

H-BRIDGE MOTOR CONTROLLER IC

 Check for Samples: [DRV8828](#)

FEATURES

- **Single H-Bridge Current-Control Motor Driver**
 - Capable of Driving One Winding of a Bipolar Stepper or One DC Motor
 - Five-Bit Winding Current Control Allows Up to 32 Current Levels
 - Low MOSFET On-Resistance
- **3-A Maximum Drive Current at 24 V, 25°C**
- **Built-In 3.3-V Reference Output**
- **Parallel Digital Control Interface**
- **8-V to 45-V Operating Supply Voltage Range**
- **Thermally Enhanced Surface Mount Package**

APPLICATIONS

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

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).

ORDERING INFORMATION⁽¹⁾

T _A	PACKAGE ⁽²⁾		ORDERABLE PART NUMBER	TOP-SIDE MARKING
–40°C to 85°C	PowerPAD™ (HTSSOP) - PWP	Reel of 2000	DRV8828PWPR	8828

(1) For the most current packaging and ordering information, see the Package Option Addendum at the end of this document, or see the TI web site at www.ti.com.

(2) Package drawings, thermal data, and symbolization are available at www.ti.com/packaging.



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

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DEVICE INFORMATION

Functional Block Diagram

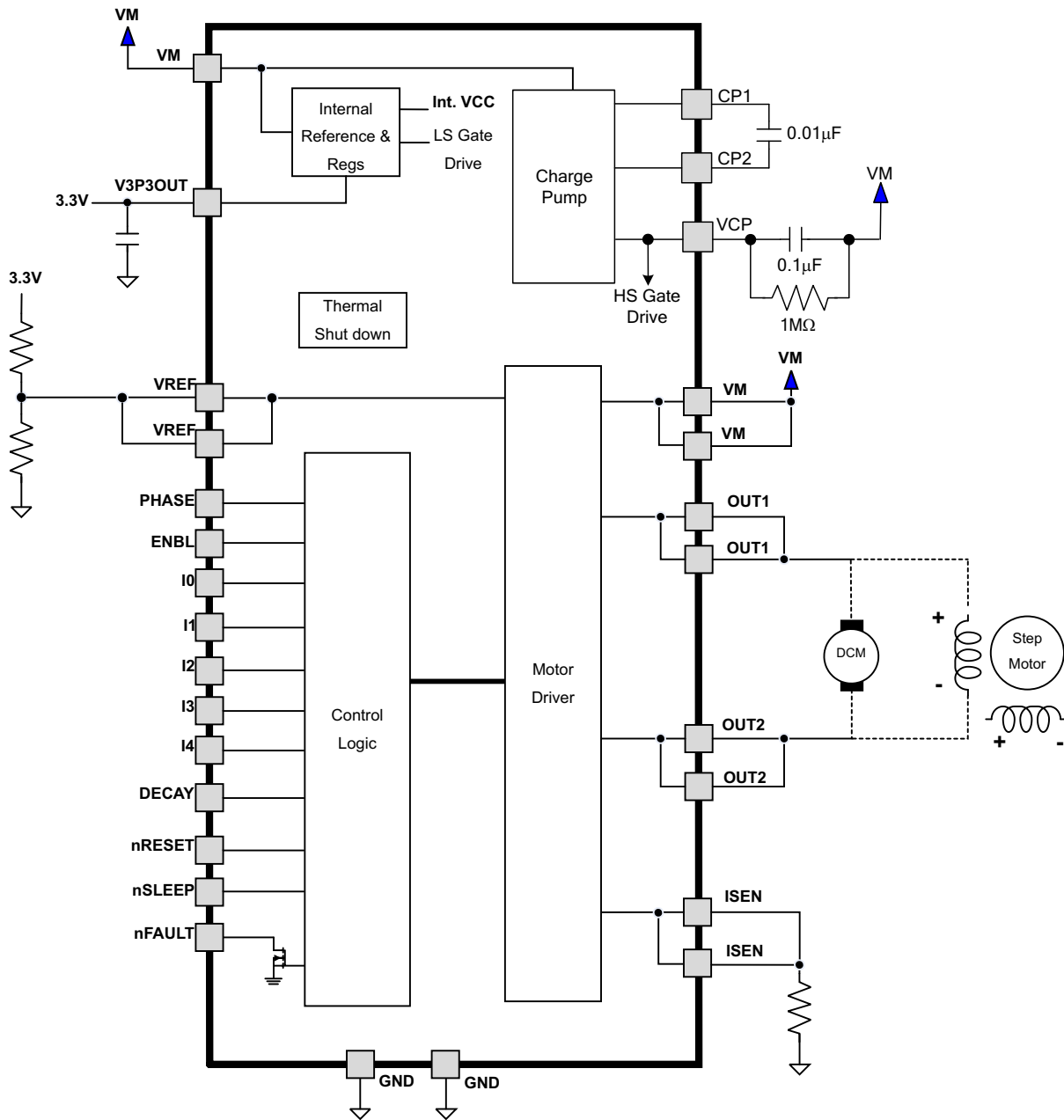
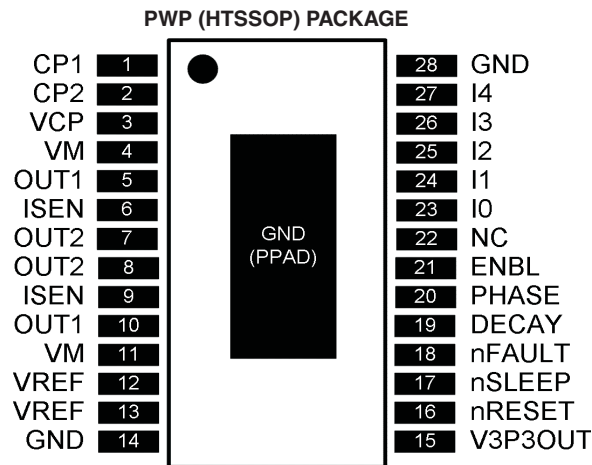


