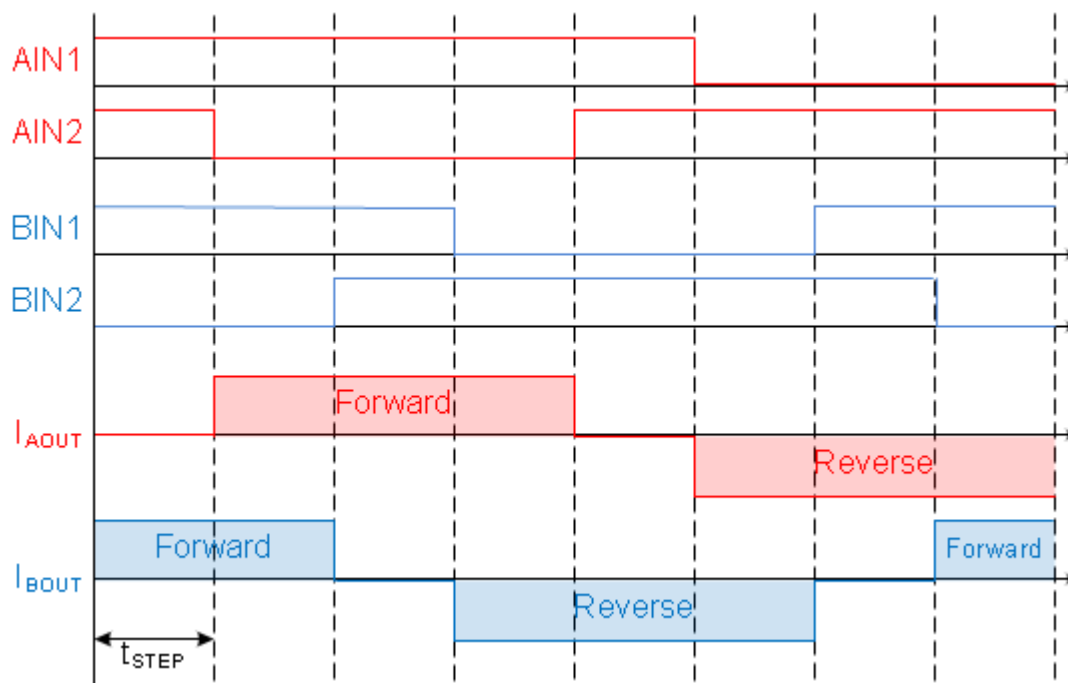


Figure 25. Example 1/2 Stepping Operation

8.2.1.2.3 Decay Modes

The DRV8881 supports several different decay modes: slow decay, fast decay, mixed decay, and AutoTune (DRV8881E only). The current through the motor windings is regulated using an adjustable fixed-time-off scheme. This means that after any drive phase, when a motor winding current has hit the current chopping threshold (I_{TRIP}), the DRV8881 will place the winding in one of the decay modes for TOFF. After TOFF, a new drive phase starts.

8.2.1.2.4 Sense Resistor

For optimal performance, it is important for the sense resistor to be:

- Surface-mount
- Low inductance
- Rated for high enough power
- Placed closely to the motor driver

The power dissipated by the sense resistor equals $I_{\text{rms}}^2 \times R$. For example, if the rms motor current is 1.4 A and a 250 mΩ sense resistor is used, the resistor will dissipate $1.4 \text{ A}^2 \times 0.25 \Omega = 0.49 \text{ W}$. The power quickly increases with higher current levels.

Resistors typically have a rated power within some ambient temperature range, along with a derated power curve for high ambient temperatures. When a PCB is shared with other components generating heat, margin should be added. It is always best to measure the actual sense resistor temperature in a final system, along with the power MOSFETs, as those are often the hottest components.

Because power resistors are larger and more expensive than standard resistors, it is common practice to use multiple standard resistors in parallel, between the sense node and ground. This distributes the current and heat dissipation.

8.2.1.3 Application Curve

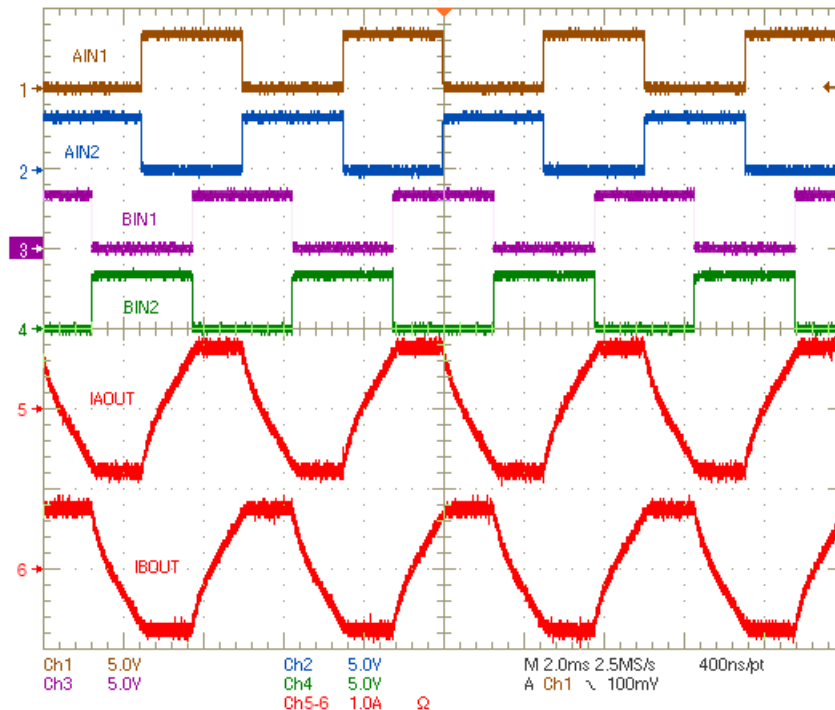


Figure 26. DRV8881P Inputs and Output Current Waveform

8.2.2 Alternate Application

In this application, the DRV8881P will be operated in parallel mode in order to drive a single brushed-DC motor.

