# TPS92530-Q1 Automotive 3-Channel, Constant-Current and Constant-Voltage Synchronous Buck LED Driver

## 1 Features

- AEC-Q100 qualified for automotive applications
  - Grade 1: –40°C to 125°C ambient operating temperature
  - Device HBM classification level H1C
  - Device CDM classification level C5
- Functional safety capable
  - Documentation available to aid functional safety system design
- 4.5V to 65V wide input voltage range
- Configurable constant voltage and constant current operation
  - Up to 2A continuous output current
  - 4% regulation accuracy (voltage and current mode)
- Adaptive on-time average current control
- Programmable switching frequency from 100kHz to 1.2MHz
- Advanced dimming operation
  - 10-bit precision analog dimming
  - 10-bit precision internal PWM dimming
  - Supports external PWM dimming input
  - Optimized for external shunt dimming including LED matrix manager
- Cycle-by-cycle switch overcurrent protection
- Switch thermal protection
- Serial Peripheral Interface (SPI)
  - Configurable analog reference, switching frequency, and PWM dimming duty cycle
  - Fault monitoring and reporting
- Limp-home (LH) and standalone mode operation

## 2 Applications

Automotive headlight and adaptive LED driving module

## 3 Description

The TPS92530-Q1 is a monolithic, 3-channel, synchronous, buck LED driver with a wide 4.5V to 65V operating input voltage range that can independently power three strings of series connected LEDs. The TPS92530-Q1 implements an adaptive on-time average current mode control and is designed to generate constant voltage or constant current output. The adaptive on-time control provides near constant switching frequency that can be set between 100kHz and 1.2MHz. In constant current mode, the device is compatible with shunt FET dimming techniques and with LED matrix manager-based dynamic beam headlamps. In constant voltage mode, the adaptive on-time control enables high bandwidth operation with fast transient response. Inductor current sensing and closed-loop feedback enables better than ±4% accuracy over wide input voltage, output voltage, and ambient temperature range.

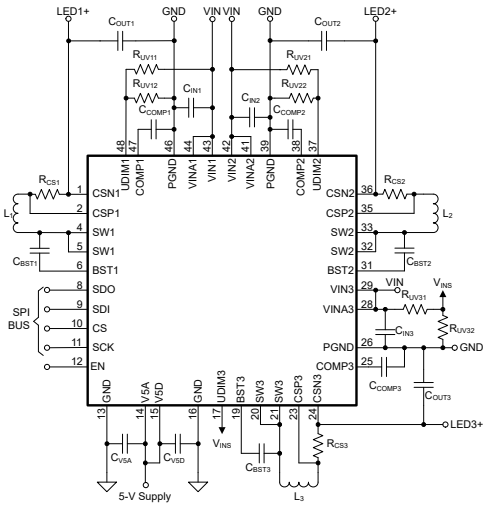
In constant current mode, the high performance LED driver can independently modulate LED current using both analog or PWM dimming techniques. Linear analog dimming response with over 16:1 range is obtained by programming the 10-bit reference value (CHxREF) through SPI. PWM dimming of LED current is achieved by directly modulating the corresponding UDIM input pin with the desired duty cycle or by enabling the internal PWM generator circuit. The PWM generator translates the 10-bit PWM register value to a corresponding duty cycle by comparing it to a programmable digital counter.

The TPS92530-Q1 incorporates advanced SPI programmable diagnostic and fault protection featuring: cycle-by-cycle switch current limit, bootstrap undervoltage, LED open, LED short, thermal warning and thermal shutdown. An on-board 10-bit ADC samples critical input parameters required for system health monitoring and diagnostics.

**Package Information**

| PART NUMBER(1) | PACKAGE | BODY SIZE (NOM) |
|---|---|---|
| TPS92530-Q1 | PKD (HTQFP, 48) | 7.00mm × 7.00mm |

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




**Simplified Schematic**

An IMPORTANT NOTICE at the end of this data sheet addresses availability, warranty, changes, use in safety-critical applications, intellectual property matters and other important disclaimers. PRODUCTION DATA.