Table 1. TERMINAL FUNCTIONS

NAME	PIN	I/O ⁽¹⁾	DESCRIPTION	EXTERNAL COMPONENTS OR CONNECTIONS
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- μ F 6.3-V ceramic capacitor. Can be used to supply VREF.
CP1	1	IO	Charge pump flying capacitor	Connect a 0.01- μ F 50-V capacitor between CP1 and CP2.
CP2	2	IO	Charge pump flying capacitor	
VCP	3	IO	High-side gate drive voltage	Connect a 0.1- μ F 16-V ceramic capacitor and a 1-M Ω resistor to VM.
CONTROL				
ENBL	21	I	Bridge enable	Logic high to enable H-bridge. Internal pull-down.
PHASE	20	I	Bridge phase (direction)	Logic high sets OUT1 high, OUT2 low. Internal pull-down.
I0	23	I	Current set inputs	Sets winding current as a percentage of full-scale. Internal pull-down.
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 Internal pull-down and pullup.
nRESET	16	I	Reset input	Active-low reset input initializes internal logic and disables the H-bridge outputs. Internal pull-down.
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- μ F 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 pull-down.
NC	22		No connect	Leave this pin unconnected.
STATUS				
nFAULT	18	OD	Fault	Logic low when in fault condition (overtemp, overcurrent)
OUTPUT				
ISEN	6, 9	IO	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	

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



ABSOLUTE MAXIMUM RATINGS

over operating free-air temperature range (unless otherwise noted) ⁽¹⁾ ⁽²⁾

		VALUE	UNIT
VM	Power supply voltage range	–0.3 to 47	V
	Digital pin voltage range	–0.5 to 7	V
VREF	Input voltage	–0.3 to 4	V
	ISENSE pin voltage	–0.3 to 0.8	V
	Peak motor drive output current, t < 1 μS	Internally limited	A
	Continuous motor drive output current ⁽³⁾	3	A
	Continuous total power dissipation	See Dissipation Ratings table	
T _J	Operating virtual junction temperature range	–40 to 150	°C
T _{stg}	Storage temperature range	–60 to 150	°C

- (1) 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.
- (2) All voltage values are with respect to network ground terminal.
- (3) Power dissipation and thermal limits must be observed.

