TPS653853-Q1 Multirail Power Supply for Microcontrollers in Safety-Relevant Applications

1 Features

- Qualified for Automotive Applications
- AEC-Q100 Qualified with the Following Results:
  - Device Temperature Grade 1: –40°C to +125°C Ambient Operating Temperature
  - Device HBM ESD Classification Level 2
  - Device CDM ESD Classification Level C4B
- Functional Safety-Compliant
  - Developed for Functional Safety Applications
  - Documentation Available to Aid ISO 26262 System Design up to ASIL D
  - Systematic Capability and Hardware Integrity up to ASIL D
- Input Voltage Range
  - 7 to 36-V for Initial Battery Power Up
  - 3.8 to 36-V Full Functionality After Initial Battery Power Up
  - Minimum 2.3 V During Operation After Wake-up
- Supply Rails (With Internal FETs)
  - 6-V Synchronous Buck-Boost Preregulator
  - 5-V, 284-mA LDO (CAN)
  - 3.3-V or 5-V, 350-mA LDO (MCU)
  - 2 LDOs Protected for Sensor Supply or Peripherals
    - 120 mA for Sensor Supply 1 (VSOUT1), 20 mA for Sensor Supply 2 (VSOUT2)
    - Configurable Tracking Mode (Tracking Input Pin), or 3.3-V or 5-V Fixed Output Voltage
    - Short-to-Ground and Battery Protection
  - Charge Pump: 6-V Minimum, 11-V Maximum Above Battery Voltage
- Monitoring and Protection
  - Independent Undervoltage and Overvoltage Monitoring on All Regulator Outputs, Battery Voltage, and Internal Supplies
  - Voltage Monitoring Circuitry, Including Independent Bandgap Reference, Supplied from Separate Battery Voltage Input Pin
  - Self-Check on All Voltage Monitoring (During Power-Up and After Power-Up Initiated by External MCU)
  - All Supplies Protected with Current Limit and Overtemperature Prewarning and Shutdown
- Steering-Angle Monitoring (SAM)
  - 2 Signal Comparators for Position Sensor Signals
  - Rotation Counter
  - Low-Power Mode With Periodically Sampling of Position Sensor Signals
  - Switches for Passing-Through Sensor Signals to MCU
- Microcontroller Interface
  - Open and Close Window or Question-Answer Watchdog Function
  - Lock-Step MCU Error-Signal Monitor
  - DIAGNOSTIC state for Performing Device Self-Tests and System Diagnostics
  - SAFE State for Device and System Protection upon Detected System Failure
  - Clock Monitor for Internal Oscillator
  - Analog and Logic Built-In Self-Test
  - CRC on Non-Volatile Memory as well as Device and System Configuration Registers and SPI Communications
  - Reset Circuit for MCU
  - Diagnostic Output Pin
- SPI With CRC on Command Plus Data
- Error Reporting Through SPI Registers for Errors on System Level and Device Level
- Enable-Drive Output for Disabling External Power-Stages on Any Detected System Failure
- Wake-up through IGN Pin (Ignition) or CAN_WU Pin (Transceiver or Other Function)
- 48-Pin HTSSOP PowerPAD™ IC Package

2 Applications

- Automotive Safety-Relevent Applications
- Industrial Safety-Relevant Applications

3 Description

The TPS653853-Q1 device is a multirail power supply designed to supply microcontrollers in safety relevant applications, such as those found in the automotive industry. The device supports microcontrollers with dual-core lockstep (LS) or loosely coupled architectures (LC).

The TPS653853-Q1 device integrates multiple supply rails to power the MCU, CAN or FlexRay, and external sensors. A buck-boost converter with internal FETs converts the input battery voltage between 2.3 V and 36 V to a 6-V preregulator output that supplies the other regulators. An integrated charge pump provides an overdrive voltage for the internal regulators, and can also be used to drive an external NMOS FET as reverse battery protection. The device supports wake-up from an ignition signal (IGN pin) or wake-up from a CAN transceiver or other signal (CAN_WU pin).

