



## DRV8828 H-Bridge Motor Controller IC

### 1 Features

- Single H-Bridge Current-Control Motor Driver
- 8.2-V to 45-V Operating Supply Voltage Range
- Capable of Driving One Winding of a Bipolar Stepper Motor or One DC Motor
- Five Bit Current Control Allows up to 32 Current Levels
- Low MOSFET  $R_{DS(on)}$  Typical  $0.65\ \Omega$  (HS + LS)
- 3-A Maximum Drive Current at 24 V, 25°C
- Built In 3.3-V Reference Output
- Parallel Digital Control Interface
- Thermal Enhanced Surface Mount Package
- Protection Features
  - Overcurrent Protection (OCP)
  - Thermal Shutdown (TSD)
  - VM Undervoltage Lockout (UVLO)
  - Fault Condition Indication Pin (nFAULT)

### 2 Applications

- Automatic Teller Machines
- Money Handling Machines
- Video Security Cameras
- Printers
- Scanners
- Office Automation Machines
- Gaming Machines
- Factory Automation
- Robotics

### 3 Description

The DRV8828 provides an integrated motor driver solution for printers, scanners, and other automated equipment applications. The device has one H-bridge driver, and can drive one winding of a bipolar stepper motor or one DC motor. The output driver block consists of N-channel power MOSFET's configured as a full H-bridge to drive the motor winding. The DRV8828 is capable of driving up to 3-A of output current (with proper heatsinking at 24 V and 25°C).

A simple parallel digital control interface is compatible with industry-standard devices. Decay mode is programmable.

Internal shutdown functions are provided for overcurrent protection, short circuit protection, undervoltage lockout and overtemperature.

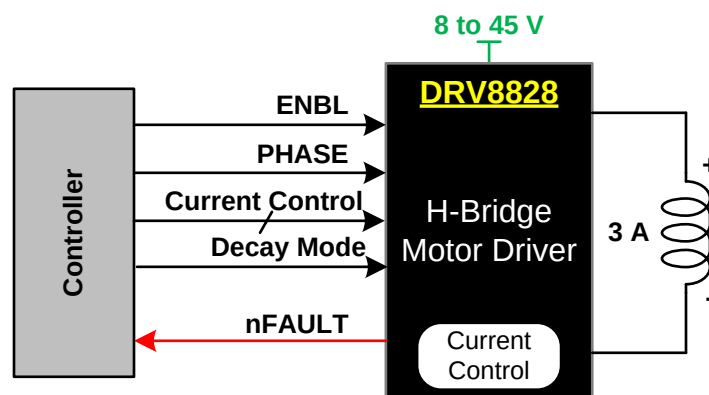
The DRV8828 is available in a 28-pin HTSSOP package with PowerPAD™ (Eco-friendly: RoHS & no Sb/Br).

#### Device Information<sup>(1)</sup>

| PART NUMBER | PACKAGE     | BODY SIZE (NOM)   |
|-------------|-------------|-------------------|
| DRV8828     | HTSSOP (28) | 9.70 mm x 4.40 mm |

(1) For all available packages, see the orderable addendum at the end of the datasheet.

#### Simplified Device Schematic



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## 4 Revision History

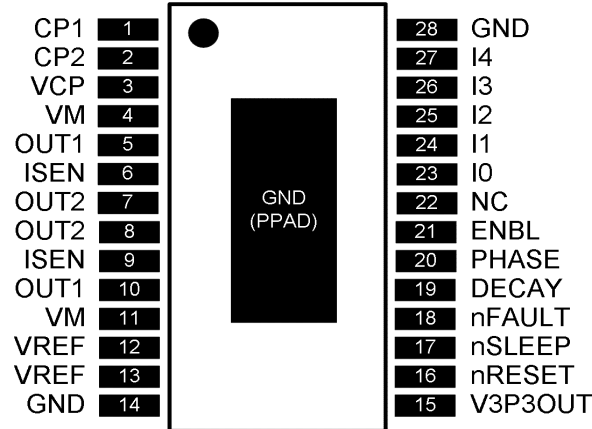
NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

| Changes from Revision F (December 2013) to Revision G                                                                                                                                                                                                                                                                                                                                               | Page |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| • Added <i>Pin Configuration and Functions</i> section, <i>ESD Rating</i> table, <i>Feature Description</i> section, <i>Device Functional Modes</i> , <i>Application and Implementation</i> section, <i>Power Supply Recommendations</i> section, <i>Layout</i> section, <i>Device and Documentation Support</i> section, and <i>Mechanical, Packaging, and Orderable Information</i> section ..... | 1    |
| • Updated Absolute Maximum Ratings Table .....                                                                                                                                                                                                                                                                                                                                                      | 1    |

| Changes from Revision E (August 2013) to Revision F                                   | Page |
|---------------------------------------------------------------------------------------|------|
| • Changed in the ELECTRICAL CHARACTERISTICS table, section DECAY INPUT, 3rd row ..... | 5    |

## 5 Pin Configuration and Functions

**PWP Package**  
**28-Pin HTSSOP With Thermal Pad**  
**Top View**



**Pin Functions**

| PIN              |        | I/O <sup>(1)</sup> | DESCRIPTION                  | EXTERNAL COMPONENTS OR CONNECTIONS                                                                                                            |
|------------------|--------|--------------------|------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|
| NAME             | NO.    |                    |                              |                                                                                                                                               |
| POWER AND GROUND |        |                    |                              |                                                                                                                                               |
| GND              | 14, 28 | -                  | Device ground                |                                                                                                                                               |
| VM               | 4, 11  | -                  | Bridge power supply          | Connect to motor supply (8 - 45 V). Both pins must be connected to same supply.                                                               |
| V3P3OUT          | 15     | O                  | 3.3-V regulator output       | Bypass to GND with a 0.47-μF 6.3-V ceramic capacitor. Can be used to supply VREF.                                                             |
| CP1              | 1      | I/O                | Charge pump flying capacitor | Connect a 0.01-μF 50-V capacitor between CP1 and CP2.                                                                                         |
| CP2              | 2      | I/O                | Charge pump flying capacitor |                                                                                                                                               |
| VCP              | 3      | I/O                | High-side gate drive voltage | Connect a 0.1-μF 16-V ceramic capacitor and a 1-MΩ resistor to VM.                                                                            |
| CONTROL          |        |                    |                              |                                                                                                                                               |
| ENBL             | 21     | I                  | Bridge enable                | Logic high to enable H-bridge. Internal pulldown.                                                                                             |
| PHASE            | 20     | I                  | Bridge phase (direction)     | Logic high sets OUT1 high, OUT2 low. Internal pulldown.                                                                                       |
| I0               | 23     | I                  | Current set inputs           | Sets winding current as a percentage of full-scale. Internal pulldown.                                                                        |
| I1               | 24     | I                  |                              |                                                                                                                                               |
| I2               | 25     | I                  |                              |                                                                                                                                               |
| I3               | 26     | I                  |                              |                                                                                                                                               |
| I4               | 27     | I                  |                              |                                                                                                                                               |
| DECAY            | 19     | I                  | Decay mode                   | Low = slow decay, open = mixed decay, high = fast decay<br>Internal pulldown and pullup.                                                      |
| nRESET           | 16     | I                  | Reset input                  | Active-low reset input initializes internal logic and disables the H-bridge outputs. Internal pulldown.                                       |
| VREF             | 12, 13 | I                  | Current set reference input  | Reference voltage for winding current set. Both pins must be connected together on the PCB. A 0.01-μF bypass capacitor to GND is recommended. |
| nSLEEP           | 17     | I                  | Sleep mode input             | Logic high to enable device, logic low to enter low-power sleep mode. Internal pulldown.                                                      |
| NC               | 22     |                    | No connect                   | Leave this pin unconnected.                                                                                                                   |

(1) Directions: I = input, O = output, OZ = tri-state output, OD = open-drain output, IO = input/output

## Pin Functions (continued)

| PIN    |       | I/O <sup>(1)</sup> | DESCRIPTION            | EXTERNAL COMPONENTS OR CONNECTIONS                                                  |
|--------|-------|--------------------|------------------------|-------------------------------------------------------------------------------------|
| NAME   | NO.   |                    |                        |                                                                                     |
| STATUS |       |                    |                        |                                                                                     |
| nFAULT | 18    | O/D                | Fault                  | Logic low when in fault condition (overtemp, overcurrent)                           |
| OUTPUT |       |                    |                        |                                                                                     |
| ISEN   | 6, 9  | I/O                | Bridge ground / Isense | Connect to current sense resistor. Both pins must be connected together on the PCB. |
| OUT1   | 5, 10 | O                  | Bridge output 1        | Connect to motor winding. Both pins must be connected together on the PCB.          |
| OUT2   | 7, 8  | O                  | Bridge output 2        |                                                                                     |

## 6 Specifications

### 6.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted) <sup>(1)(2)</sup>

|                  |                                                      | MIN                                     | MAX                | UNIT |
|------------------|------------------------------------------------------|-----------------------------------------|--------------------|------|
| VM               | Power supply voltage                                 | −0.3                                    | 47                 | V    |
|                  | Digital pin voltage                                  | −0.5                                    | 7                  | V    |
| VREF             | Input voltage                                        | −0.3                                    | 4                  | V    |
|                  | ISENSE pin voltage                                   | −0.8                                    | 0.8 <sup>(3)</sup> | V    |
|                  | Peak motor drive output current, t < 1 μs            | Internally limited                      |                    | A    |
|                  | Continuous motor drive output current <sup>(4)</sup> | 0                                       | 3                  | A    |
|                  | Continuous total power dissipation                   | See <a href="#">Thermal Information</a> |                    |      |
| T <sub>J</sub>   | Operating virtual junction temperature               | −40                                     | 150                | °C   |
| T <sub>stg</sub> | Storage temperature                                  | −60                                     | 150                | °C   |

- Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under [Recommended Operating Conditions](#) is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
- All voltage values are with respect to network ground pin.
- Transients of +/- 1V for less than 25 ns are acceptable.
- Power dissipation and thermal limits must be observed.