THERMAL INFORMATION

THERMAL METRIC ⁽¹⁾		DRV8828	UNITS
		PWP	
		28 PINS	
θ_{JA}	Junction-to-ambient thermal resistance ⁽²⁾	38.9	°C/W
θ_{JcTop}	Junction-to-case (top) thermal resistance ⁽³⁾	23.3	
θ_{JB}	Junction-to-board thermal resistance ⁽⁴⁾	21.2	
ψ_{JT}	Junction-to-top characterization parameter ⁽⁵⁾	0.8	
ψ_{JB}	Junction-to-board characterization parameter ⁽⁶⁾	20.9	
θ_{JcBot}	Junction-to-case (bottom) thermal resistance ⁽⁷⁾	2.6	

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

(2) The junction-to-ambient thermal resistance under natural convection is obtained in a simulation on a JEDEC-standard, high-K board, as specified in JESD51-7, in an environment described in JESD51-2a.

(3) The junction-to-case (top) thermal resistance is obtained by simulating a cold plate test on the package top. No specific JEDEC-standard test exists, but a close description can be found in the ANSI SEMI standard G30-88.

(4) The junction-to-board thermal resistance is obtained by simulating in an environment with a ring cold plate fixture to control the PCB temperature, as described in JESD51-8.

(5) The junction-to-top characterization parameter, ψ_{JT} , estimates the junction temperature of a device in a real system and is extracted from the simulation data for obtaining θ_{JA} , using a procedure described in JESD51-2a (sections 6 and 7).

(6) The junction-to-board characterization parameter, ψ_{JB} , estimates the junction temperature of a device in a real system and is extracted from the simulation data for obtaining θ_{JA} , using a procedure described in JESD51-2a (sections 6 and 7).

(7) The junction-to-case (bottom) thermal resistance is obtained by simulating a cold plate test on the exposed (power) pad. No specific JEDEC standard test exists, but a close description can be found in the ANSI SEMI standard G30-88.

RECOMMENDED OPERATING CONDITIONS

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

		MIN	NOM	MAX	UNIT
V_M	Motor power supply voltage range ⁽¹⁾	8.2		45	V
V_{REF}	VREF input voltage ⁽²⁾	1		3.5	V
I_{V3P3}	V3P3OUT load current			1	mA

(1) All V_M pins must be connected to the same supply voltage.

(2) Operational at VREF between 0 V and 1 V, but accuracy is degraded.