The device has a steering-angle monitoring (SAM) unit that allows the ECU to indirectly capture the position of the steering wheel through the motor-position sensors. A dedicated low-power mode allows this SAM unit to operate even when the ECU is in sleep mode. Integrated SAM-switches allow passing-through of the Motor-Position Sensor signals to the MCU during normal operation, or decoupling the MCU ADC inputs from the motor-position sensor signals when the ECU is in sleep mode.

An independent voltage monitoring unit inside the device monitors undervoltage and overvoltage on all internal supply rails and regulator outputs of the battery supply. Regulator current limits and temperature protections are also implemented. The TPS653853-Q1 device features a question-answer watchdog, MCU error-signal monitor, clock monitoring on internal oscillator, self-check on clock monitor, cyclic redundancy check (CRC) on non-volatile memory and SPI communication, a diagnostic output pin allowing MCU to observe device internal analog and digital signals, a reset circuit for the MCU (NRES pin) and a safing output (ENDRV pin) to disable external power-stages on any detected system-failure. The device automatically runs a built-in self-test (BIST) at start up and the MCU may re-run the BIST during system run time through software control if needed. A dedicated DIAGNOSTIC state allows the MCU to check TPS653853-Q1 functionality.

The TPS653853-Q1 device also has an error reporting capability through the SPI register. The device has separate status bits in the SPI register for each specific error on the system level or device level. When the device detects a particular error condition, it sets the appropriate status bit and keeps this status bit set until the MCU reads-out the SPI register in which this status bit was set. Based on which status bit was set, the MCU can decide whether it must keep the system in a safe state or whether it can resume with the operation of the system.

The TPS653853-Q1 device is available in a 48-pin HTSSOP PowerPAD™ IC package.

Device Information (1)

PART NUMBER	PACKAGE	BODY SIZE
TPS65853-Q1	HTSSOP (48)	12.50 mm × 6.10 mm

(1) For more information, see Section 6.