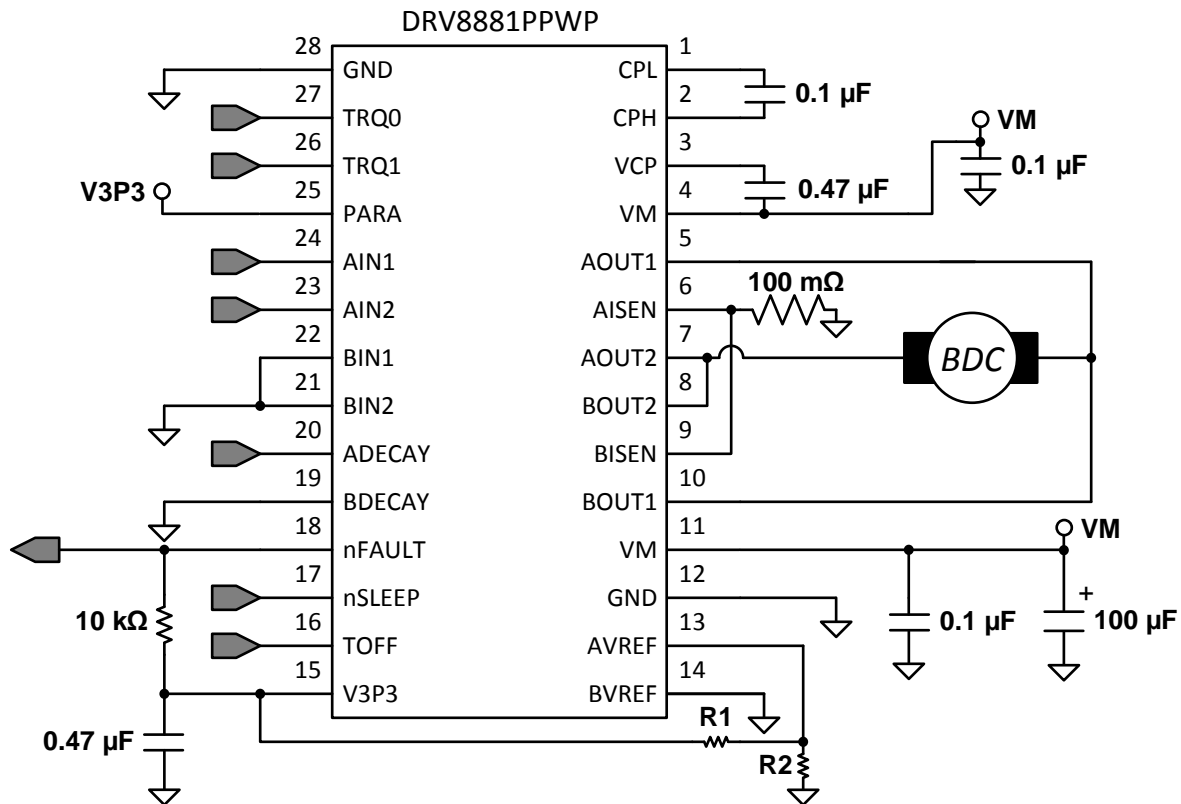


Figure 27. Typical Application Schematic

8.2.2.1 Design Requirements

Table 11 gives design input parameters for system design.

Table 11. Design Parameters

| DESIGN PARAMETER | REFERENCE | EXAMPLE VALUE |
|------------------------------|------------|---------------|
| Supply voltage | VM | 24 V |
| Motor winding resistance | R_L | 6 Ω |
| Motor winding inductance | L_L | 4.1 mH |
| Target maximum motor current | I_{TRIP} | 2 A |

8.2.2.2 Detailed Design Procedure

8.2.2.2.1 Current Regulation

The maximum current (I_{TRIP}) is set by the TRQ pins, the xVREF analog voltage, and the sense resistor value (R_{SENSE}). In parallel mode the winding current is set by AVREF only and BVREF is ignored. When starting a brushed-DC motor, a large inrush current may occur because there is no back-EMF. Current regulation will act to limit this inrush current and prevent high current on startup.

Example: If the desired regulation current is 2 A

Set $R_{SENSE} = 100 \text{ m}\Omega$, assume TRQ = 100%.

AVREF would have to be 1.32 V.

Create a resistor divider from V3P3 (3.3 V) to set AVREF $\approx 1.32 \text{ V}$: Set $R_2 = 10 \text{ k}\Omega$, set $R_1 = 15 \text{ k}\Omega$