ELECTRICAL CHARACTERISTICS

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

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
POWER SUPPLIES						
I_{VM}	VM operating supply current	$V_M = 24\text{ V}$, $f_{PWM} < 50\text{ kHz}$		5	8	mA
I_{VMQ}	VM sleep mode supply current	$V_M = 24\text{ V}$		10	20	μA
V_{UVLO}	VM undervoltage lockout voltage	V_M rising		7.8	8.2	V
V3P3OUT REGULATOR						
V_{3P3}	V3P3OUT voltage	$I_{OUT} = 0\text{ to }1\text{ mA}$, $V_M = 24\text{ V}$, $T_J = 25^\circ\text{C}$	3.18	3.30	3.42	V
		$I_{OUT} = 0\text{ to }1\text{ mA}$	3.10	3.30	3.50	
LOGIC-LEVEL INPUTS						
V_{IL}	Input low voltage			0.6	0.7	V
V_{IH}	Input high voltage		2		5.25	V
V_{HYS}	Input hysteresis			0.45		V
I_{IL}	Input low current	$V_{IN} = 0$	-20		20	μA
I_{IH}	Input high current	$V_{IN} = 3.3\text{ V}$			100	μA
R_{PD}	Internal pulldown resistance	ENBL, PHASE, I0, I1, I2, I3, I4, nRESET		100		k Ω
		nSLEEP		1		M Ω
nFAULT OUTPUT (OPEN-DRAIN OUTPUT)						
V_{OL}	Output low voltage	$I_O = 5\text{ mA}$			0.5	V
I_{OH}	Output high leakage current	$V_O = 3.3\text{ V}$			1	μA
DECAY INPUT						
V_{IL}	Input low threshold voltage	For slow decay mode			0.8	V
V_{IH}	Input high threshold voltage	For fast decay mode	2			V
I_{IN}	Input current				± 40	μA
R_{PU}	Internal pullup resistance			130		k Ω
R_{PD}	Internal pulldown resistance			80		k Ω
H-BRIDGE FETS						
$R_{DS(ON)}$	HS FET on resistance	$V_M = 24\text{ V}$, $I_O = 1\text{ A}$, $T_J = 25^\circ\text{C}$		0.32		Ω
		$V_M = 24\text{ V}$, $I_O = 1\text{ A}$, $T_J = 85^\circ\text{C}$		0.39	0.45	
$R_{DS(ON)}$	LS FET on resistance	$V_M = 24\text{ V}$, $I_O = 1\text{ A}$, $T_J = 25^\circ\text{C}$		0.33		Ω
		$V_M = 24\text{ V}$, $I_O = 1\text{ A}$, $T_J = 85^\circ\text{C}$		0.39	0.45	
I_{OFF}	Off-state leakage current		-40		40	μA
MOTOR DRIVER						
f_{PWM}	PWM frequency			50		kHz
t_{BLANK}	Current sense blanking time			3.75		μs
t_R	Rise time	$V_M = 24\text{ V}$	100		360	ns
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	μs

ELECTRICAL CHARACTERISTICS (continued)

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

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
PROTECTION CIRCUITS						
I_{OCP}	Overcurrent protection trip level		3.6		10	A
t_{TSD}	Thermal shutdown temperature	Die temperature	150	160	180	°C
CURRENT CONTROL						
I_{REF}	VREF input current	VREF = 3.3 V	-3		3	μA
V_{TRIP}	ISENSE trip voltage	VREF = 3.3 V, 100% current setting	635	660	685	mV
ΔI_{TRIP}	Current trip accuracy (relative to programmed value)	VREF = 3.3V, 5% current setting	-25		25	%
		VREF = 3.3V, 10% - 34% current setting	-15		15	
		VREF = 3.3 V, 38% - 67% current setting	-10		10	
		VREF = 3.3 V, 71% - 100% current setting	-5		5	
A_{ISENSE}	Current sense amplifier gain	Reference only		5		V/V

FUNCTIONAL DESCRIPTION

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 1. A bipolar stepper motor is shown, but the driver can also drive a DC motor.