3.1 Typical Application Diagram

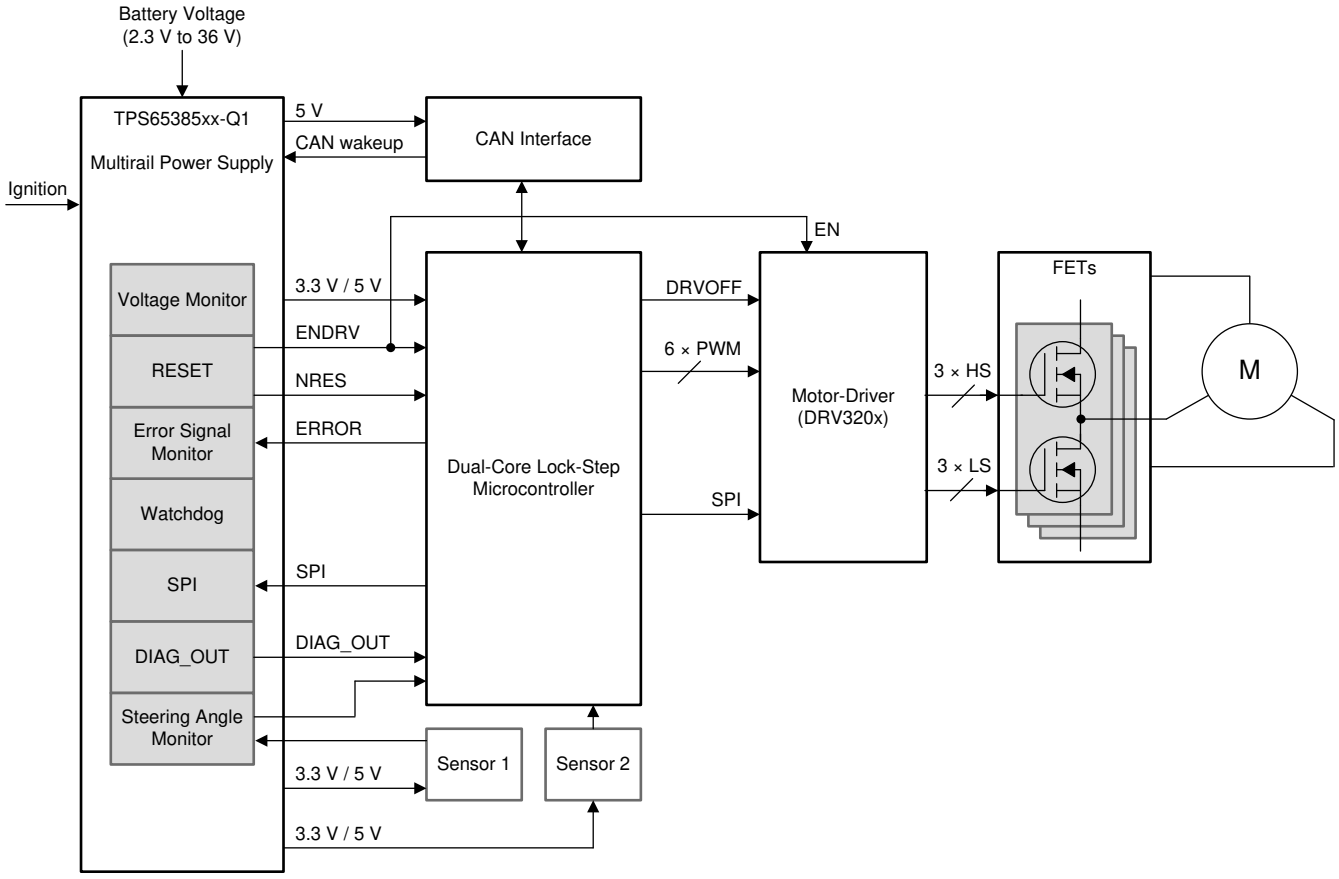

Table of Contents

4 Revision History

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

Changes from Revision A (November 2017) to Revision B (February 2021)	Page
• Added the Functional Safety-Compliant status to the *Features* section.	1
• Updated the numbering format for tables, figures, and cross-references throughout the document	1

Changes from Revision * (December 2016) to Revision A (November 2017)	Page
• Changed 200 mA VDD5 output current to 284 mA in the *Features* and *Functional Block Diagram* section	1

5 Device and Documentation Support

5.1 Documentation Support

5.1.1 Related Documentation

For related documentation see the following:

- Texas instruments, *A Guide to Board Layout for Best Thermal Resistance for Exposed Packages* application report
- Texas instruments, *PowerPAD™ Made Easy* application report
- Texas instruments, *PowerPad™ Thermally Enhanced Package* application report

5.2 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.

5.3 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.

Linked content is 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.

5.4 Trademarks

PowerPAD™ and TI E2E™ are trademarks of Texas Instruments.
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5.5 Electrostatic Discharge Caution

This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

5.6 Glossary

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

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.

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)
O3853QDCARQ1	Active	Production	HTSSOP (DCA) | 48	2000 | LARGE T&R	Yes	NIPDAU	Level-3-260C-168 HR	-40 to 125	O3853
O3853QDCARQ1.A	Active	Production	HTSSOP (DCA) | 48	2000 | LARGE T&R	Yes	NIPDAU	Level-3-260C-168 HR	-40 to 125	O3853

(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.