### 6.2 ESD Ratings

|                    |                         | VALUE                                                                          | UNIT  |
|--------------------|-------------------------|--------------------------------------------------------------------------------|-------|
| V <sub>(ESD)</sub> | Electrostatic discharge | Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001 <sup>(1)</sup>              | ±2000 |
|                    |                         | Charged-device model (CDM), per JEDEC specification JESD22-C101 <sup>(2)</sup> | ±500  |

- JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
- 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 | NOM | MAX | UNIT |
|-------------------|-------------------------------------------------|-----|-----|-----|------|
| V <sub>M</sub>    | Motor power supply voltage range <sup>(1)</sup> | 8.2 |     | 45  | V    |
| V <sub>REF</sub>  | VREF input voltage <sup>(2)</sup>               | 1   |     | 3.5 | V    |
| I <sub>V3P3</sub> | V3P3OUT load current                            |     |     | 1   | mA   |

- All V<sub>M</sub> pins must be connected to the same supply voltage.
- Operational at VREF between 0 V and 1 V, but accuracy is degraded.

## 6.4 Thermal Information

| THERMAL METRIC <sup>(1)</sup> |                                              | DRV8828      | UNIT |
|-------------------------------|----------------------------------------------|--------------|------|
|                               |                                              | PWP (HTSSOP) |      |
|                               |                                              | 28 PINS      |      |
| R <sub>θJA</sub>              | Junction-to-ambient thermal resistance       | 38.9         | °C/W |
| R <sub>θJC(top)</sub>         | Junction-to-case (top) thermal resistance    | 23.3         | °C/W |
| R <sub>θJB</sub>              | Junction-to-board thermal resistance         | 21.2         | °C/W |
| ψ <sub>JT</sub>               | Junction-to-top characterization parameter   | 0.8          | °C/W |
| ψ <sub>JB</sub>               | Junction-to-board characterization parameter | 20.9         | °C/W |
| R <sub>θJC(bot)</sub>         | Junction-to-case (bottom) thermal resistance | 2.6          | °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 |
|------------------------------------------|-----------------------------------------------------------------------------------------------|------|------|------|------|
| <b>POWER SUPPLIES</b>                    |                                                                                               |      |      |      |      |
| I <sub>VM</sub>                          | VM operating supply current<br>V <sub>M</sub> = 24 V, f <sub>PWM</sub> < 50 kHz               |      | 5    | 8    | mA   |
| I <sub>VMQ</sub>                         | VM sleep mode supply current<br>V <sub>M</sub> = 24 V                                         |      | 10   | 20   | μA   |
| V <sub>UVLO</sub>                        | VM undervoltage lockout voltage<br>V <sub>M</sub> rising                                      |      | 7.8  | 8.2  | V    |
| <b>V3P3OUT REGULATOR</b>                 |                                                                                               |      |      |      |      |
| V <sub>3P3</sub>                         | V3P3OUT voltage<br>I <sub>OUT</sub> = 0 to 1 mA, V <sub>M</sub> = 24 V, T <sub>J</sub> = 25°C | 3.18 | 3.30 | 3.42 | V    |
|                                          | I <sub>OUT</sub> = 0 to 1 mA                                                                  | 3.10 | 3.30 | 3.50 | V    |
| <b>LOGIC-LEVEL INPUTS</b>                |                                                                                               |      |      |      |      |
| V <sub>IL</sub>                          | Input low voltage                                                                             |      | 0.6  | 0.7  | V    |
| V <sub>IH</sub>                          | Input high voltage                                                                            | 2    |      | 5.25 | V    |
| V <sub>HYS</sub>                         | Input hysteresis                                                                              |      | 0.45 |      | V    |
| I <sub>IL</sub>                          | Input low current<br>VIN = 0                                                                  | –20  |      | 20   | μA   |
| I <sub>IH</sub>                          | Input high current<br>VIN = 3.3 V                                                             |      |      | 100  | μA   |
| R <sub>PD</sub>                          | Internal pulldown resistance<br>ENBL, PHASE, I0, I1, I2, I3, I4, nRESET                       |      | 100  |      | kΩ   |
|                                          | nSLEEP                                                                                        |      | 1    |      | MΩ   |
| <b>nFAULT OUTPUT (OPEN-DRAIN OUTPUT)</b> |                                                                                               |      |      |      |      |
| V <sub>OL</sub>                          | Output low voltage<br>I <sub>O</sub> = 5 mA                                                   |      |      | 0.5  | V    |
| I <sub>OH</sub>                          | Output high leakage current<br>V <sub>O</sub> = 3.3 V                                         |      |      | 1    | μA   |
| <b>DECAY INPUT</b>                       |                                                                                               |      |      |      |      |
| V <sub>IL</sub>                          | Input low threshold voltage<br>For slow decay mode                                            |      |      | 0.8  | V    |
| V <sub>IH</sub>                          | Input high threshold voltage<br>For fast decay mode                                           | 2    |      |      | V    |
| I <sub>IN</sub>                          | Input current                                                                                 | –100 |      | 100  | μA   |
| R <sub>PU</sub>                          | Internal pullup resistance                                                                    |      | 130  |      | kΩ   |
| R <sub>PD</sub>                          | Internal pulldown resistance                                                                  |      | 80   |      | kΩ   |
| <b>H-BRIDGE FETS</b>                     |                                                                                               |      |      |      |      |
| R <sub>DS(ON)</sub>                      | HS FET on resistance<br>V <sub>M</sub> = 24 V, I <sub>O</sub> = 1 A, T <sub>J</sub> = 25°C    |      | 0.32 |      | Ω    |
|                                          |                                                                                               |      | 0.39 | 0.45 | Ω    |
| R <sub>DS(ON)</sub>                      | LS FET on resistance<br>V <sub>M</sub> = 24 V, I <sub>O</sub> = 1 A, T <sub>J</sub> = 25°C    |      | 0.33 |      | Ω    |
|                                          |                                                                                               |      | 0.39 | 0.45 | Ω    |
| I <sub>OFF</sub>                         | Off-state leakage current                                                                     | –40  |      | 40   | μA   |
| <b>MOTOR DRIVER</b>                      |                                                                                               |      |      |      |      |
| f <sub>PWM</sub>                         | PWM frequency                                                                                 |      | 50   |      | kHz  |
| t <sub>BLANK</sub>                       | Current sense blanking time                                                                   |      | 3.75 |      | μs   |
| t <sub>R</sub>                           | Rise time<br>V <sub>M</sub> = 24 V                                                            | 100  |      | 360  | ns   |

## Electrical Characteristics (continued)

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

| PARAMETER                  |                                                         | TEST CONDITIONS                                       | MIN  | TYP | MAX | UNIT               |
|----------------------------|---------------------------------------------------------|-------------------------------------------------------|------|-----|-----|--------------------|
| $t_F$                      | Fall time                                               | $V_M = 24\text{ V}$                                   | 80   |     | 250 | ns                 |
| $t_{DEAD}$                 | Dead time                                               |                                                       |      | 400 |     | ns                 |
| $t_{DEG}$                  | Input deglitch time                                     |                                                       | 1.3  |     | 2.9 | $\mu\text{s}$      |
| <b>PROTECTION CIRCUITS</b> |                                                         |                                                       |      |     |     |                    |
| $I_{OCP}$                  | Overcurrent protection trip level                       |                                                       | 3.6  |     | 10  | A                  |
| $t_{TSD}$                  | Thermal shutdown temperature                            | Die temperature                                       | 150  | 160 | 180 | $^{\circ}\text{C}$ |
| <b>CURRENT CONTROL</b>     |                                                         |                                                       |      |     |     |                    |
| $I_{REF}$                  | VREF input current                                      | $V_{REF} = 3.3\text{ V}$                              | –3   |     | 3   | $\mu\text{A}$      |
| $V_{TRIP}$                 | ISENSE trip voltage                                     | $V_{REF} = 3.3\text{ V}$ , 100% current setting       | 635  | 660 | 685 | mV                 |
| $\Delta I_{TRIP}$          | Current trip accuracy<br>(relative to programmed value) | $V_{REF} = 3.3\text{ V}$ , 5% current setting         | –25% |     | 25% |                    |
|                            |                                                         | $V_{REF} = 3.3\text{ V}$ , 10% - 34% current setting  | –15% |     | 15% |                    |
|                            |                                                         | $V_{REF} = 3.3\text{ V}$ , 38% - 67% current setting  | –10% |     | 10% |                    |
|                            |                                                         | $V_{REF} = 3.3\text{ V}$ , 71% - 100% current setting | –5%  |     | 5%  |                    |
| $A_{ISENSE}$               | Current sense amplifier gain                            | Reference only                                        |      | 5   |     | V/V                |