8.2.2.3 Application Curves

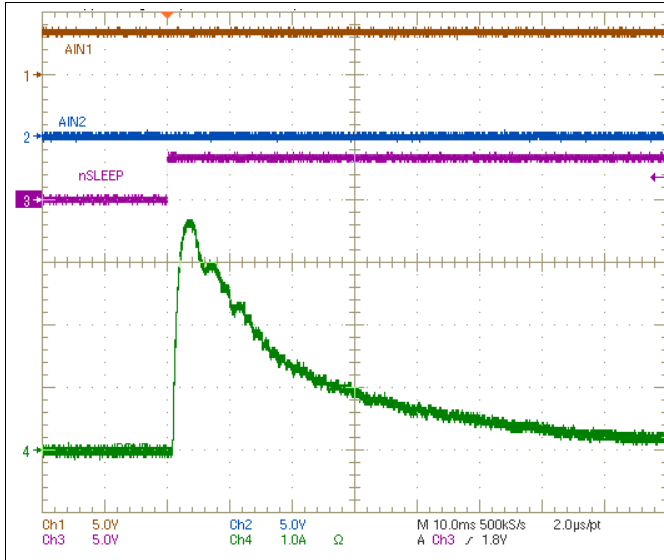


Figure 28. DRV8881P Startup Current Waveform Without Current Regulation

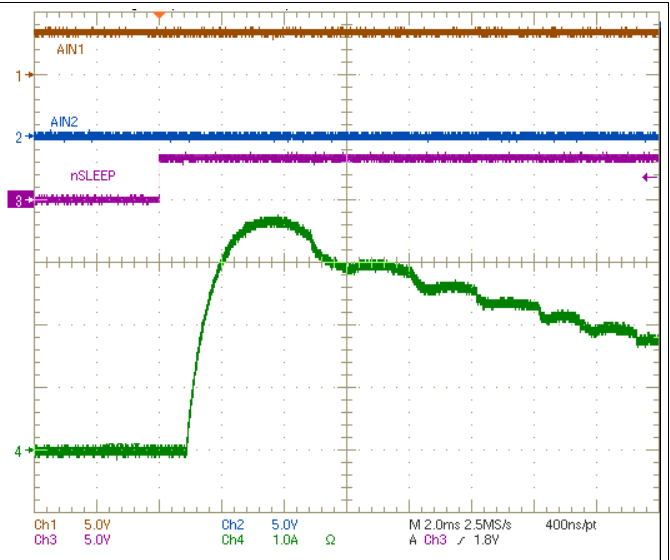


Figure 29. DRV8881P Startup Current Waveform Without Current Regulation (Zoomed In)

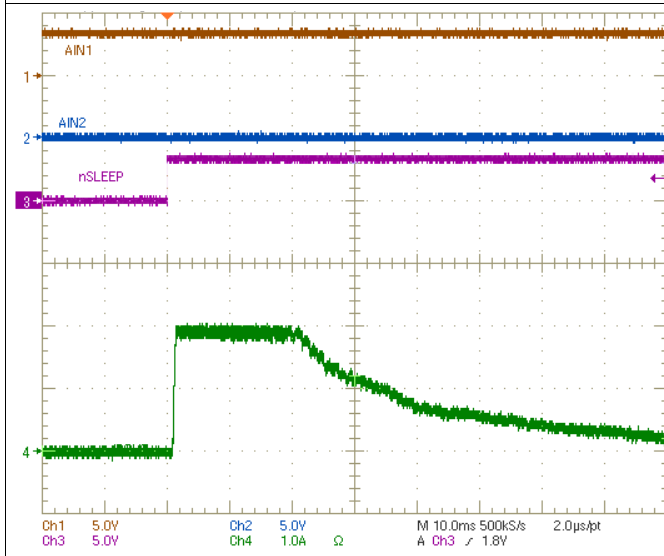


Figure 30. DRV8881P Startup Current Waveform With 2-A Current Regulation

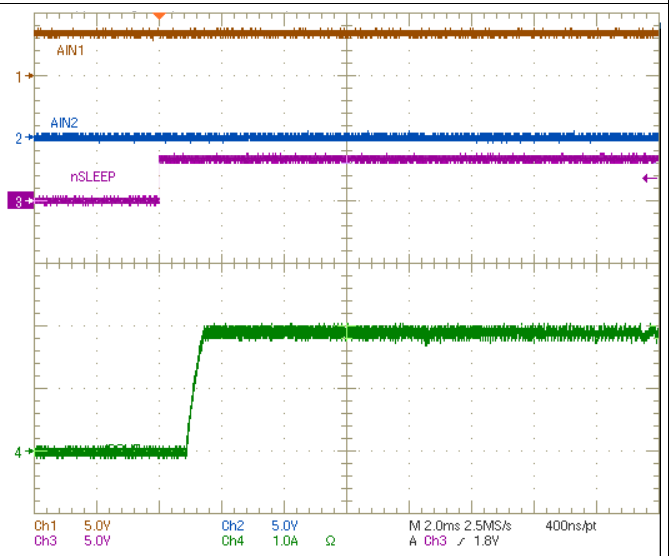


Figure 31. DRV8881P Startup Current Waveform With 2-A Current Regulation (Zoomed In)

9 Power Supply Recommendations

The DRV8881 is designed to operate from an input voltage supply (VM) range between 6.5 V and 45 V. The device has an absolute maximum rating of 50 V. A 0.1 μF ceramic capacitor rated for VM must be placed at each VM pin as close to the DRV8881 as possible. In addition, a bulk capacitor must be included on VM.

9.1 Bulk Capacitance Sizing

Having appropriate local bulk capacitance is an important factor in motor drive system design. It is generally beneficial to have more bulk capacitance, while the disadvantages are increased cost and physical size.

The amount of local capacitance needed depends on a variety of factors, including:

- The highest current required by the motor system
- The power supply's capacitance and ability to source current
- The amount of parasitic inductance between the power supply and motor system
- The acceptable voltage ripple
- The type of motor used (brushed DC, brushless DC, stepper)
- The motor braking method

The inductance between the power supply and motor drive system will limit the rate current can change from the power supply. If the local bulk capacitance is too small, the system will respond to excessive current demands or dumps from the motor with a change in voltage. When adequate bulk capacitance is used, the motor voltage remains stable and high current can be quickly supplied.

The data sheet generally provides a recommended value, but system-level testing is required to determine the appropriate sized bulk capacitor.

The voltage rating for bulk capacitors should be higher than the operating voltage, to provide margin for cases when the motor transfers energy to the supply.