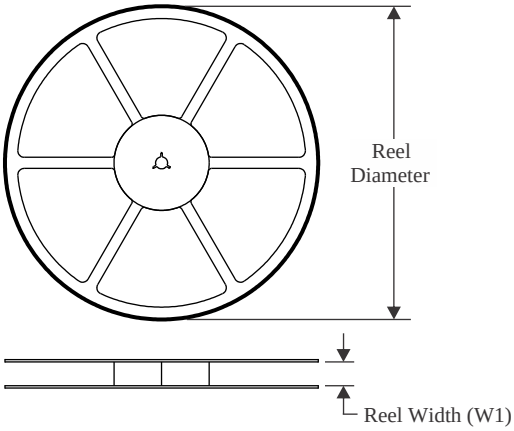
(5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will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

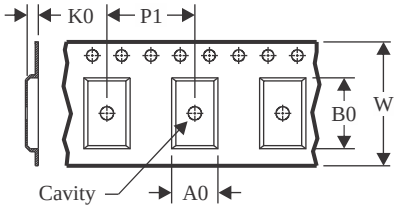
Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

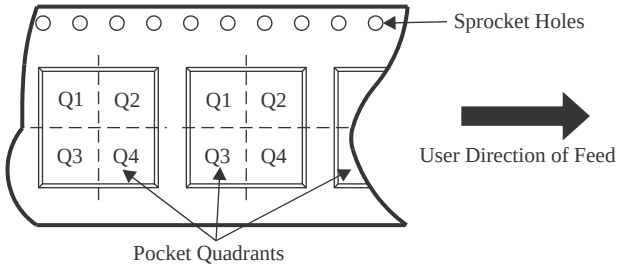


TAPE DIMENSIONS



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

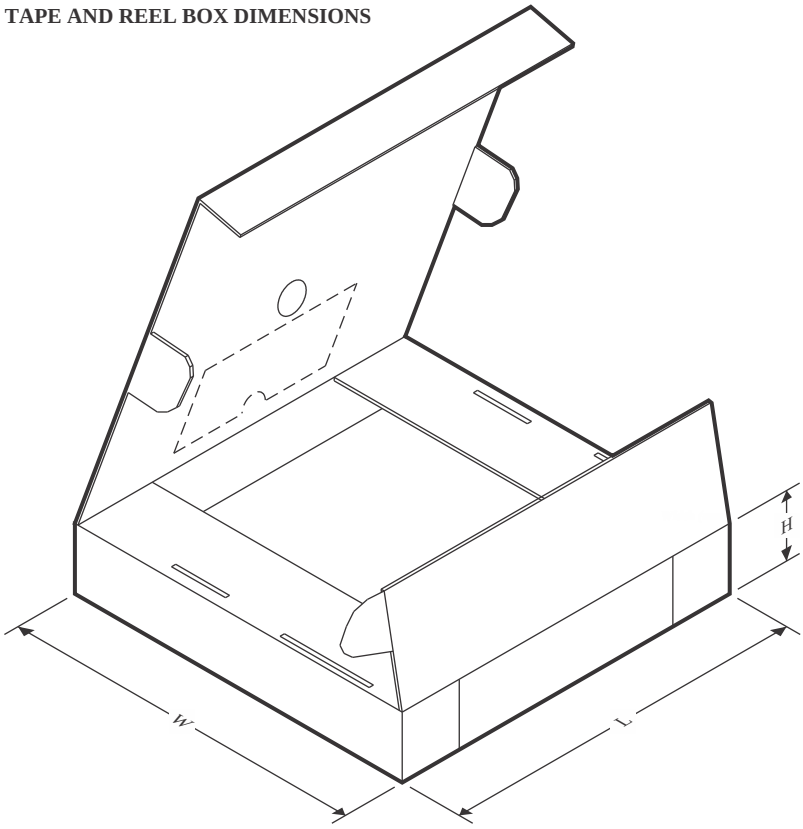
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
O3853QDCARQ1	HTSSOP	DCA	48	2000	330.0	24.4	8.6	13.0	1.8	12.0	24.0	Q1

TAPE AND REEL BOX DIMENSIONS



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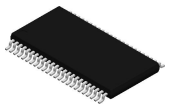
O3853QDCARQ1	HTSSOP	DCA	48	2000	350.0	350.0	43.0