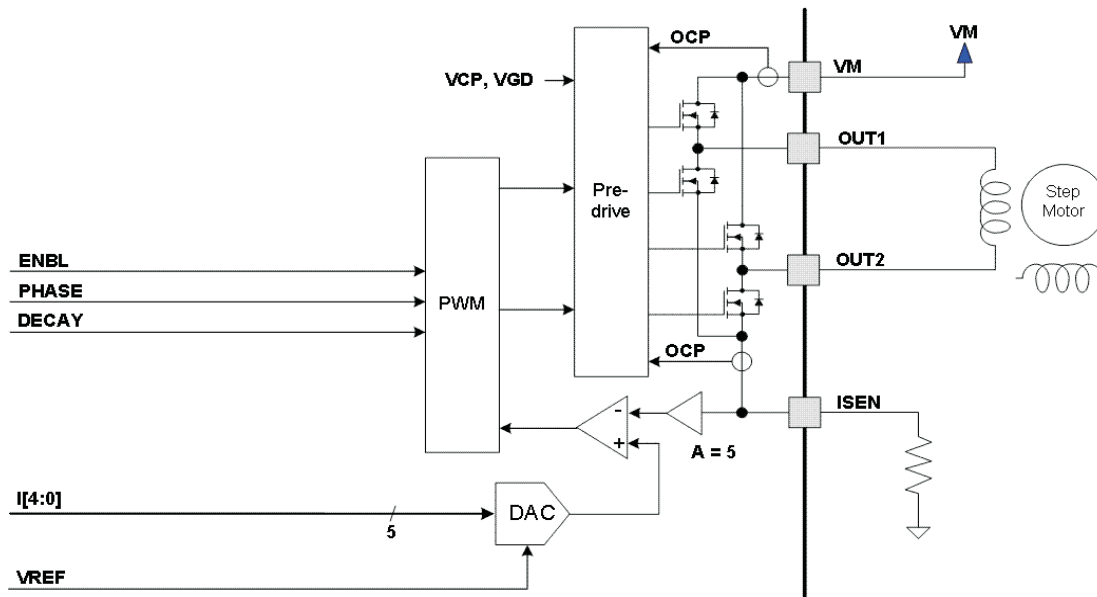


Figure 1. Motor Control Circuitry

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

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 2 shows the logic.

Table 2. H-Bridge Logic

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

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 3](#).

Table 3. H-Bridge Pin Functions

I[4..0]	RELATIVE CURRENT (% 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%

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 2](#) 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 2 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 2 as case 3.

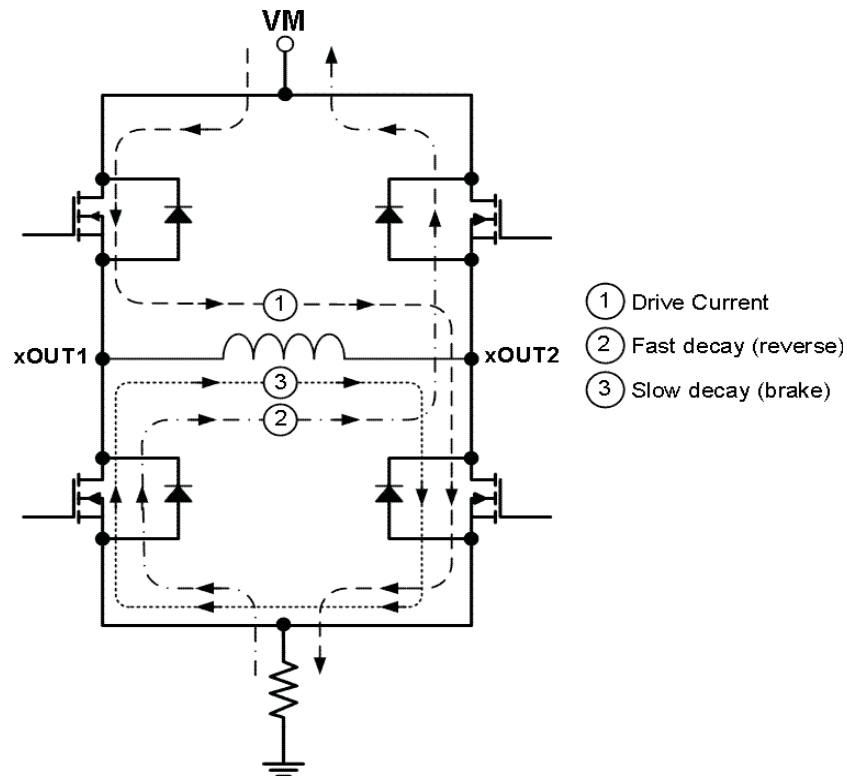


Figure 2. Decay Mode

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 k Ω and an internal pulldown resistor of approximately 80 k Ω . 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.

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 μ s. Note that the blanking time also sets the minimum on time of the PWM.

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 Ω . The nSLEEP pin has an internal pulldown resistor of 1 M Ω .

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.

Protection Circuits

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

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.

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.

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.

THERMAL INFORMATION

Thermal Protection

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.