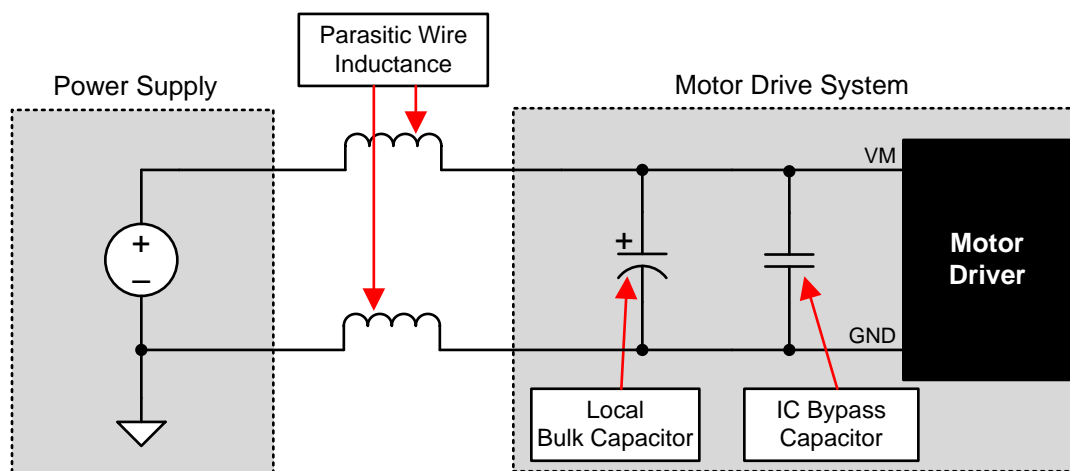


Figure 32. Setup of Motor Drive System With External Power Supply

10 Layout

10.1 Layout Guidelines

Each VM terminal must be bypassed to GND using a low-ESR ceramic bypass capacitors with recommended values of 0.1 μF rated for VM. These capacitors should be placed as close to the VM pins as possible with a thick trace or ground plane connection to the device GND pin.

The VM pin must be bypassed to ground using a bulk capacitor rated for VM. This component may be an electrolytic.

A low-ESR ceramic capacitor must be placed in between the CPL and CPH pins. A value of 0.1 μF rated for VM is recommended. Place this component as close to the pins as possible.

A low-ESR ceramic capacitor must be placed in between the VM and VCP pins. A value of 0.47 μF rated for 16 V is recommended. Place this component as close to the pins as possible.

Bypass V3P3 to ground with a ceramic capacitor rated 6.3 V. Place this bypassing capacitor as close to the pin as possible.

The current sense resistors should be placed as close as possible to the device pins in order to minimize trace inductance between the pin and resistor.

10.2 Layout Example

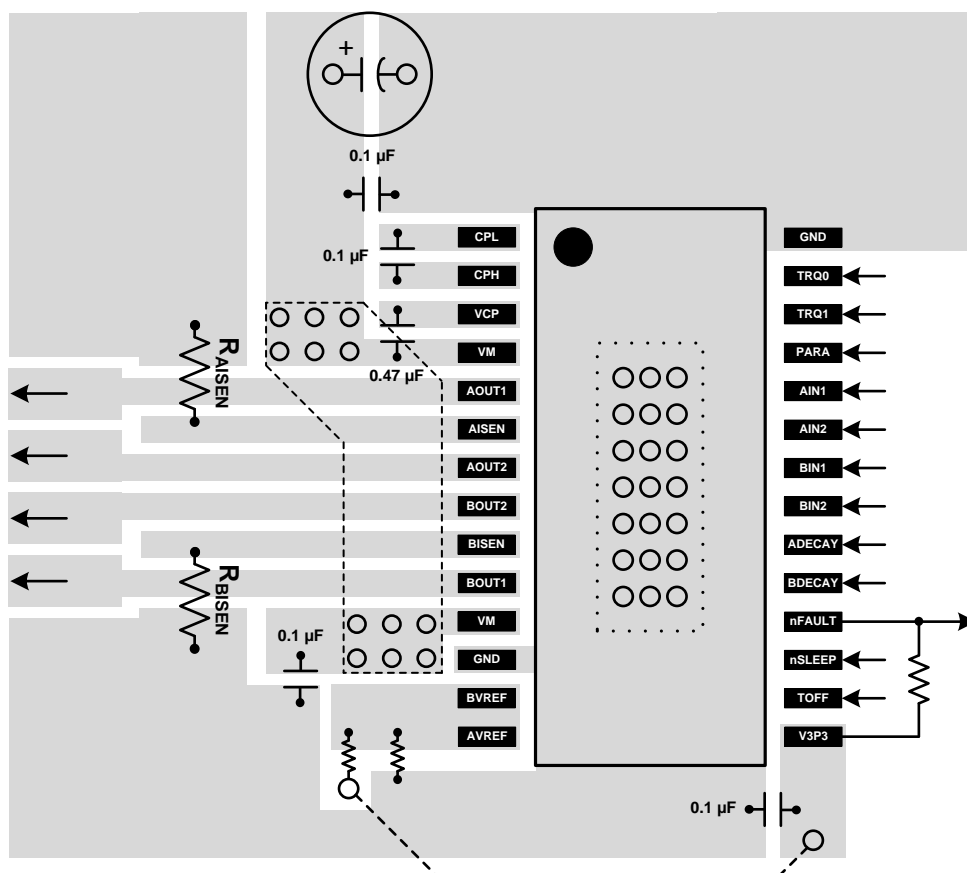


Figure 33. Layout Recommendation

11 器件和文档支持

11.1 文档支持

11.1.1 相关文档

- 《PowerPAD™ 耐热增强型封装》， [SLMA002](#)
- 《PowerPAD™ 速成》， [SLMA004](#)
- 《电流再循环和衰减模式》， [SLVA321](#)
- 《计算电机驱动器的功耗》， [SLVA504](#)
- 《了解电机驱动器的额定电流》， [SLVA505](#)
- 《采用 DRV88xx 系列的高分辨率微步进驱动器》， [SLVA416](#)

11.2 社区资源

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11.5 Glossary

[SLYZ022](#) — *TI Glossary*.

This glossary lists and explains terms, acronyms, and definitions.

