TPS653860/61-Q1 Power Management IC For 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 temperature grade 0: –40°C to +150°C ambient operating temperature
  - Device HBM ESD classification level 2
  - Device CDM ESD classification level C4B
- Functional Safety-Compliant (targets, confirmed on device release)
  - 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
  - 5 to 36V for initial power up
  - 3.5 to 36V full functionality after initial power up, limited operation to 2.3V
- Output Supply Rails
  - Synchronous buck-boost preregulator with configurable spread-spectrum, 4.3V, 5 V, 6V or 6.8V and low IQ mode with the following options:
    - 2.8A in buck mode (option 0 variant)
    - 1.5A in buck mode (option 1 variant)
  - Four LDOs: 1.0V to 1.8V in 50mV steps, 2.5 V, 3.0V, 3.3V, 5V, bypass or voltage monitor mode. Each LDO with independent configurable current limit.
    - LDO1 and LDO2: Low IQ, up to 600mA
    - LDO3 and LDO4: low noise, low IQ, 1% accuracy, up to 225mA
  - Two protected LDOs for sensor or peripheral supplies, PLDO1 and PLDO2
    - Configurable for tracking mode or fixed output/VMON mode configurable for 1.0V to 1.8V in 50mV steps, 2.5V, 3.0V, 3.3V or 5V up to 200mA
    - Short-to-chassis (–2V) and supply (+36V) protection
- Power sequence control:
  - Configurable power-up and down sequences (NVM default including output voltages)
  - Output rails, external voltage monitor and external enable signals can be included
- Monitoring, protection and diagnostics
  - Undervoltage and overvoltage monitoring on all regulator outputs, battery voltage, and internal supplies
  - Two external voltage monitors (pins)
  - All regulator outputs protected with independent current limit
  - All regulators protected with independent overtemperature prewarning and shutdown
  - Watchdog: configurable for open and close window or question-answer
  - Error signal monitor (ESM) for monitoring MCU error output (PWM and level modes)
  - SAFE state for device and system protection
  - Clock monitor for internal oscillators
  - Analog and logic built-in self-test (BIST)
  - CRC on non-volatile memory (NVM), device configuration registers, and SPI communication
  - Diagnostic output pin: multiplexes analog and digital signals to MCU ADC and input
- Compare module: 2 channels configurable as general purpose comparators or up to 4 channels of voltage monitoring
- Timer (low IQ) for wake-up and measurement, 64µs to 203.6 days
- SPI for configuration, status and error reporting
- Reset output (NRST), two configurable safing outputs (SAFE_OUTx) for system safe state on detected faults interrupt output (NINT), and power good output (PGOOD)
- Two configurable wake-up pins (WAKEx)
- 48-Pin HTSSOP PowerPAD™ IC package

2 Applications

- Safety-Relevant Automotive Applications

3 Description

The TPS65386x-Q1 device is a multirail power supply designed to supply microcontrollers, sensors, transceivers and peripherals in safety relevant applications.

Package Information

PART NUMBER(2)	PREREGULATOR	PACKAGE(1)
TPS653860-Q1	Buck-Boost 2.8A	DCA (HTSSOP, 48)
TPS653861-Q1	Buck-Boost 1.5A	DCA (HTSSOP, 48)

(1) For all available packages and more information, see Section 6, *Mechanical Packaging and Orderable Information* at the end of the data sheet.
(2) For additional details on device sub-family variants and NVM default configuration options, see Device Comparison Table.