## 6.6 Typical Characteristics

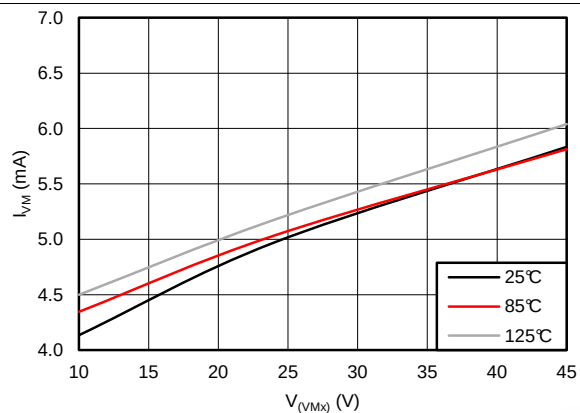


Figure 1.  $I_{VM}$  vs  $V_{(VMx)}$

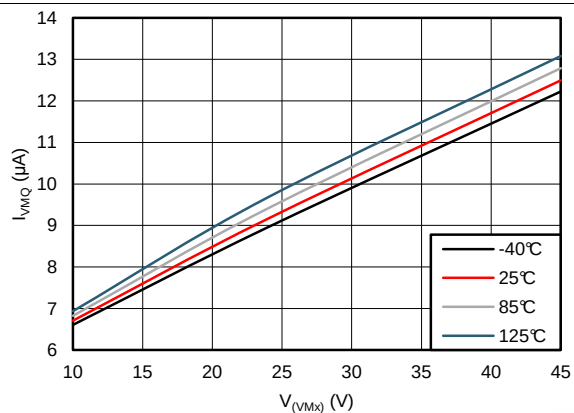


Figure 2.  $I_{VMQ}$  vs  $V_{(VMx)}$

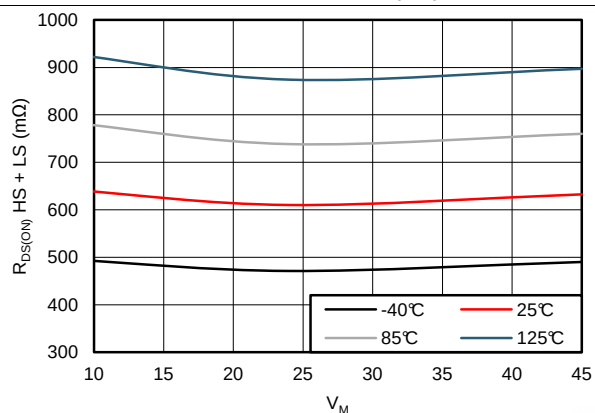


Figure 3.  $R_{DS(ON)}$  vs  $V_{(VMx)}$

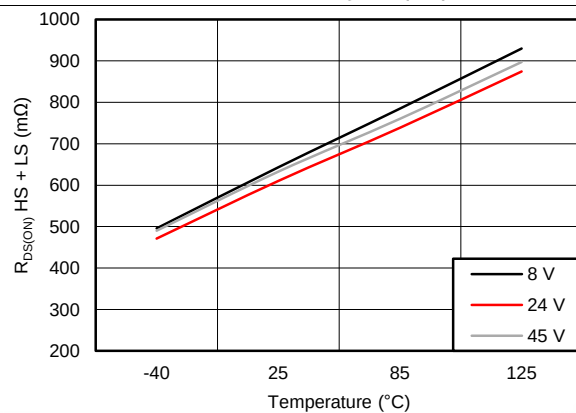


Figure 4.  $R_{DS(ON)}$  vs Temperature

## 7 Detailed Description

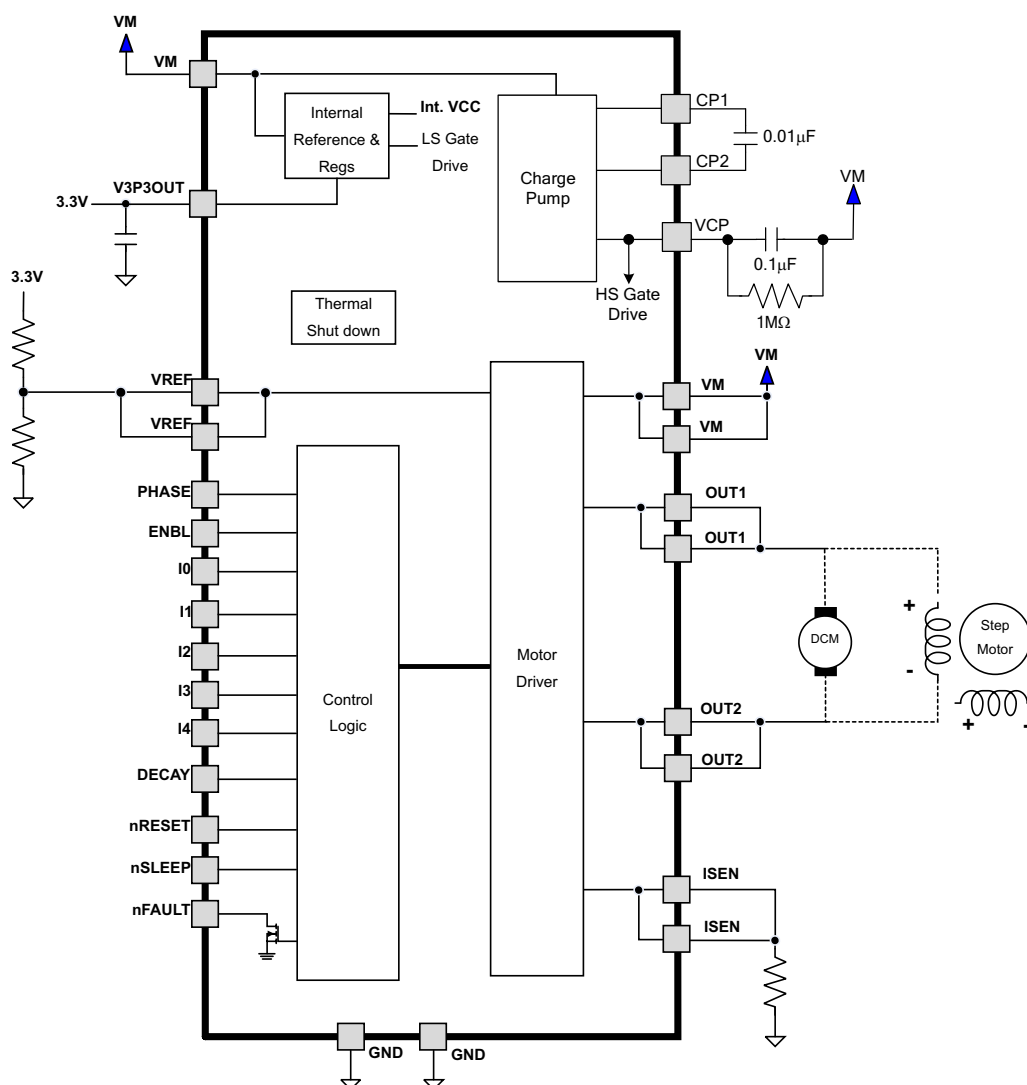
### 7.1 Overview

The DRV8828 is an integrated motor driver solution for printers, scanners, and other automated equipment applications. The device integrates a single NMOS H-bridge, charge pump, current sense, current regulation, and device protection circuitry. The DRV8828 can be powered from a single voltage supply between 8.2 and 45 V and is capable of providing a continuous output current up to 3 A.

A simple PHASE/ENBL interface allows for easy interfacing to an external controller. A 5 bit current control scheme allows for up to 32 discrete current levels. The current regulation method is adjustable between slow, mixed, and fast decay.

Integrated protection circuits allows the device to monitor and protect against overcurrent, undervoltage, and overtemperature faults which are all reported through a fault indication pin (nFAULT). A low power sleep mode is integrated which allows the system to lower power consumption when not driving the motor.

### 7.2 Functional Block Diagram

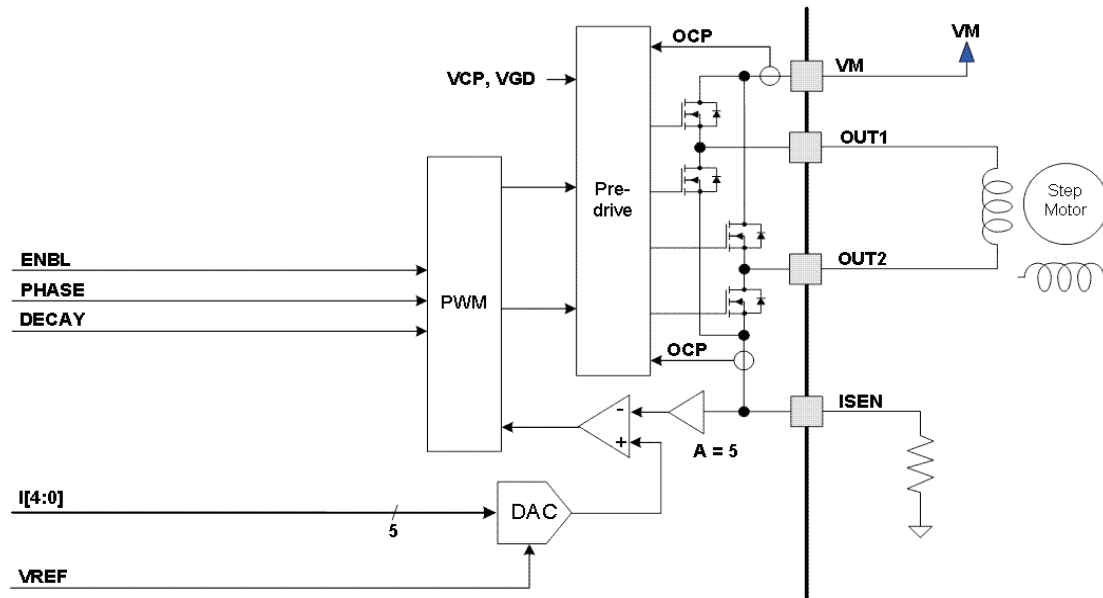




## 7.3 Feature Description

### 7.3.1 PWM Motor Drivers

The DRV8828 contains one H-bridge motor driver with current-control PWM circuitry. A block diagram of the motor control circuitry is shown in Figure 5. A bipolar stepper motor is shown, but the driver can also drive a DC motor.