12 机械、封装和可订购信息

以下页中包括机械、封装和可订购信息。 这些信息是针对指定器件可提供的最新数据。 这些数据会在无通知且不对本文档进行修订的情况下发生改变。 欲获得该数据表的浏览器版本，请查阅左侧的导航栏。

PACKAGING INFORMATION

| Orderable part number | Status (1) | Material type (2) | Package Pins | Package qty Carrier | RoHS (3) | Lead finish/ Ball material (4) | MSL rating/ Peak reflow (5) | Op temp (°C) | Part marking (6) |
|------------------------------|---------------|----------------------|-------------------|-----------------------|-------------|--------------------------------------|-----------------------------------|--------------|---------------------|
| DRV8881EPWP | Obsolete | Production | HTSSOP (PWP) 28 | - | - | Call TI | Call TI | -40 to 125 | DRV8881E |
| DRV8881EPWPR | Active | Production | HTSSOP (PWP) 28 | 2000 LARGE T&R | Yes | NIPDAU | Level-3-260C-168 HR | -40 to 125 | DRV8881E |
| DRV8881EPWPR.A | Active | Production | HTSSOP (PWP) 28 | 2000 LARGE T&R | Yes | NIPDAU | Level-3-260C-168 HR | -40 to 125 | DRV8881E |
| DRV8881EPWPR.B | Active | Production | HTSSOP (PWP) 28 | 2000 LARGE T&R | Yes | NIPDAU | Level-3-260C-168 HR | -40 to 125 | DRV8881E |
| DRV8881EPWPRG4 | Active | Production | HTSSOP (PWP) 28 | 2000 LARGE T&R | Yes | NIPDAU | Level-3-260C-168 HR | -40 to 125 | DRV8881E |
| DRV8881EPWPRG4.A | Active | Production | HTSSOP (PWP) 28 | 2000 LARGE T&R | Yes | NIPDAU | Level-3-260C-168 HR | -40 to 125 | DRV8881E |
| DRV8881EPWPRG4.B | Active | Production | HTSSOP (PWP) 28 | 2000 LARGE T&R | Yes | NIPDAU | Level-3-260C-168 HR | -40 to 125 | DRV8881E |
| DRV8881ERHRR | Active | Production | WQFN (RHR) 28 | 3000 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | DRV8881E |
| DRV8881ERHRR.A | Active | Production | WQFN (RHR) 28 | 3000 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | DRV8881E |
| DRV8881ERHRR.B | Active | Production | WQFN (RHR) 28 | 3000 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | DRV8881E |
| DRV8881ERHRT | Obsolete | Production | WQFN (RHR) 28 | - | - | Call TI | Call TI | -40 to 125 | DRV8881E |
| DRV8881PPWP | Obsolete | Production | HTSSOP (PWP) 28 | - | - | Call TI | Call TI | -40 to 125 | DRV8881P |
| DRV8881PPWPR | Active | Production | HTSSOP (PWP) 28 | 2000 LARGE T&R | Yes | NIPDAU | Level-3-260C-168 HR | -40 to 125 | DRV8881P |
| DRV8881PPWPR.A | Active | Production | HTSSOP (PWP) 28 | 2000 LARGE T&R | Yes | NIPDAU | Level-3-260C-168 HR | -40 to 125 | DRV8881P |
| DRV8881PPWPR.B | Active | Production | HTSSOP (PWP) 28 | 2000 LARGE T&R | Yes | NIPDAU | Level-3-260C-168 HR | -40 to 125 | DRV8881P |
| DRV8881PRHRR | Active | Production | WQFN (RHR) 28 | 3000 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | DRV8881P |
| DRV8881PRHRR.A | Active | Production | WQFN (RHR) 28 | 3000 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | DRV8881P |
| DRV8881PRHRR.B | Active | Production | WQFN (RHR) 28 | 3000 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | DRV8881P |
| DRV8881PRHRT | Obsolete | Production | WQFN (RHR) 28 | - | - | Call TI | Call TI | -40 to 125 | DRV8881P |

⁽¹⁾ **Status:** For more details on status, see our [product life cycle](#).

⁽²⁾ **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

⁽³⁾ **RoHS values:** Yes, No, RoHS Exempt. See the [TI RoHS Statement](#) for additional information and value definition.

⁽⁴⁾ **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

⁽⁵⁾ **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

⁽⁶⁾ **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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TAPE AND REEL INFORMATION



*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|----------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| DRV8881EPWPR | HTSSOP | PWP | 28 | 2000 | 330.0 | 16.4 | 6.9 | 10.2 | 1.8 | 12.0 | 16.0 | Q1 |
| DRV8881EPWPRG4 | HTSSOP | PWP | 28 | 2000 | 330.0 | 16.4 | 6.9 | 10.2 | 1.8 | 12.0 | 16.0 | Q1 |
| DRV8881ERHRR | WQFN | RHR | 28 | 3000 | 330.0 | 12.4 | 3.8 | 5.8 | 1.2 | 8.0 | 12.0 | Q1 |
| DRV8881PPWPR | HTSSOP | PWP | 28 | 2000 | 330.0 | 16.4 | 6.9 | 10.2 | 1.8 | 12.0 | 16.0 | Q1 |
| DRV8881PRHRR | WQFN | RHR | 28 | 3000 | 330.0 | 12.4 | 3.8 | 5.8 | 1.2 | 8.0 | 12.0 | Q1 |

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|----------------|--------------|-----------------|------|------|-------------|------------|-------------|
| DRV8881EPWPR | HTSSOP | PWP | 28 | 2000 | 350.0 | 350.0 | 43.0 |
| DRV8881EPWPRG4 | HTSSOP | PWP | 28 | 2000 | 350.0 | 350.0 | 43.0 |
| DRV8881ERHRR | WQFN | RHR | 28 | 3000 | 346.0 | 346.0 | 33.0 |
| DRV8881PPWPR | HTSSOP | PWP | 28 | 2000 | 350.0 | 350.0 | 43.0 |
| DRV8881PRHRR | WQFN | RHR | 28 | 3000 | 346.0 | 346.0 | 33.0 |

GENERIC PACKAGE VIEW

PWP 28

PowerPAD™ TSSOP - 1.2 mm max height

4.4 x 9.7, 0.65 mm pitch

SMALL OUTLINE PACKAGE

This image is a representation of the package family, actual package may vary.
Refer to the product data sheet for package details.