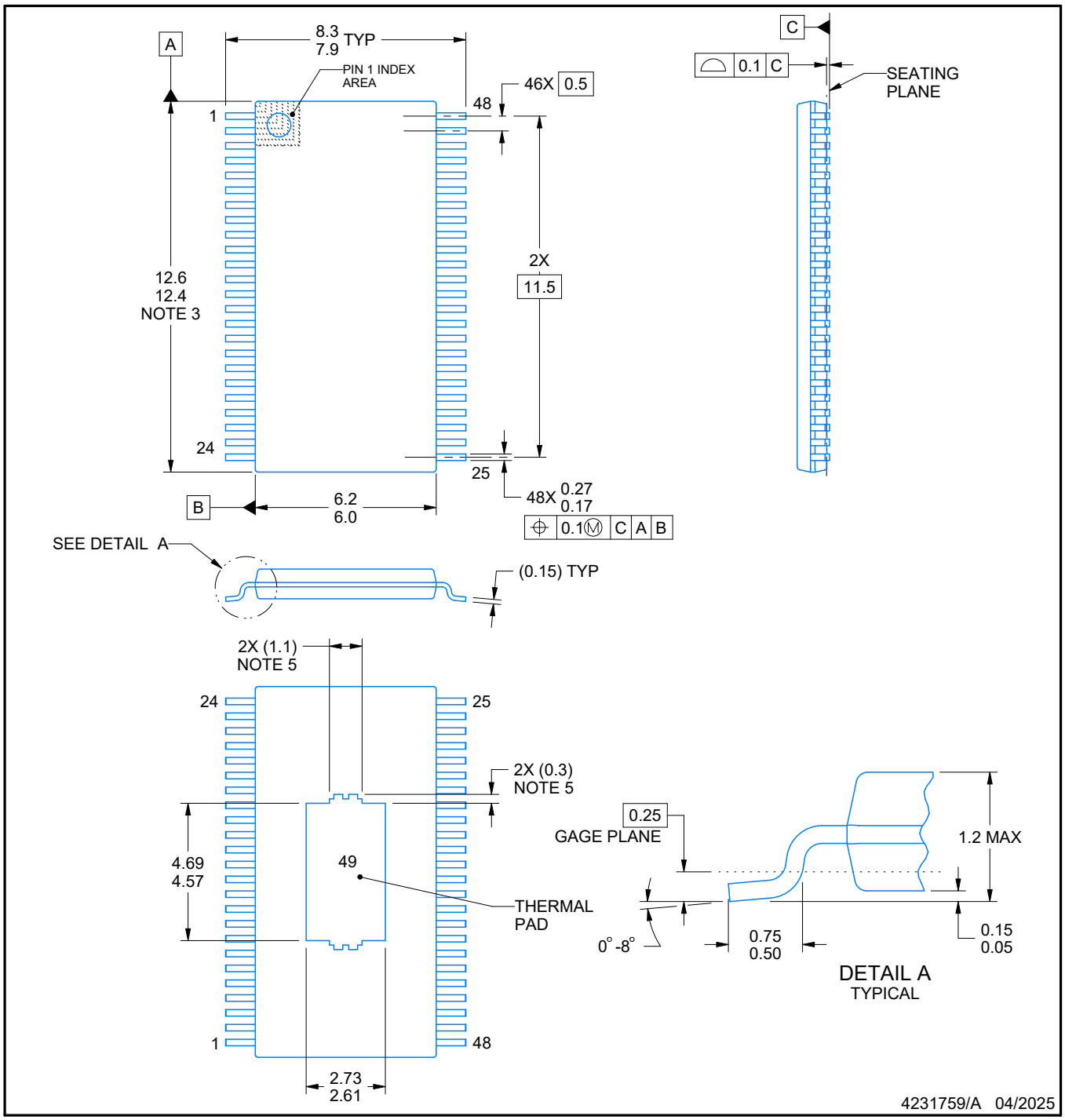
PACKAGE OUTLINE

DCA0048B-C01



PowerPAD™ TSSOP - 1.2 mm max height