**Figure 5. Motor Control Circuitry**

Note that there are multiple VM, ISEN, OUT, and VREF pins. All like-named pins must be connected together on the PCB.

### 7.3.2 Bridge Control

The PHASE input pin controls the direction of current flow through the H-bridge. The ENBL input pin enables the H-bridge outputs when active high. The logic inputs ENBL and PHASE have internal pulldown resistors of 100 kΩ. Table 1 shows the logic.

**Table 1. H-Bridge Logic**

| ENBL | PHASE | OUT1 | OUT2 |
|------|-------|------|------|
| 0    | X     | Z    | Z    |
| 1    | 1     | H    | L    |
| 1    | 0     | L    | H    |

### 7.3.3 Current Regulation

The current through the motor winding is regulated by a fixed-frequency PWM current regulation, or current chopping. When the H-bridge is enabled, current rises through the winding at a rate dependent on the DC voltage and inductance of the winding. Once the current hits the current chopping threshold, the bridge disables the current until the beginning of the next PWM cycle.

For stepping motors, current regulation is normally used at all times, and changing the current can be used to microstep the motor. For DC motors, current regulation is used to limit the start-up and stall current of the motor.

The PWM chopping current in the bridge is set by a comparator which compares the voltage across a current sense resistor connected to the ISEN pin, multiplied by a factor of 5, with a reference voltage. The reference voltage is input from the xVREF pins, and is scaled by a 5-bit DAC that allows current settings of zero to 100% in an approximately sinusoidal sequence.

The full-scale (100%) chopping current is calculated in [Equation 1](#).

$$I_{CHOP} = \frac{V_{REFX}}{5 \cdot R_{ISENSE}} \quad (1)$$

Example:

If a 0.5-Ω sense resistor is used and the VREFx pin is 3.3 V, the full-scale (100%) chopping current will be 3.3 V / (5 x 0.5 Ω) = 1.32 A.

Five input pins (I0 - I4) are used to scale the current in the bridge as a percentage of the full-scale current set by the VREF input pin and sense resistance. The logic inputs I0, I1, I2, I3 and I4 have internal pulldown resistors of 100 kΩ. The function of the pins is shown in [Table 2](#).

**Table 2. H-Bridge Pin Functions**

| I[4..0] | RELATIVE CURRENT<br>(% FULL-SCALE CHOPPING CURRENT) |
|---------|-----------------------------------------------------|
| 0x00h   | 0%                                                  |
| 0x01h   | 5%                                                  |
| 0x02h   | 10%                                                 |
| 0x03h   | 15%                                                 |
| 0x04h   | 20%                                                 |
| 0x05h   | 24%                                                 |
| 0x06h   | 29%                                                 |
| 0x07h   | 34%                                                 |
| 0x08h   | 38%                                                 |
| 0x09h   | 43%                                                 |
| 0x0Ah   | 47%                                                 |
| 0x0Bh   | 51%                                                 |
| 0x0Ch   | 56%                                                 |
| 0x0Dh   | 60%                                                 |
| 0x0Eh   | 63%                                                 |
| 0x0Fh   | 67%                                                 |
| 0x10h   | 71%                                                 |
| 0x11h   | 74%                                                 |
| 0x12h   | 77%                                                 |
| 0x13h   | 80%                                                 |
| 0x14h   | 83%                                                 |
| 0x15h   | 86%                                                 |
| 0x16h   | 88%                                                 |
| 0x17h   | 90%                                                 |
| 0x18h   | 92%                                                 |
| 0x19h   | 94%                                                 |
| 0x1Ah   | 96%                                                 |
| 0x1Bh   | 97%                                                 |
| 0x1Ch   | 98%                                                 |
| 0x1Dh   | 99%                                                 |
| 0x1Eh   | 100%                                                |
| 0x1Fh   | 100%                                                |

### 7.3.4 Decay Mode

During PWM current chopping, the H-bridge is enabled to drive current through the motor winding until the PWM current chopping threshold is reached. This is shown in Figure 6 as case 1. The current flow direction shown indicates the state when the PHASE pin is high.

Once the chopping current threshold is reached, the H-bridge can operate in two different states, fast decay or slow decay.

In fast decay mode, once the PWM chopping current level has been reached, the H-bridge reverses state to allow winding current to flow in a reverse direction. As the winding current approaches zero, the bridge is disabled to prevent any reverse current flow. Fast decay mode is shown in Figure 6 as case 2.

In slow decay mode, winding current is re-circulated by enabling both of the low-side FETs in the bridge. This is shown in Figure 6 as case 3.

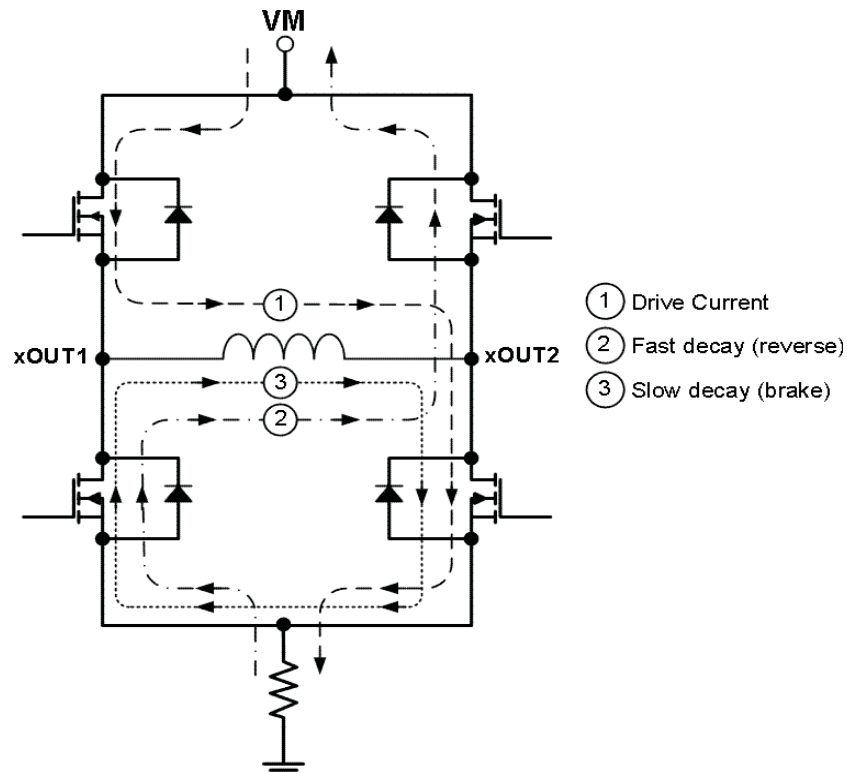


Figure 6. Decay Mode

The DRV8828 supports fast decay, slow decay and a mixed decay mode. Slow, fast, or mixed decay mode is selected by the state of the DECAY pin - logic low selects slow decay, open selects mixed decay operation, and logic high sets fast decay mode. The DECAY pin has both an internal pullup resistor of approximately 130 kΩ and an internal pulldown resistor of approximately 80 kΩ. This sets the mixed decay mode if the pin is left open or undriven.

Mixed decay mode begins as fast decay, but at a fixed period of time (75% of the PWM cycle) switches to slow decay mode for the remainder of the fixed PWM period.

### 7.3.5 Blanking Time

After the current is enabled in the H-bridge, the voltage on the ISEN pin is ignored for a fixed period of time before enabling the current sense circuitry. This blanking time is fixed at 3.75 μs. Note that the blanking time also sets the minimum on time of the PWM.

### 7.3.6 Protection Circuits

The DRV8828 is fully protected against undervoltage, overcurrent and overtemperature events.

### **7.3.6.1 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 the OCP time, all FETs in the H-bridge will be disabled and the nFAULT pin will be driven low. The device will remain disabled until either nRESET pin is applied, or VM is removed and re-applied.

Overcurrent conditions on both high and low side devices; i.e., a short to ground, supply, or across the motor winding will all result in an overcurrent shutdown. Note that overcurrent protection does not use the current sense circuitry used for PWM current control, and is independent of the  $I_{SENSE}$  resistor value or VREF voltage.

### **7.3.6.2 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. Once the die temperature has fallen to a safe level operation will automatically resume.

### **7.3.6.3 Undervoltage Lockout (UVLO)**

If at any time the voltage on the VM pins falls below the undervoltage lockout threshold voltage, all circuitry in the device will be disabled and internal logic will be reset. Operation will resume when  $V_M$  rises above the UVLO threshold.

## **7.4 Device Functional Modes**

### **7.4.1 nRESET and nSLEEP Operation**

The nRESET pin, when driven active low, resets the internal logic. It also disables the H-bridge drivers. All inputs are ignored while nRESET is active. The nRESET pin has an internal pulldown resistor of 100 k $\Omega$ . The nSLEEP pin has an internal pulldown resistor of 1 M $\Omega$ .