4224765/B



PowerPAD is a trademark of Texas Instruments.

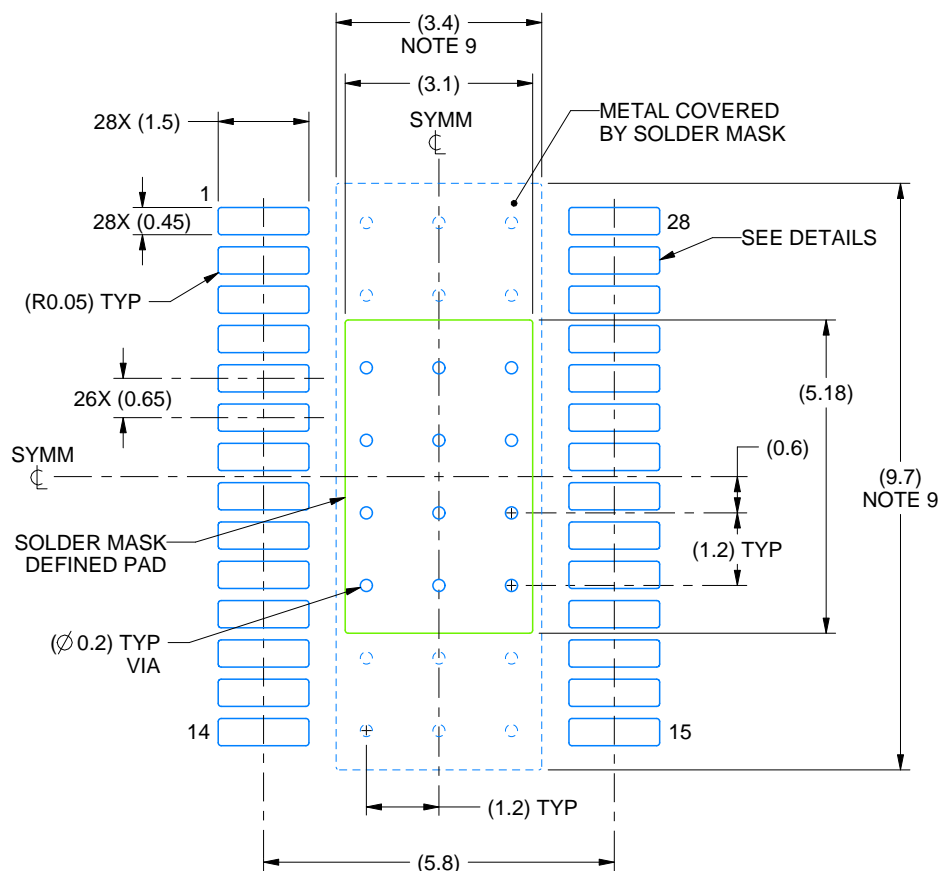
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
4. Reference JEDEC registration MO-153.
5. Features may differ or may not be present.

EXAMPLE BOARD LAYOUT

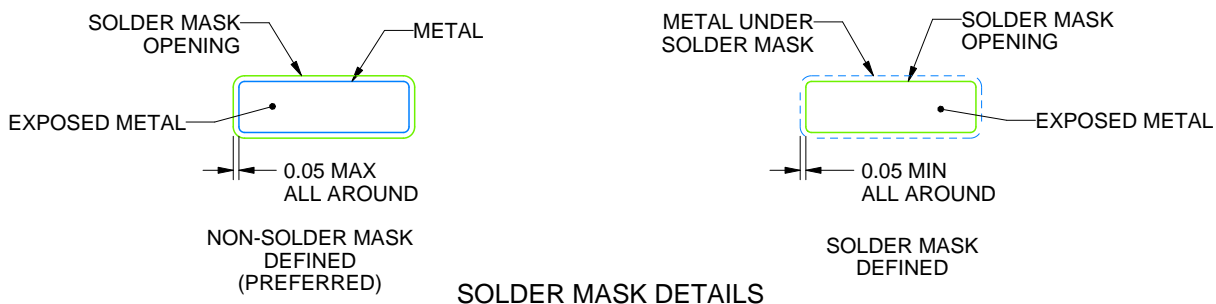
PWP0028C

PowerPAD™ TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 8X



4223582/A 03/2017

NOTES: (continued)

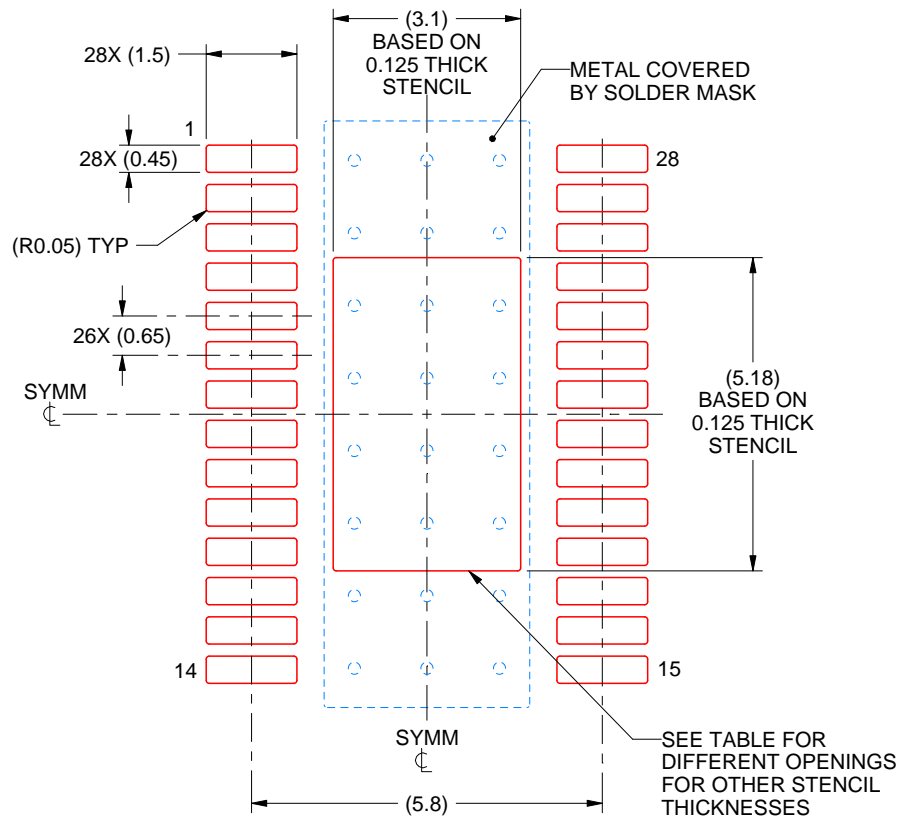
- Publication IPC-7351 may have alternate designs.
- Solder mask tolerances between and around signal pads can vary based on board fabrication site.
- This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature numbers SLMA002 (www.ti.com/lit/slma002) and SLMA004 (www.ti.com/lit/slma004).
- Size of metal pad may vary due to creepage requirement.
- Vias are optional depending on application, refer to device data sheet. It is recommended that vias under paste be filled, plugged or tented.