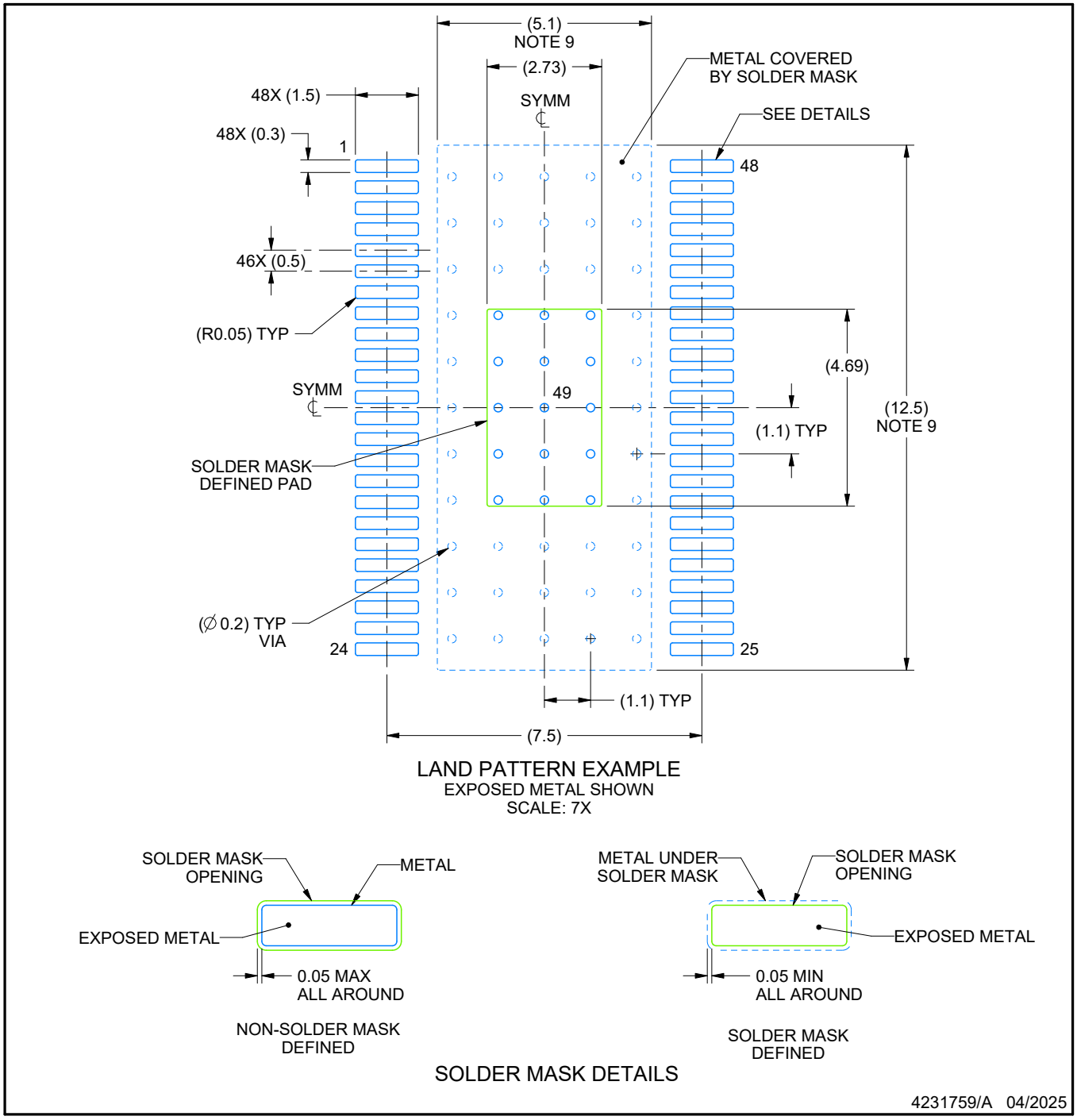
SMALL OUTLINE PACKAGE



PowerPAD is a trademark of Texas Instruments.