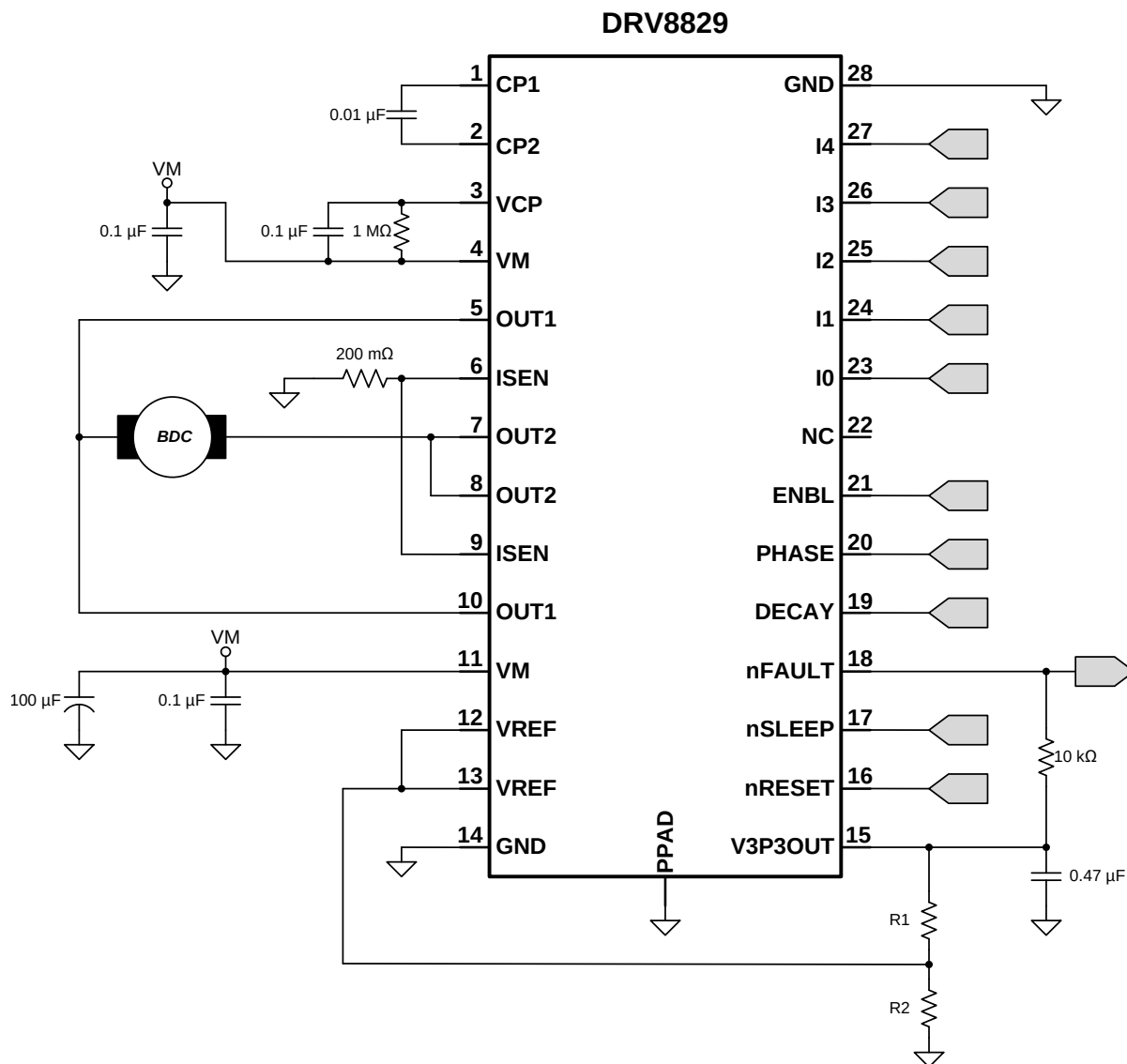
Driving nSLEEP low will put the device into a low power sleep state. In this state, the H-bridge is disabled, the gate drive charge pump is stopped, the V3P3OUT regulator is disabled, and all internal clocks are stopped. In this state all inputs are ignored until nSLEEP returns inactive high. When returning from sleep mode, some time (approximately 1 ms) needs to pass before the motor driver becomes fully operational.

### 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.

The DRV8828 is used in brushed motor or stepper motor control. The onboard current regulation allows for limiting the motor current through simple pin configurations.

## 8.2 Typical Application



### Figure 7. Motor Control Circuitry

## Typical Application (continued)

### 8.2.1 Design Requirements

For this design example, use the parameters listed in [Table 3](#)

**Table 3. Design Parameters**

| PARAMETER                | REFERENCE          | VALUE   |
|--------------------------|--------------------|---------|
| Supply Voltage           | VM                 | 24 V    |
| Motor Winding Resistance | R <sub>M</sub>     | 3.9 Ohm |
| Motor Winding Inductance | L <sub>M</sub>     | 2.9 mH  |
| Target Chopping Current  | I <sub>TRIP</sub>  | 1.5 A   |
| Sense Resistor           | R <sub>SENSE</sub> | 200 mΩ  |
| VREF Voltage             | VREF               | 1.5 V   |

### 8.2.2 Detailed Design Procedure

#### 8.2.2.1 Current Regulation

The maximum current (ITRIP) is set by the Ix pins, the VREF analog voltage, and the sense resistor value (RSENSE). When starting a brushed DC motor, a large inrush current may occur because there is no back-EMF and high detent torque. Current regulation will act to limit this inrush current and prevent high current on start-up.

$$I_{TRIP} = \frac{VREF}{(5 \times R_{SENSE})} \quad (2)$$

Example - If the desired chopping current is 1.5 A:

- Set R<sub>SENSE</sub> = 200 mΩ
- VREF would have to be 1.5 V
- Create a resistor divider network from V3P3OUT (3.3 V) to set VREF = 1.5 V
- Set R2 = 10 kΩ and set R1 = 12 kΩ

#### 8.2.2.2 Sense Resistor

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

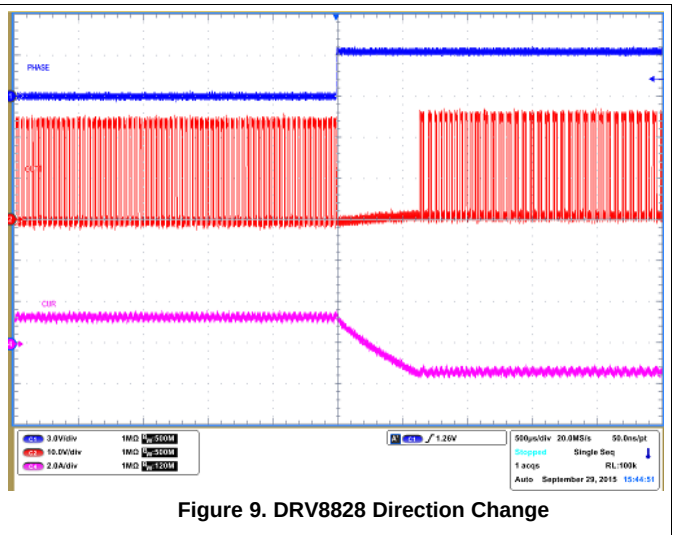
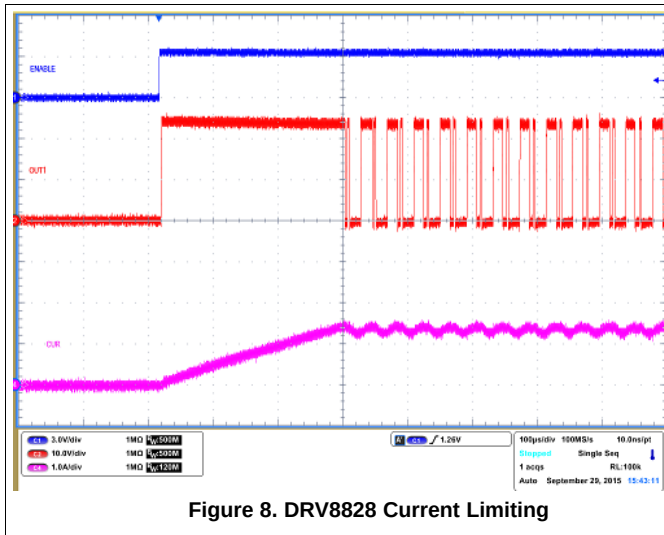
- Surface-mount
- Low inductance
- Rated for high enough power
- Placed closely to the motor driver

The power dissipated by the sense resistor equals Irms<sup>2</sup> x R. For example, if the RMS motor current is 1.5 A and a 200 mΩ sense resistor is used, the resistor will dissipate 1.5 A<sup>2</sup> x 0.2 Ω = 0.3 W. The power quickly increases with greater current levels.

Resistors typically have a rated power within some ambient temperature range, along with a de-rated 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.

## 8.2.3 Application Curves



## 9 Power Supply Recommendations

The DRV8828 is designed to operate from an input voltage supply (VM) range from 8.2 V to 45 V. The device has an absolute maximum rating of 47 V. A 0.1- $\mu$ F ceramic capacitor rated for VM must be placed at each VM pin as close to the DRV8828 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.