EXAMPLE STENCIL DESIGN

PWP0028C

PowerPAD™ TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



SOLDER PASTE EXAMPLE
 BASED ON 0.125 mm THICK STENCIL
 SCALE: 8X

| STENCIL THICKNESS | SOLDER STENCIL OPENING |
|-------------------|------------------------|
| 0.1 | 3.47 X 5.79 |
| 0.125 | 3.10 X 5.18 (SHOWN) |
| 0.15 | 2.83 X 4.73 |
| 0.175 | 2.62 X 4.38 |

4223582/A 03/2017

NOTES: (continued)

11. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
12. Board assembly site may have different recommendations for stencil design.

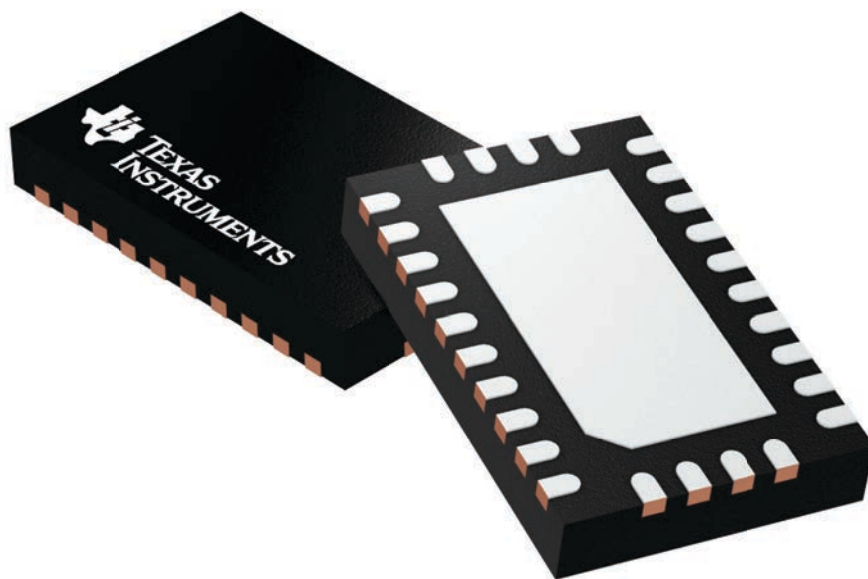
GENERIC PACKAGE VIEW

RHR 28

WQFN - 0.8 mm max height

3.5 x 5.5, 0.5 mm pitch

PLASTIC QUAD FLATPACK - NO LEAD



Images above are just a representation of the package family, actual package may vary.
Refer to the product data sheet for package details.