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 stepper motor can be roughly estimated by [Equation 2](#).

$$P_{TOT} = 4 \cdot R_{DS(ON)} \cdot (I_{OUT(RMS)})^2 \quad (2)$$

where P_{TOT} is the total power dissipation, $R_{DS(ON)}$ is the resistance of each FET, and $I_{OUT(RMS)}$ is the RMS output current being applied to each winding. $I_{OUT(RMS)}$ is equal to the approximately 0.7x the full-scale output current setting. The factor of 4 comes from the fact that there are two motor windings, and at any instant two FETs are conducting winding current for each winding (one high-side and one low-side).

The maximum amount of power that can be dissipated in the device is dependent on ambient temperature and heatsinking.

Note that $R_{DS(ON)}$ increases with temperature, so as the device heats, the power dissipation increases. This must be taken into consideration when sizing the heatsink.

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.

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

PACKAGING INFORMATION

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

(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.

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TAPE AND REEL INFORMATION

QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE


*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



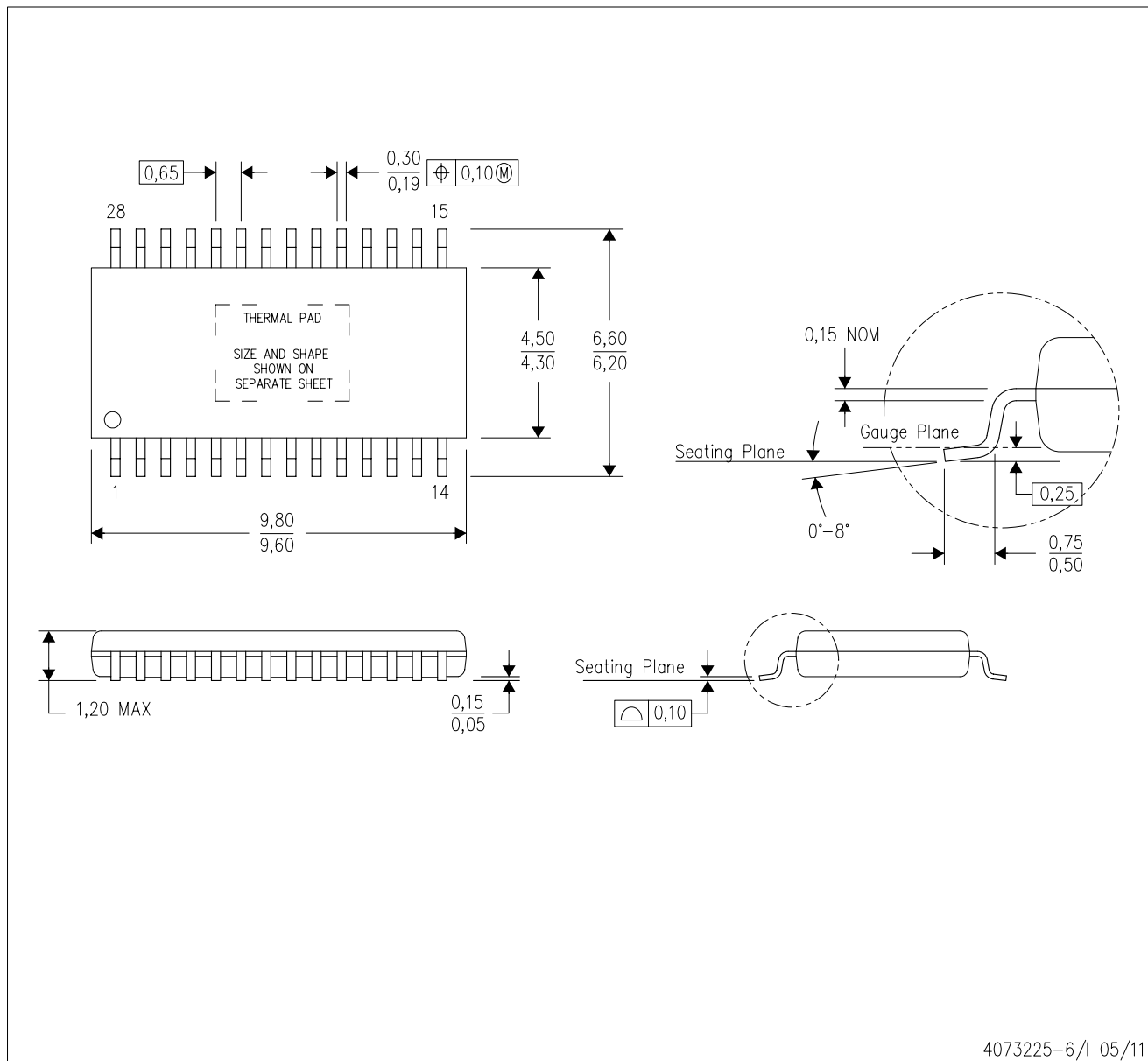
*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
DRV8828PWPR	HTSSOP	PWP	28	2000	367.0	367.0	38.0