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# 4 Device and Documentation Support

## 4.1 Documentation Support

### 4.1.1 Related Documentation

For related documentation see the following:

Texas Instruments, *TPS92530-Q1 Launchpad Evaluation Module* user's guide

## 4.2 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. In the upper right corner, click on *Alert me* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

## 4.3 Support Resources

TI E2E™ support forums are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

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## 4.4 Trademarks

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## 4.5 Glossary

| | |
|---|---|
| TI Glossary | This glossary lists and explains terms, acronyms, and definitions. |

# 5 Revision History

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

| DATE | REVISION | NOTES |
|---|---|---|
| December 2023 | * | Initial Release |

# 6 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.

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## 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) |
|---|---|---|---|---|---|---|---|---|---|
| TPS92530QPKDRQ1 | Active | Production | HTQFP (PKD) \| 48 | 1000 \| LARGE T&R | Yes | NIPDAU | Level-3-260C-168 HR | -40 to 125 | TPS92530 |
| TPS92530QPKDRQ1.A | Active | Production | HTQFP (PKD) \| 48 | 1000 \| LARGE T&R | Yes | NIPDAU | Level-3-260C-168 HR | -40 to 125 | TPS92530 |
| TPS92530QPKDRQ1.B | Active | Production | HTQFP (PKD) \| 48 | 1000 \| LARGE T&R | - | NIPDAU | Level-3-260C-168 HR | -40 to 125 | TPS92530 |

(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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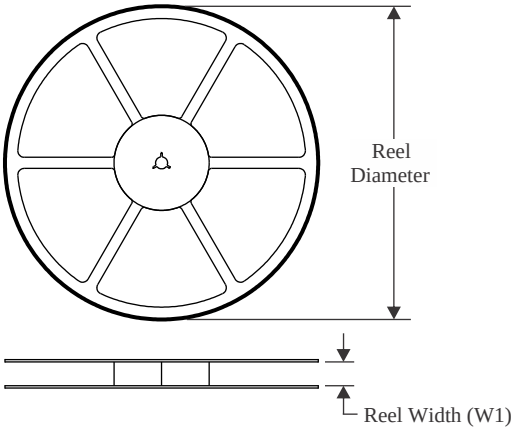
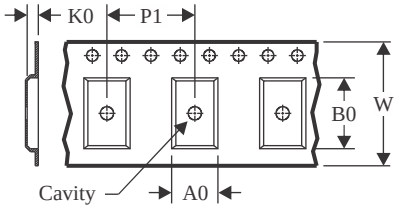
## TAPE AND REEL INFORMATION

**REEL DIMENSIONS**

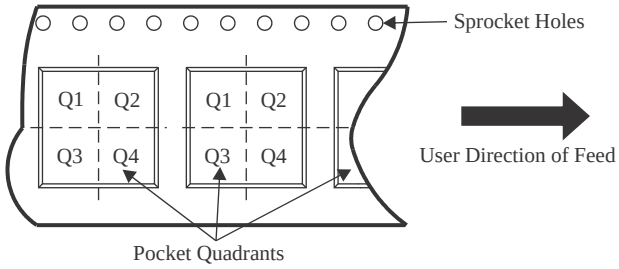



**TAPE DIMENSIONS**




| | |
|---|---|
| A0 | Dimension designed to accommodate the component width |
| B0 | Dimension designed to accommodate the component length |
| K0 | Dimension designed to accommodate the component thickness |
| W | Overall width of the carrier tape |
| P1 | Pitch between successive cavity centers |

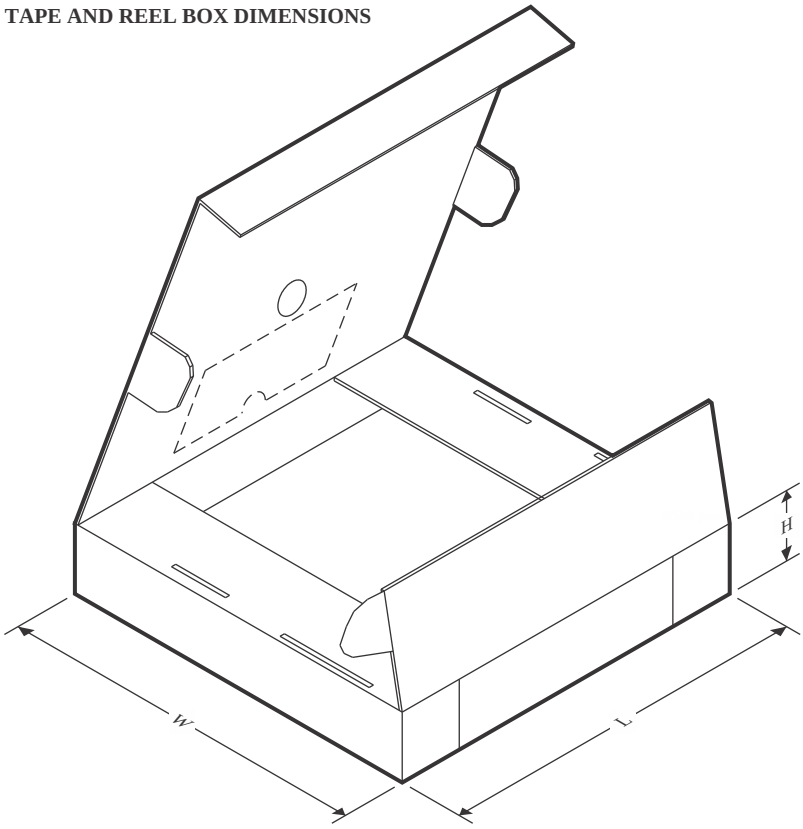
**QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE**