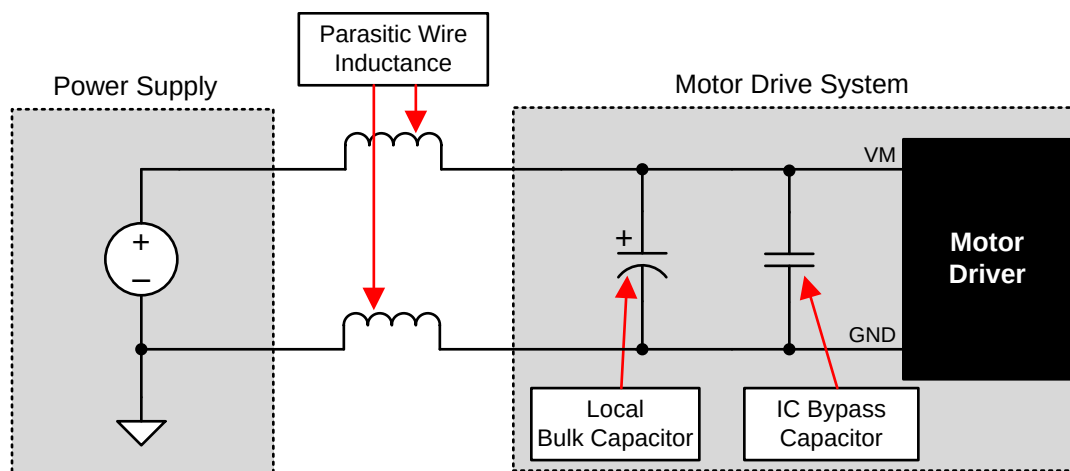
The amount of local capacitance needed depends on a variety of factors, including:

- 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 greater than the operating voltage, to provide margin for cases when the motor transfers energy to the supply.



**Figure 10. 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  $\mu\text{F}$  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.

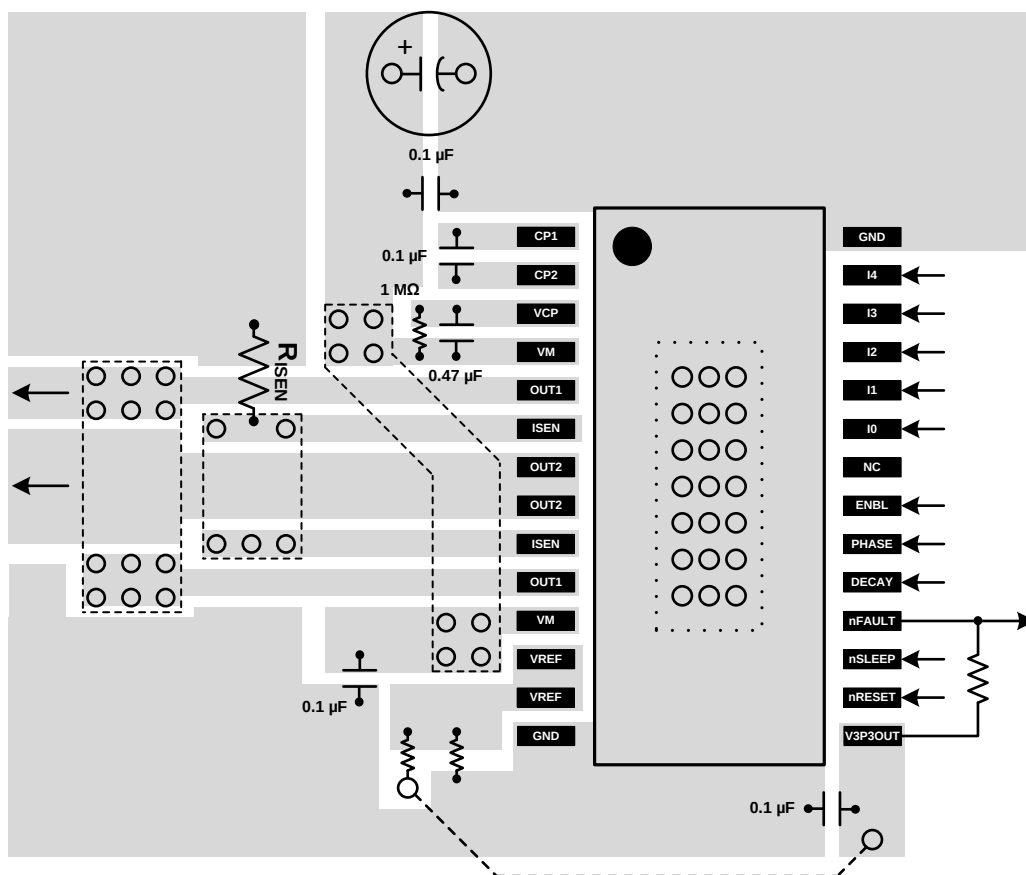
A low-ESR ceramic capacitor must be placed in between the CP1 and CP2 pins. TI recommends a value of 0.1  $\mu\text{F}$  rated for VM. Place this component as close to the pins as possible.

A low-ESR ceramic capacitor must be placed in between the VM and VCP pins. TI recommends a value of 0.47  $\mu\text{F}$  rated for 16 V. Place this component as close to the pins as possible. In addition, place a 1 M $\Omega$  between VM and VCP.

Bypass V3P3OUT to ground with a ceramic capacitor rated 6.3 V. Place this bypassing capacitor as close to the pin as possible.

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

### 10.2 Layout Example



**Figure 11. Example Layout**

### 10.3 Power Dissipation

Power dissipation in the DRV8828 is dominated by the power dissipated in the output FET resistance, or  $R_{DS(on)}$ . Average power dissipation when running a brushed DC motor can be roughly estimated by Equation 3.

$$P_{TOT} = 2 \times R_{DS(on)} \times I_{OUT(RMS)}^2 \quad (3)$$

Where:

- $P_{TOT}$  is the total power dissipation
- $R_{DS(on)}$  is the resistance of each FET (high-side and low-side)
- $I_{OUT(RMS)}$  is the RMS output current being applied to the motor

The maximum amount of power that can be dissipated in the devices is dependent on ambient temperature and heatsinking.  $R_{DS(on)}$  increases with temperature, so as the device heats, the power dissipation increases. This must be taken into consideration when sizing the heatsink.

### 10.4 Heatsinking

The PowerPAD™ package uses an exposed pad to remove heat from the device. For proper operation, this pad must be thermally connected to copper on the PCB to dissipate heat. On a multi-layer PCB with a ground plane, this can be accomplished by adding a number of vias to connect the thermal pad to the ground plane. On PCBs without internal planes, copper area can be added on either side of the PCB to dissipate heat. If the copper area is on the opposite side of the PCB from the device, thermal vias are used to transfer the heat between top and bottom layers.

For details about how to design the PCB, refer to TI application report [SLMA002](#), *PowerPAD™ Thermally Enhanced Package* and TI application brief [SLMA004](#), *PowerPAD™ Made Easy*, available at [www.ti.com](http://www.ti.com).

In general, the more copper area that can be provided, the more power can be dissipated.

#### 10.4.1 Thermal Information

The DRV8828 has thermal shutdown (TSD) as described above. If the die temperature exceeds approximately 150°C, the device will be disabled until the temperature drops to a safe level.

Any tendency of the device to enter TSD is an indication of either excessive power dissipation, insufficient heatsinking, or too high an ambient temperature.

## 11 Device and Documentation Support

### 11.1 Documentation Support

#### 11.1.1 Related Documentation

For related documentation see the following:

- PowerPAD™ Thermally Enhanced Package, [SLMA002](#)
- PowerPAD™ Made Easy, [SLMA004](#)

### 11.2 Community Resources

The following links connect to TI community resources. Linked contents are provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's [Terms of Use](#).

**TI E2E™ Online Community** *TI's Engineer-to-Engineer (E2E) Community*. Created to foster collaboration among engineers. At [e2e.ti.com](#), you can ask questions, share knowledge, explore ideas and help solve problems with fellow engineers.

**Design Support** *TI's Design Support* Quickly find helpful E2E forums along with design support tools and contact information for technical support.

### 11.3 Trademarks

PowerPAD, E2E are trademarks of Texas Instruments.  
All other trademarks are the property of their respective owners.

### 11.4 Electrostatic Discharge Caution



These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

### 11.5 Glossary

[SLYZ022](#) — *TI Glossary*.

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

## 12 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

## PACKAGING INFORMATION

| Orderable Device | Status<br>(1) | Package Type | Package<br>Drawing | Pins | Package<br>Qty | Eco Plan<br>(2)            | Lead/Ball Finish<br>(6) | MSL Peak Temp<br>(3) | Op Temp (°C) | Device Marking<br>(4/5) | Samples                 |
|------------------|---------------|--------------|--------------------|------|----------------|----------------------------|-------------------------|----------------------|--------------|-------------------------|-------------------------|
| DRV8828PWP       | ACTIVE        | HTSSOP       | PWP                | 28   | 50             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 85    | DRV8828                 | <a href="#">Samples</a> |
| DRV8828PWPR      | ACTIVE        | HTSSOP       | PWP                | 28   | 2000           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 85    | DRV8828                 | <a href="#">Samples</a> |

(1) The marketing status values are defined as follows:

**ACTIVE:** Product device recommended for new designs.

**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.

**OBSOLETE:** TI has discontinued the production of the device.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

**TBD:** The Pb-Free/Green conversion plan has not been defined.

**Pb-Free (RoHS):** TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

**Pb-Free (RoHS Exempt):** This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

**Green (RoHS & no Sb/Br):** TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

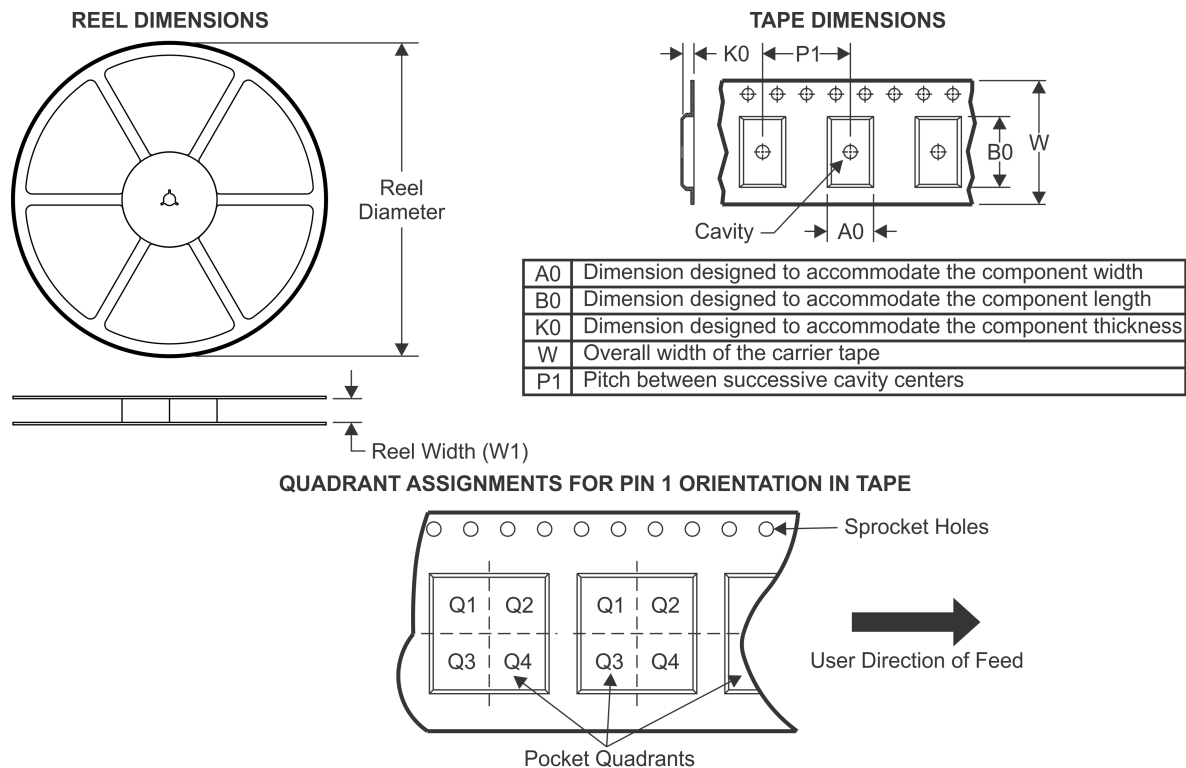
(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

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

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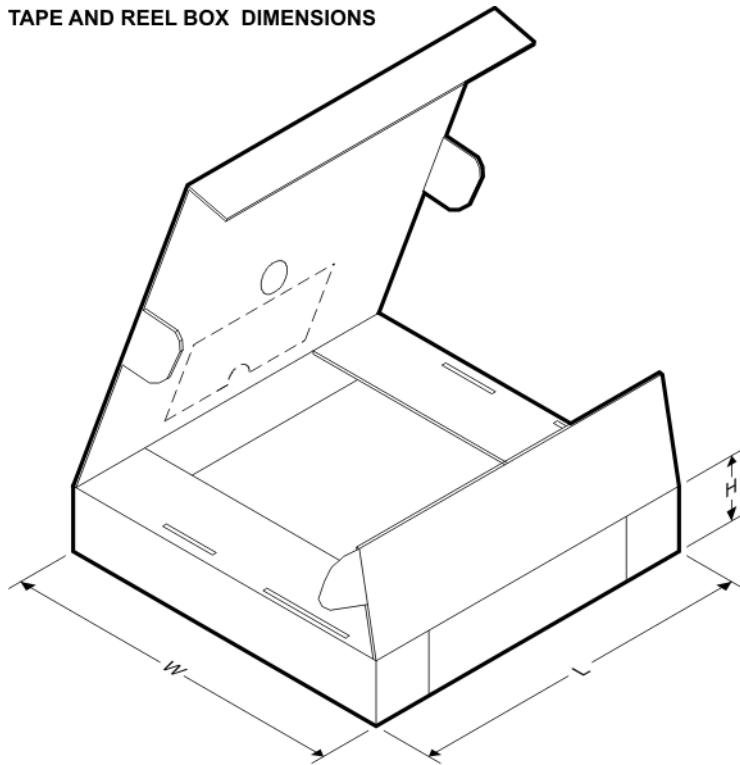
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**TAPE AND REEL INFORMATION**


\*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 |
|-------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| DRV8828PWPR | HTSSOP       | PWP             | 28   | 2000 | 330.0              | 16.4               | 6.9     | 10.2    | 1.8     | 12.0    | 16.0   | Q1            |

## TAPE AND REEL BOX DIMENSIONS



\*All dimensions are nominal

| Device      | Package Type | Package Drawing | Pins | SPQ  | Length (mm) | Width (mm) | Height (mm) |
|-------------|--------------|-----------------|------|------|-------------|------------|-------------|
| DRV8828PWPR | HTSSOP       | PWP             | 28   | 2000 | 350.0       | 350.0      | 43.0        |

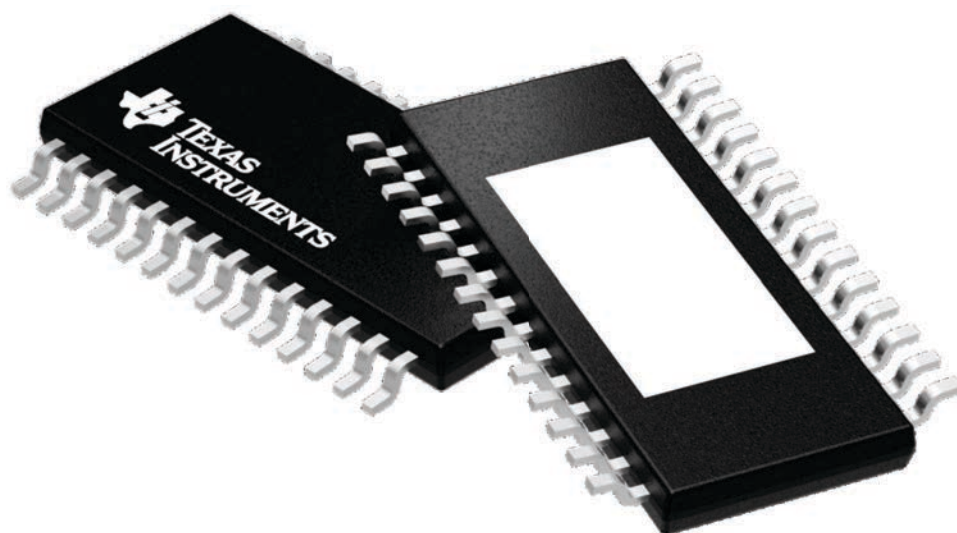
## GENERIC PACKAGE VIEW

**PWP 28**

**PowerPAD™ TSSOP - 1.2 mm max height**

4.4 x 9.7, 0.65 mm pitch

SMALL OUTLINE PACKAGE



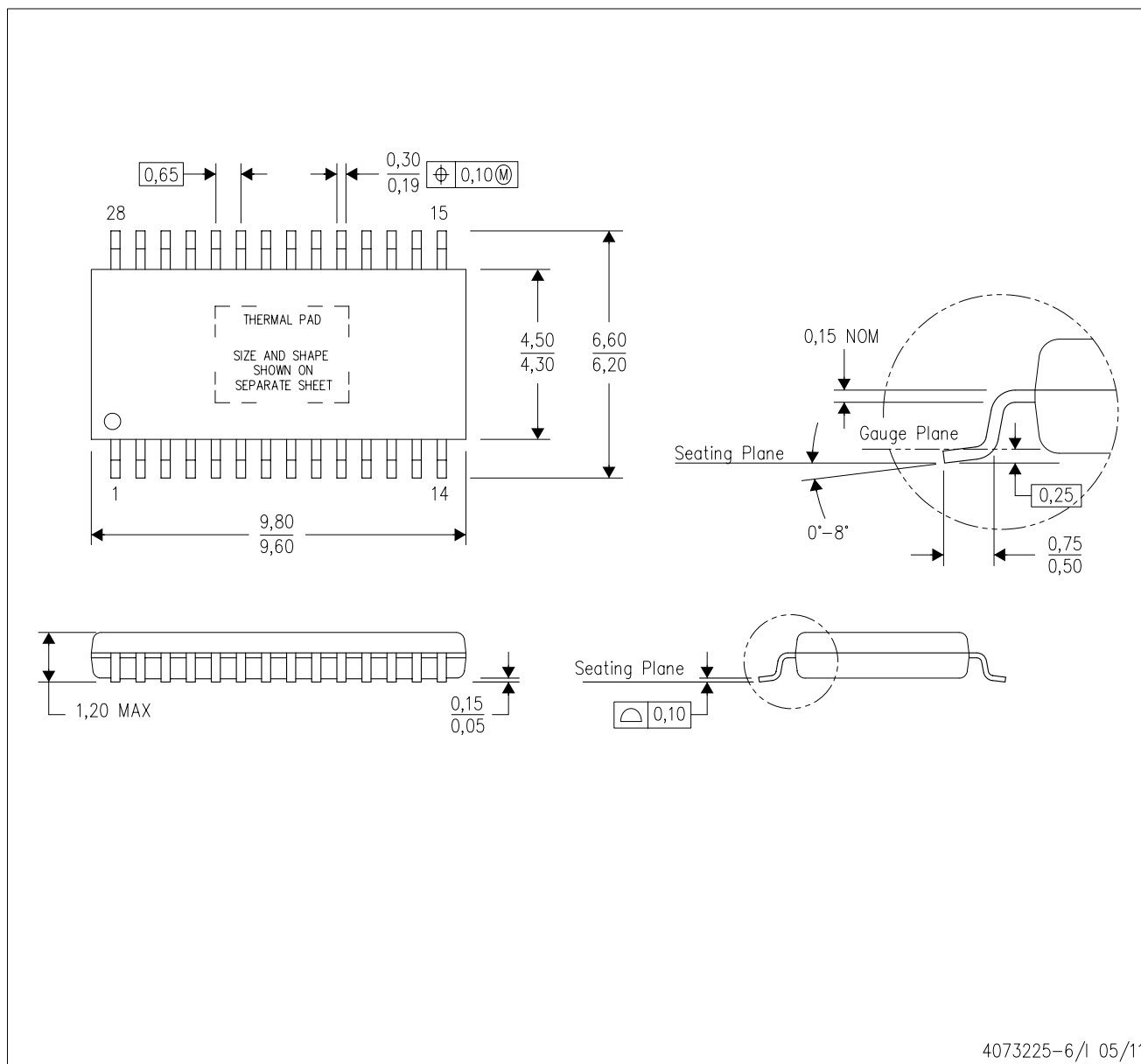
Images above are just a representation of the package family, actual package may vary.  
Refer to the product data sheet for package details.