MECHANICAL DATA

PWP (R-PDSO-G28)

PowerPAD™ PLASTIC SMALL OUTLINE



4073225-6/1 05/11

- NOTES:
- All linear dimensions are in millimeters.
 - This drawing is subject to change without notice.
 - Body dimensions do not include mold flash or protrusions. Mold flash and protrusion shall not exceed 0.15 per side.
 - 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>>.
 - See the additional figure in the Product Data Sheet for details regarding the exposed thermal pad features and dimensions.
 - Falls within JEDEC MO-153

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THERMAL PAD MECHANICAL DATA

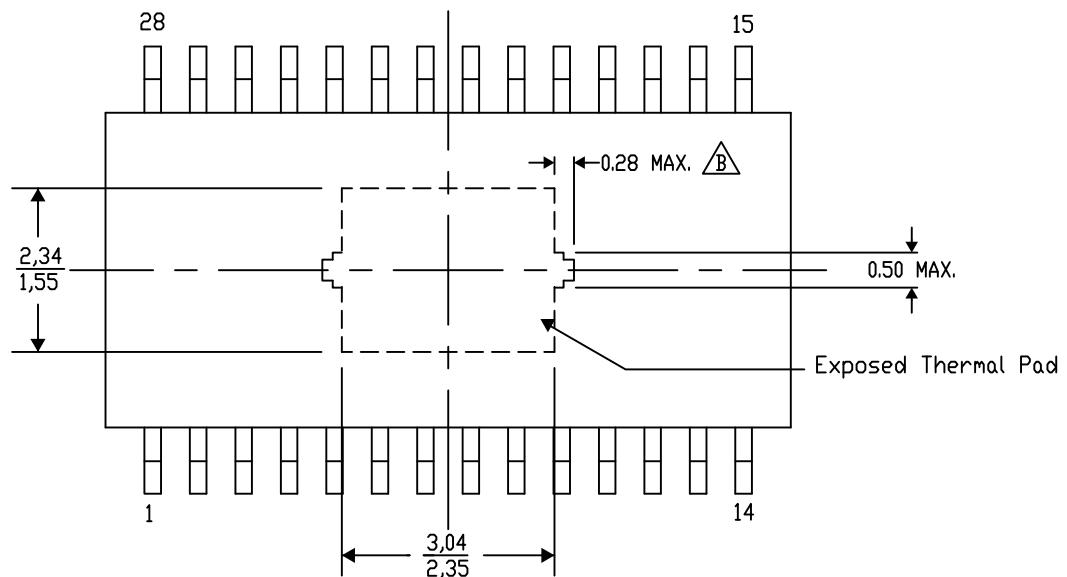
PWP (R-PDSO-G28) PowerPAD™ SMALL PLASTIC OUTLINE

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.