*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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TPS92530QPKDRQ1 | HTQFP | PKD | 48 | 1000 | 330.0 | 16.4 | 9.6 | 9.6 | 1.5 | 12.0 | 16.0 | Q2 |

TAPE AND REEL BOX DIMENSIONS




*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|---|---|---|---|---|---|---|---|
| TPS92530QPKDRQ1 | HTQFP | PKD | 48 | 1000 | 336.6 | 336.6 | 31.8 |

# GENERIC PACKAGE VIEW

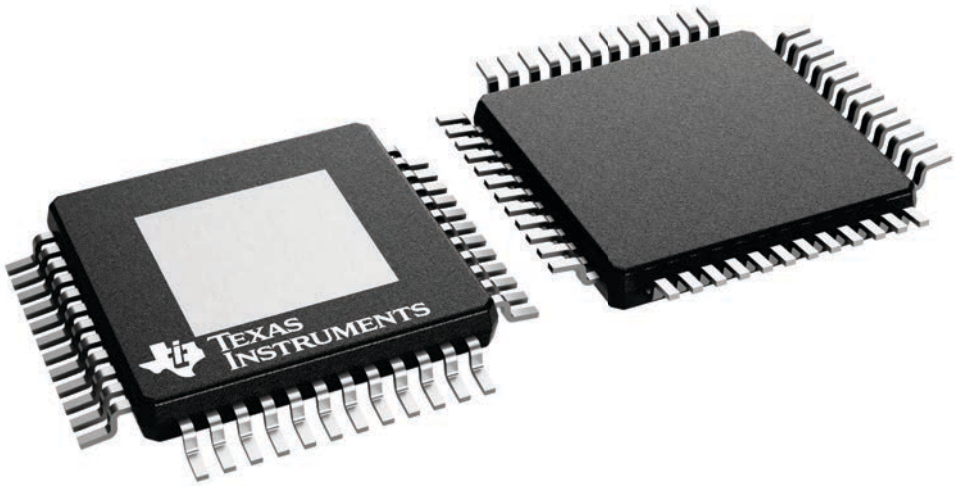
## PKD 48

## PowerPAD™ HTQFP - 1.15 mm max height

**7 x 7, 0.5 mm pitch**

PLASTIC QUAD FLATPACK

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

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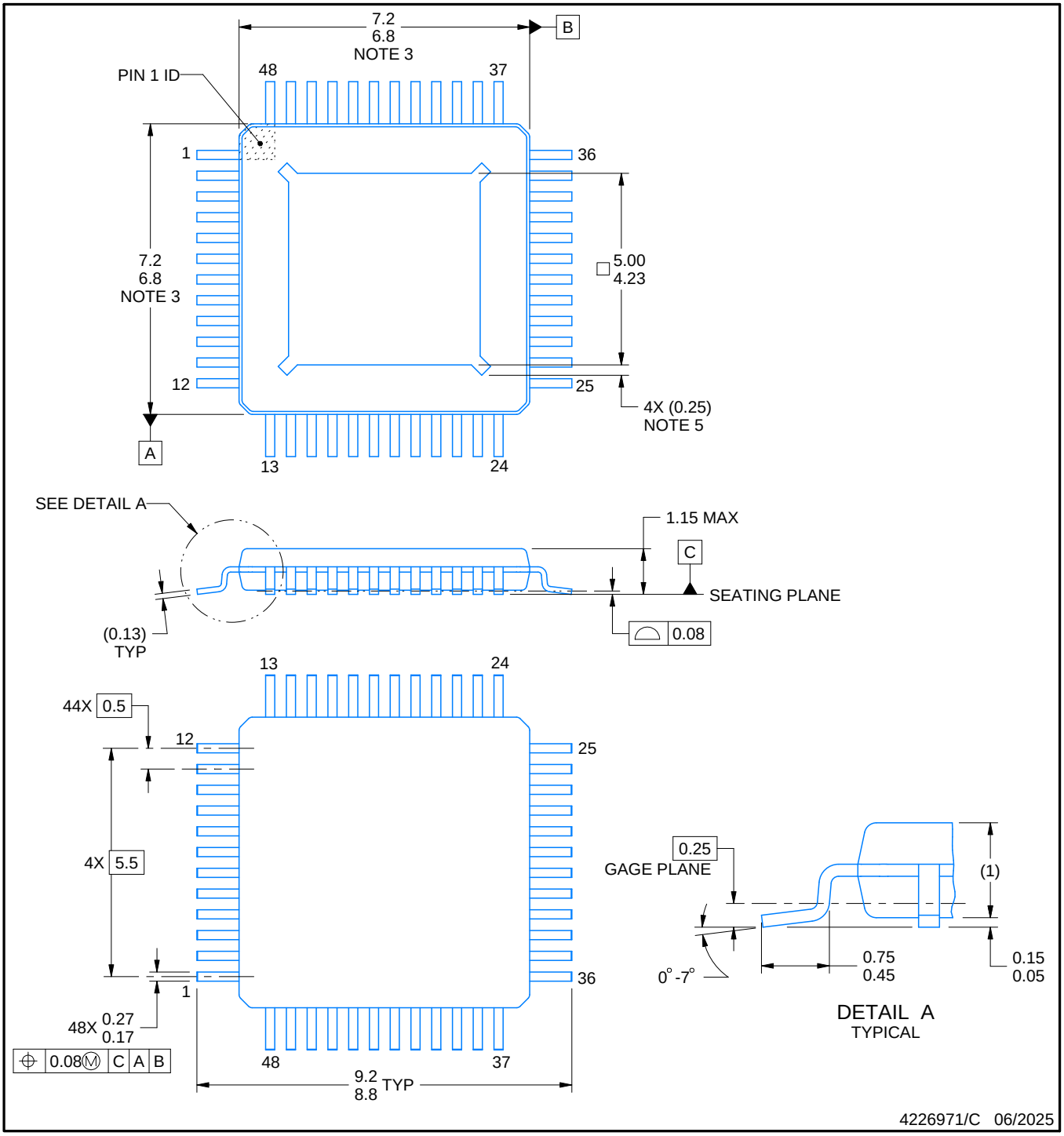
# PACKAGE OUTLINE