4224765/A



PWP (R-PDSO-G28)

PowerPAD™ PLASTIC SMALL OUTLINE



- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Body dimensions do not include mold flash or protrusions. Mold flash and protrusion shall not exceed 0.15 per side.
  - D. This package is designed to be soldered to a thermal pad on the board. Refer to Technical Brief, PowerPad Thermally Enhanced Package, Texas Instruments Literature No. SLMA002 for information regarding recommended board layout. This document is available at [www.ti.com](http://www.ti.com) <<http://www.ti.com>>.
  - E. See the additional figure in the Product Data Sheet for details regarding the exposed thermal pad features and dimensions.
  - E. Falls within JEDEC MO-153

PowerPAD is a trademark of Texas Instruments.

## THERMAL PAD MECHANICAL DATA

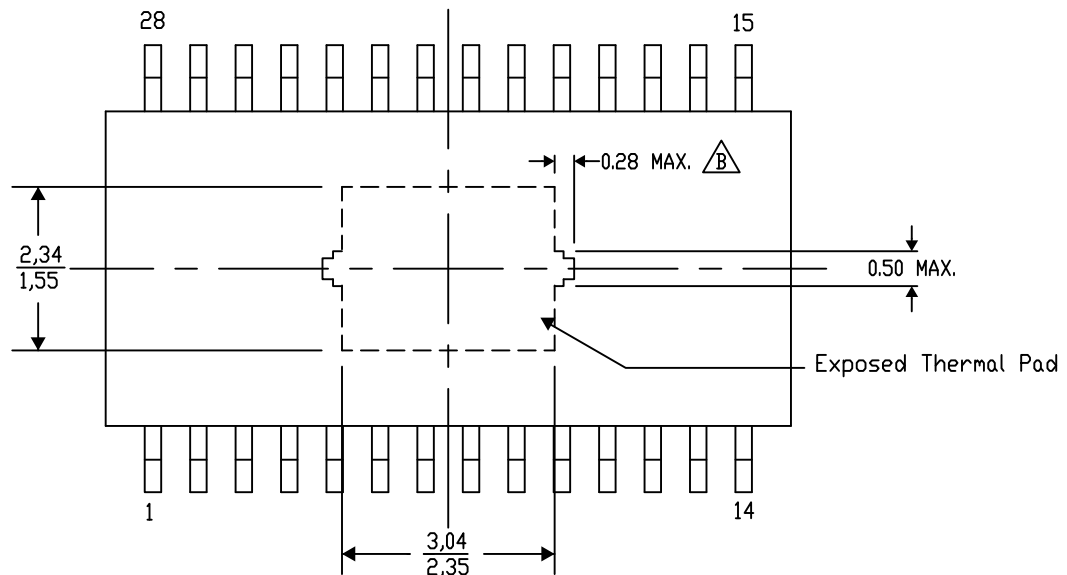
### PWP (R-PDSO-G28) PowerPAD™ SMALL PLASTIC OUTLINE

#### THERMAL INFORMATION

This PowerPAD™ package incorporates an exposed thermal pad that is designed to be attached to a printed circuit board (PCB). The thermal pad must be soldered directly to the PCB. After soldering, the PCB can be used as a heatsink. In addition, through the use of thermal vias, the thermal pad can be attached directly to the appropriate copper plane shown in the electrical schematic for the device, or alternatively, can be attached to a special heatsink structure designed into the PCB. This design optimizes the heat transfer from the integrated circuit (IC).

For additional information on the PowerPAD package and how to take advantage of its heat dissipating abilities, refer to Technical Brief, PowerPAD Thermally Enhanced Package, Texas Instruments Literature No. SLMA002 and Application Brief, PowerPAD Made Easy, Texas Instruments Literature No. SLMA004. Both documents are available at [www.ti.com](http://www.ti.com).

The exposed thermal pad dimensions for this package are shown in the following illustration.



Top View

Exposed Thermal Pad Dimensions

4206332-39/AO 01/16

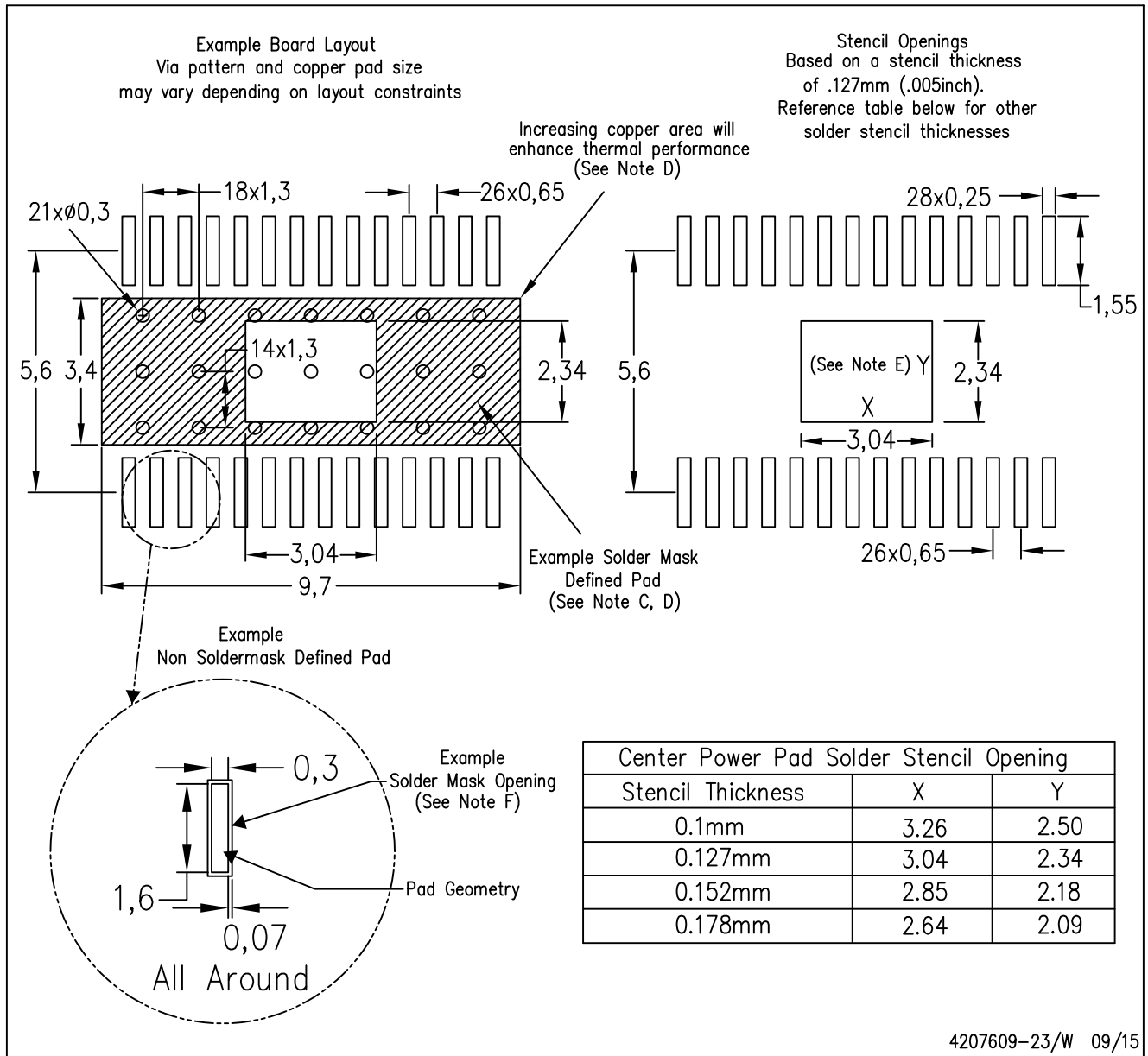
NOTE: A. All linear dimensions are in millimeters

 Exposed tie strap features may not be present.

PowerPAD is a trademark of Texas Instruments

## PWP (R-PDSO-G28)

## PowerPAD™ PLASTIC SMALL OUTLINE



- NOTES:
- All linear dimensions are in millimeters.
  - This drawing is subject to change without notice.
  - Customers should place a note on the circuit board fabrication drawing not to alter the center solder mask defined pad.
  - This package is designed to be soldered to a thermal pad on the board. Refer to Technical Brief, PowerPad Thermally Enhanced Package, Texas Instruments Literature No. SLMA002, SLMA004, and also the Product Data Sheets for specific thermal information, via requirements, and recommended board layout. These documents are available at [www.ti.com](http://www.ti.com) <<http://www.ti.com>>. Publication IPC-7351 is recommended for alternate designs.
  - Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Example stencil design based on a 50% volumetric metal load solder paste. Refer to IPC-7525 for other stencil recommendations.
  - Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

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