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



Exposed Thermal Pad Dimensions

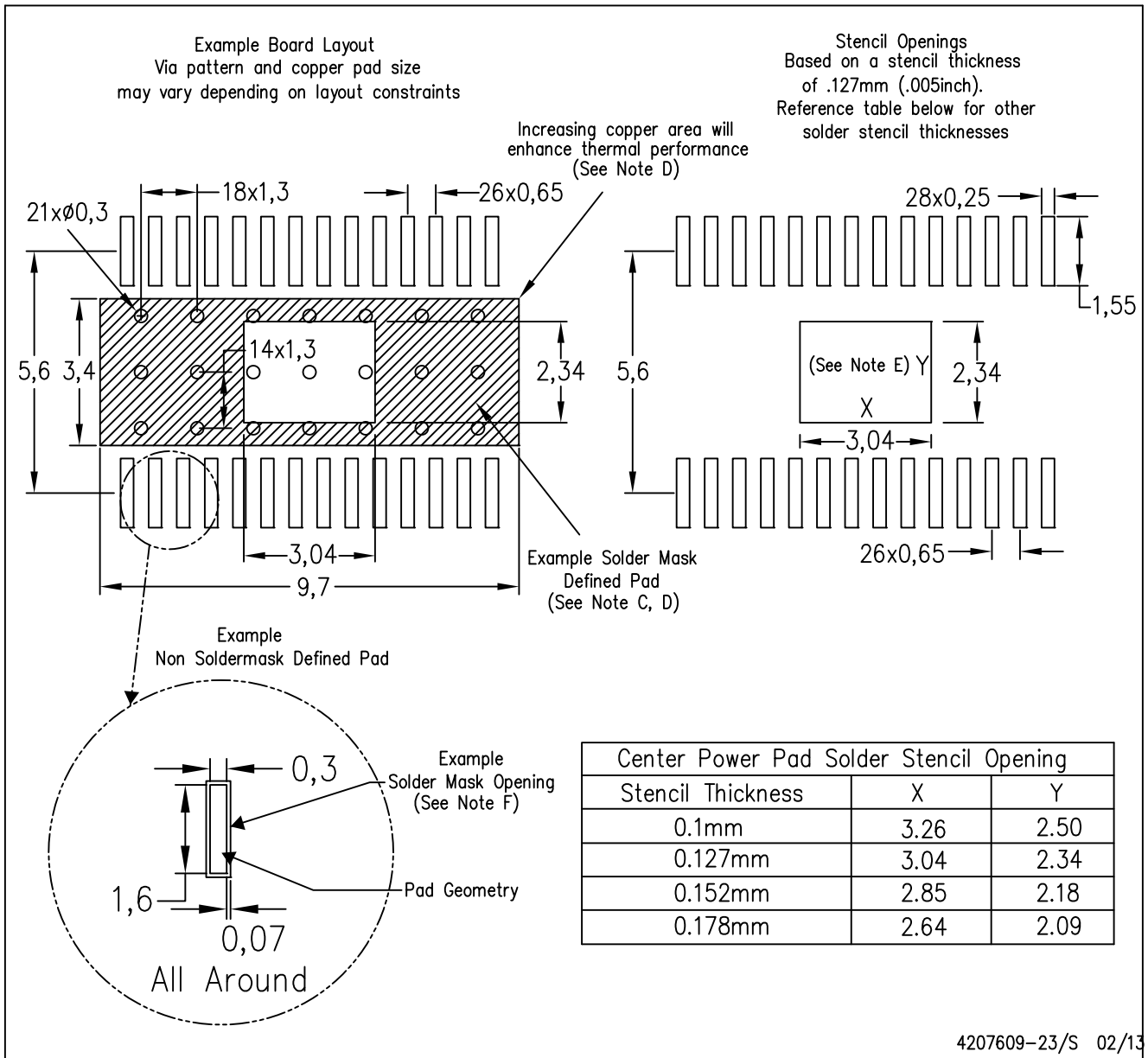
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NOTE: A. All linear dimensions are in millimeters
⚠ Exposed tie strap features may not be present.

PowerPAD is a trademark of Texas Instruments

PWP (R-PDSO-G28)

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- NOTES:
- A. All linear dimensions are in millimeters.
 - B. This drawing is subject to change without notice.
 - C. Customers should place a note on the circuit board fabrication drawing not to alter the center solder mask defined pad.
 - 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, 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>>. Publication IPC-7351 is recommended for alternate designs.
 - E. 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.
 - F. Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

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