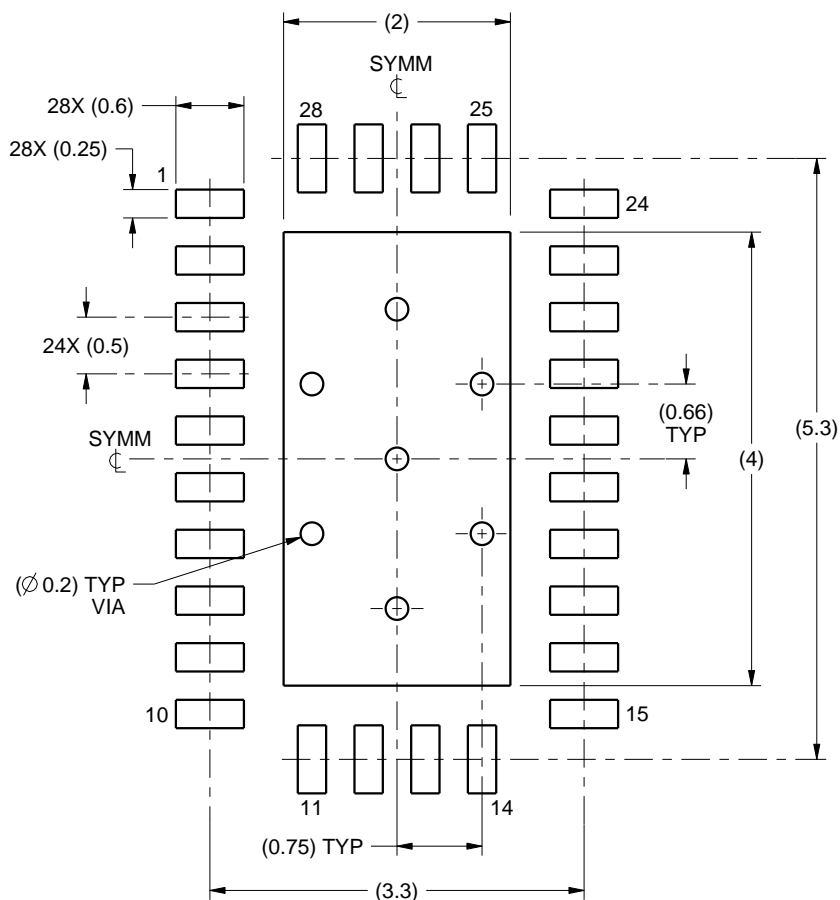
4210249/B

EXAMPLE BOARD LAYOUT

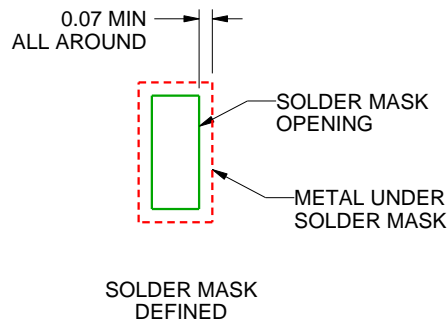
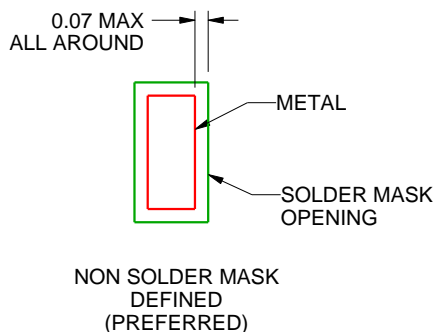
RHR0028A

WQFN - 0.8 mm max height

PLASTIC QUAD FLATPACK - NO LEAD



LAND PATTERN EXAMPLE
SCALE:15X



SOLDER MASK DETAILS

4219075/A 11/2014

NOTES: (continued)

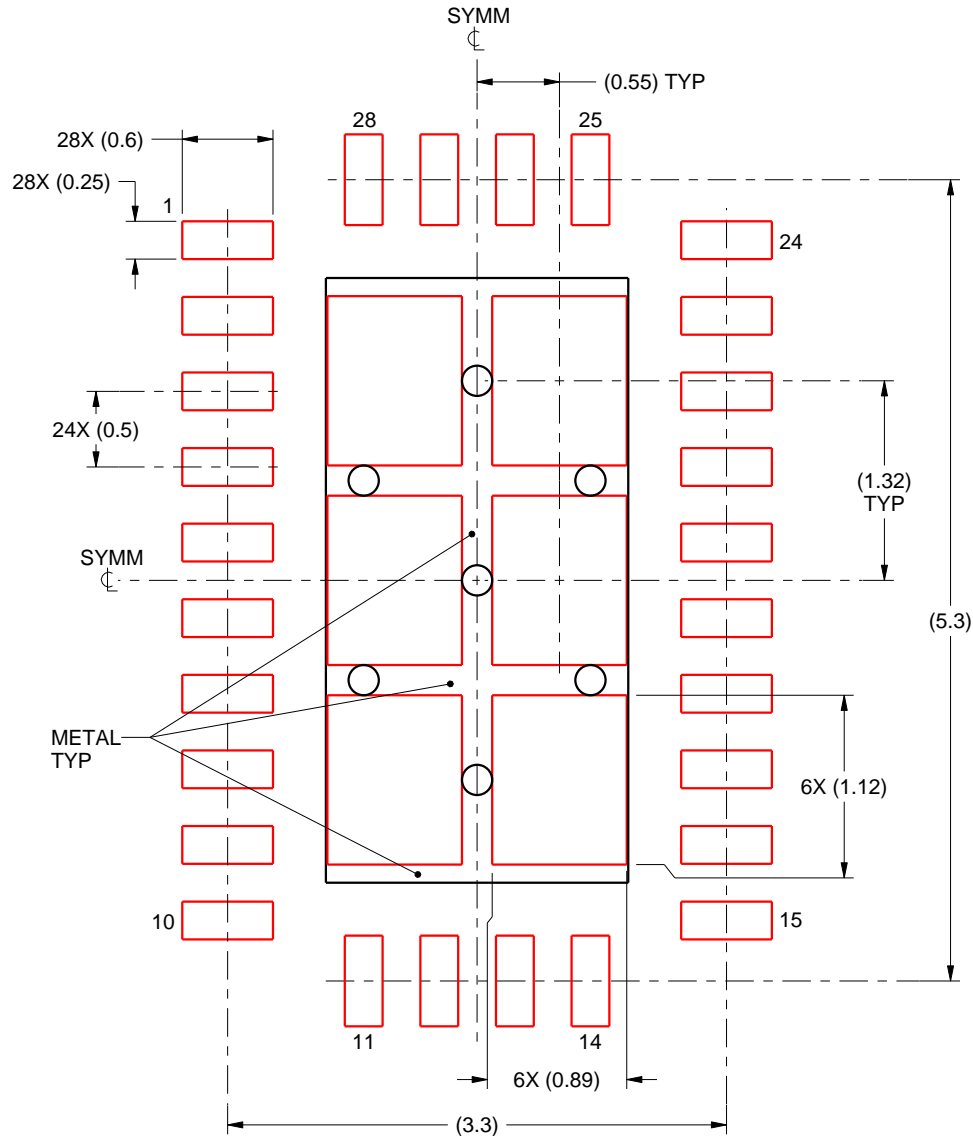
- This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 (www.ti.com/lit/sluea271).

EXAMPLE STENCIL DESIGN

RHR0028A

WQFN - 0.8 mm max height

PLASTIC QUAD FLATPACK - NO LEAD



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL

EXPOSED PAD
75% PRINTED SOLDER COVERAGE BY AREA
SCALE:20X

4219075/A 11/2014

NOTES: (continued)

5. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.

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最后更新日期：2025 年 10 月