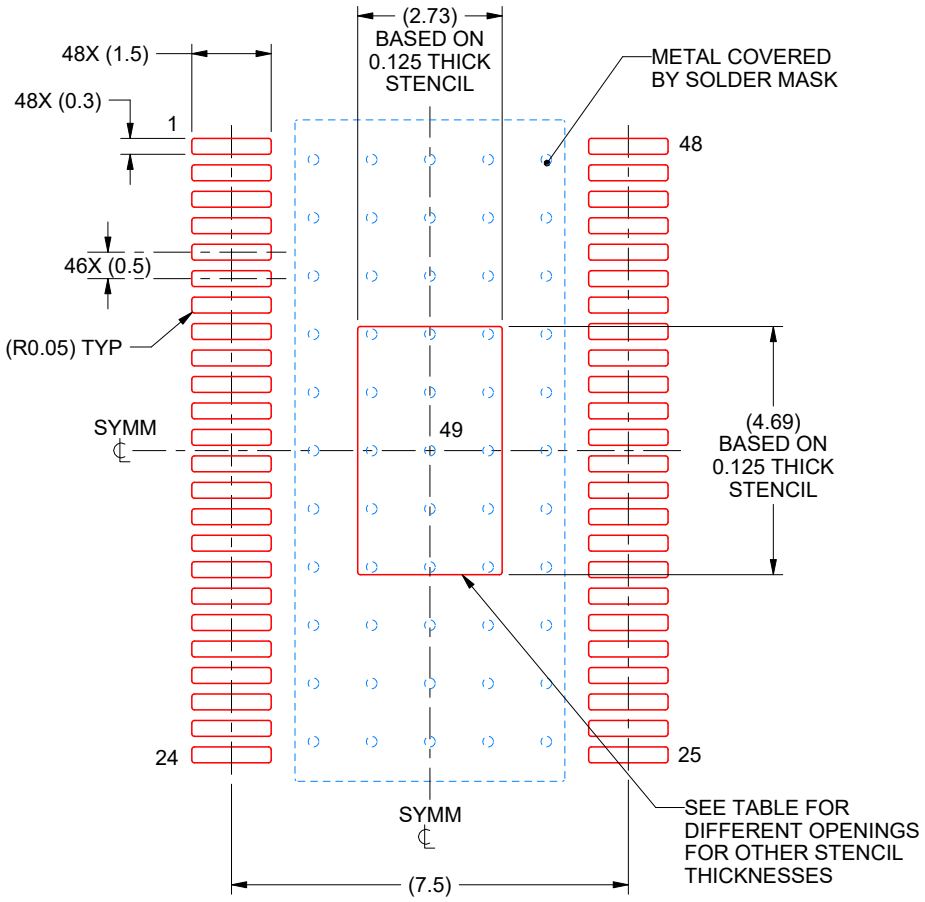
NOTES:

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 MO-153.
5. Features may differ or may not be present.



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. For more information, see Texas Instruments literature numbers SLMA002 (www.ti.com/lit/slma002) and SLMA004 (www.ti.com/lit/slma004).
9. Size of metal pad may vary due to creepage requirement.
10. Vias are optional depending on application, refer to device data sheet. It is recommended that vias under paste be filled, plugged or tented.