## PKD0048A

## PowerPAD ™HTQFP - 1.15 mm max height

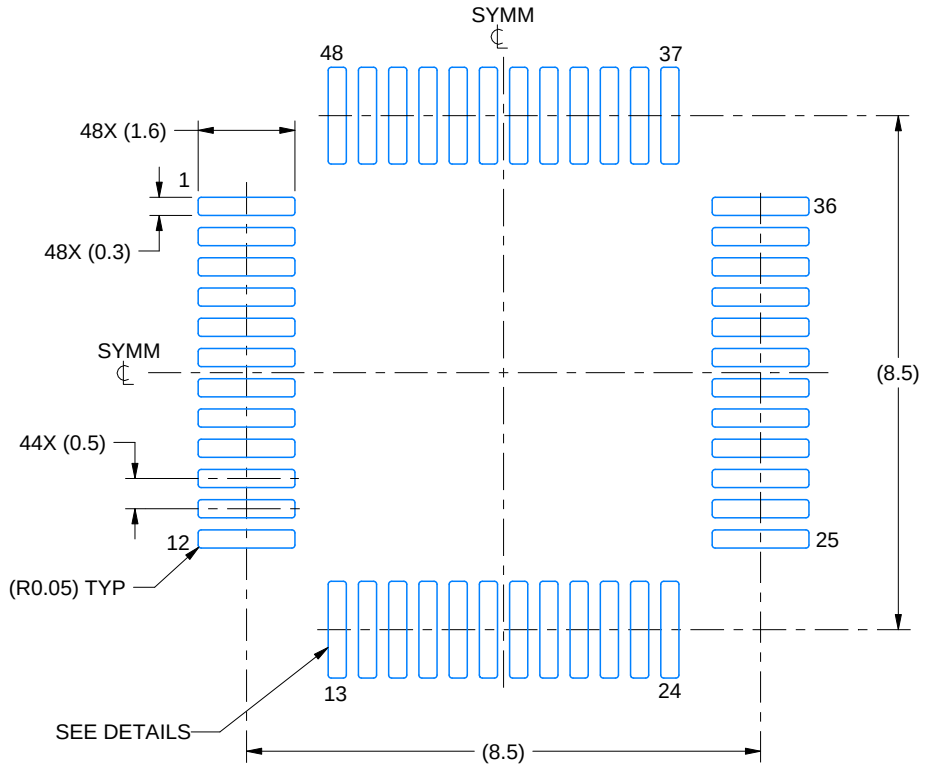
PLASTIC QUAD FLATPACK



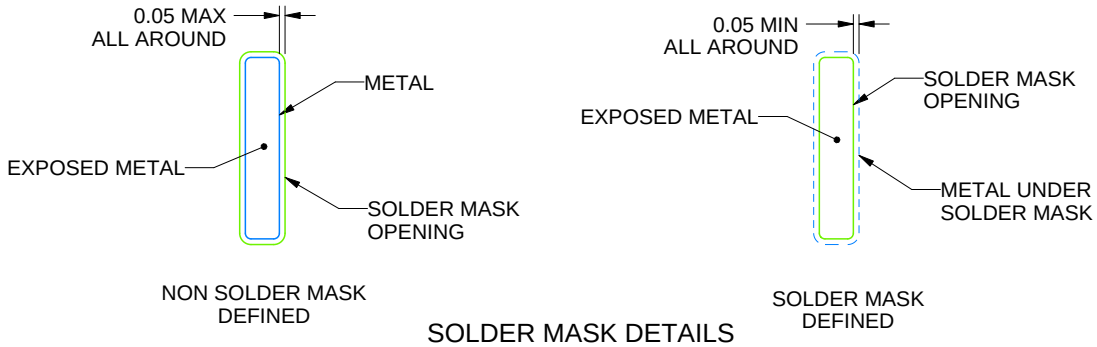

PowerPAD is a trademark of Texas Instruments.

NOTES:

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 MS-026.
5. Feature may not be present.




LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:8X




SOLDER MASK DETAILS

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NOTES: (continued)

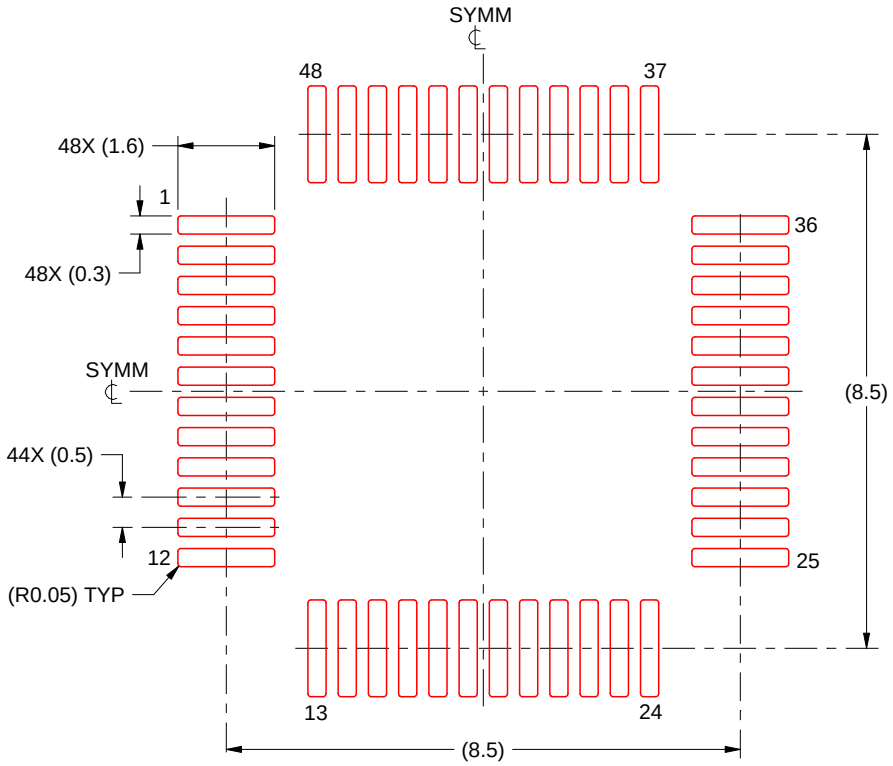
6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.
8. This package is designed to be soldered to a thermal pad on the board. See technical brief, Powerpad thermally enhanced package, Texas Instruments Literature No. SLMA002 (www.ti.com/lit/slma002) and SLMA004 (www.ti.com/lit/slma004).
9. Vias are optional depending on application, refer to device data sheet. It is recommended that vias under paste be filled, plugged or tented.
10. Size of metal pad may vary due to creepage requirement.

# EXAMPLE STENCIL DESIGN

## PKD0048A

## PowerPAD ™HTQFP - 1.15 mm max height

PLASTIC QUAD FLATPACK




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

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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.

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