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL
SCALE: 7X

STENCIL THICKNESS	SOLDER STENCIL OPENING
0.1	3.05 X 5.24
0.125	2.73 X 4.69 (SHOWN)
0.15	2.49 X 4.28
0.175	2.31 X 3.96

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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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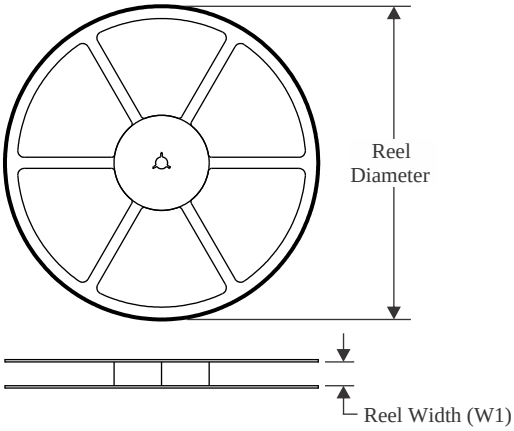

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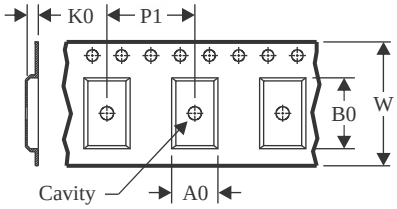

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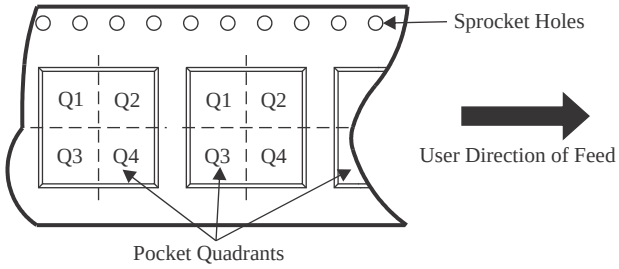

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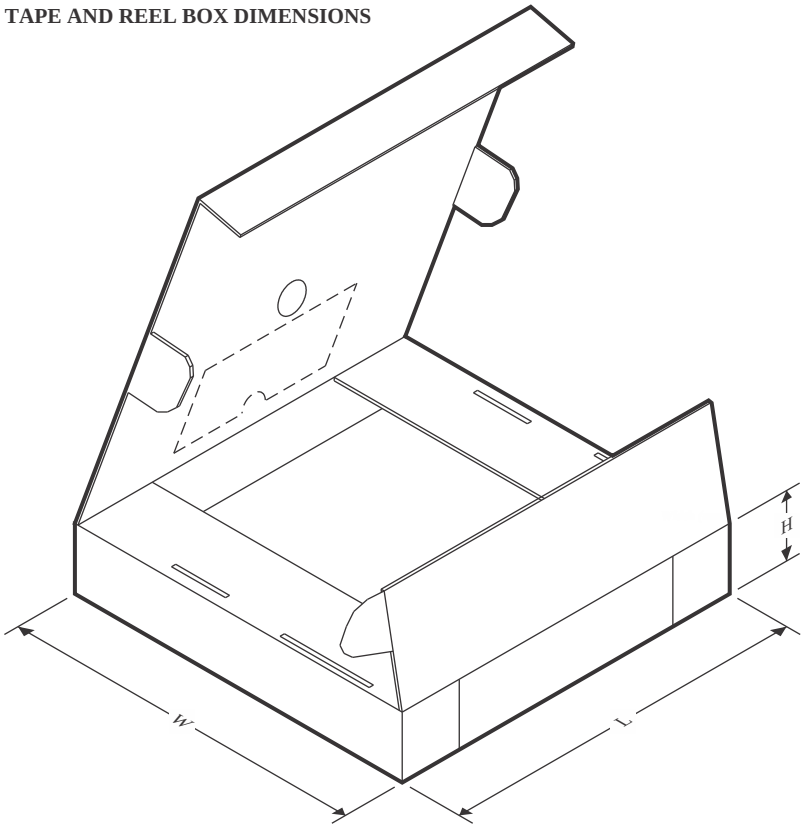

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