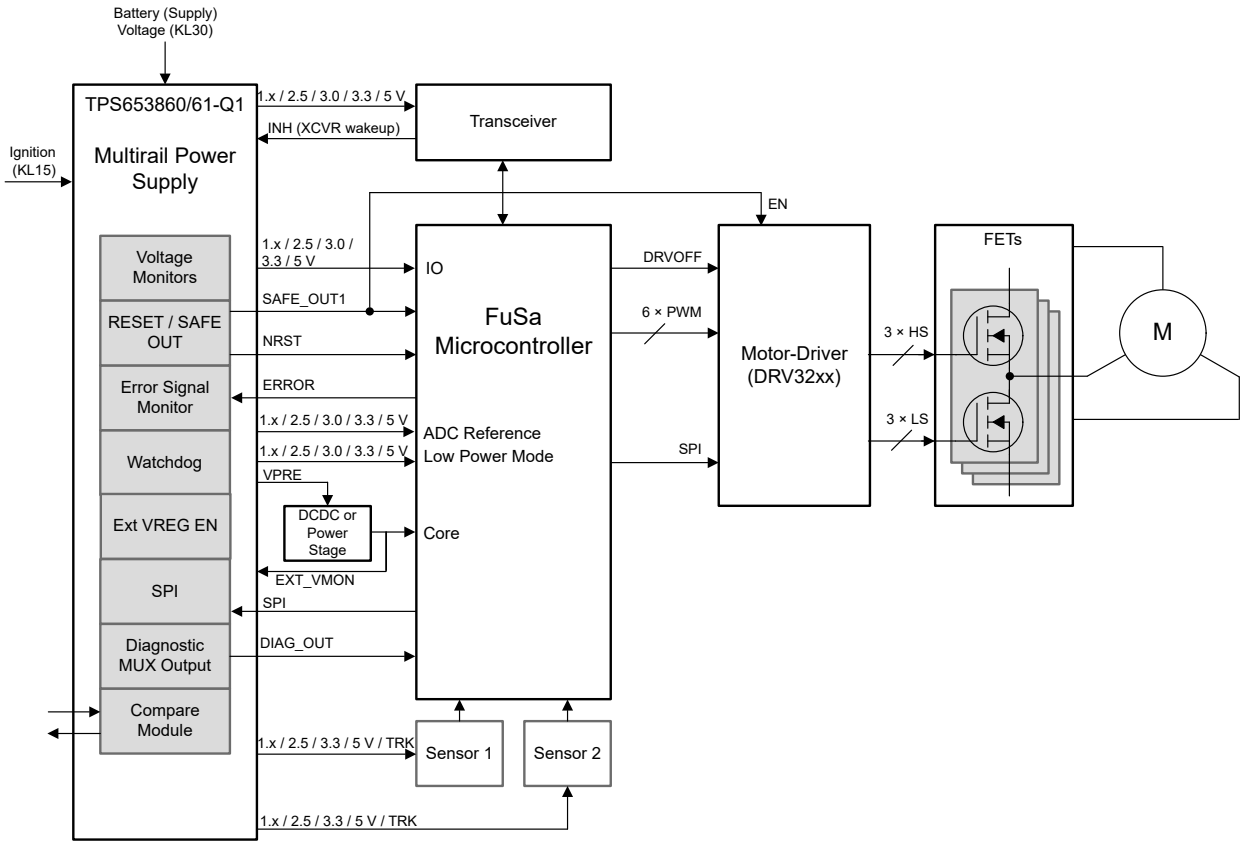

Figure 3-1. Typical Application Diagram

Table of Contents

4 Device and Documentation Support

4.1 Documentation Support

4.1.1 Related Documentation

For related documentation see the following:

- Texas Instruments, full data sheet, application notes and functional safety information such as the Functional Safety Manual for TPS65386zyz-Q1 Multirail Power Supply, are available under non-disclosure agreement. Request more information using the link on the www.ti.com product folder, TPS653860-Q1 or TPS653861-Q1 .
- 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

4.1.2 Related Links

The table below lists quick access links. Categories include technical documents, support and community resources, tools and software, and quick access to order now.

4.2 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. Click on *Notifications* 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.

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.

4.4 Trademarks

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All trademarks are the property of their respective owners.

4.5 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.

4.6 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.

Changes from Revision * (October 2023) to Revision A (October 2024)	Page
• Changed the device status from Advance Information to Production Data	1

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)
O386000QDCARQ1	Active	Production	HTSSOP (DCA) | 48	2500 | LARGE T&R	Yes	NIPDAU	Level-3-260C-168 HR	-40 to 125	O386000Q DCARQ1
O386001QDCARQ1	Active	Production	HTSSOP (DCA) | 48	2500 | LARGE T&R	Yes	NIPDAU	Level-3-260C-168 HR	-40 to 125	O386001Q DCARQ1
O386003QDCARQ1	Active	Production	HTSSOP (DCA) | 48	2500 | LARGE T&R	Yes	NIPDAU	Level-3-260C-168 HR	-40 to 125	O386003Q DCARQ1
O386003QDCARQ1.A	Active	Production	HTSSOP (DCA) | 48	2500 | LARGE T&R	Yes	NIPDAU	Level-3-260C-168 HR	-40 to 125	O386003Q DCARQ1
O386005QDCARQ1	Active	Production	HTSSOP (DCA) | 48	2500 | LARGE T&R	Yes	NIPDAU	Level-3-260C-168 HR	-40 to 125	O386005Q DCARQ1
O386027QDCARQ1	Active	Production	HTSSOP (DCA) | 48	2500 | LARGE T&R	Yes	NIPDAU	Level-3-260C-168 HR	-40 to 125	O386027Q DCARQ1
O386050EDCARQ1	Active	Production	HTSSOP (DCA) | 48	2500 | LARGE T&R	Yes	NIPDAU	Level-3-260C-168 HR	-40 to 125	O386050E DCARQ1
O386050EDCARQ1.A	Active	Production	HTSSOP (DCA) | 48	2500 | LARGE T&R	Yes	NIPDAU	Level-3-260C-168 HR	-40 to 125	O386050E DCARQ1

(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.

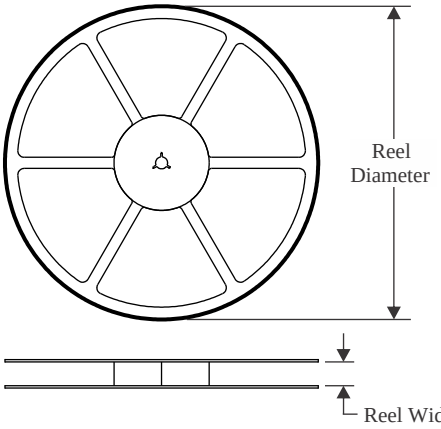
(5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will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

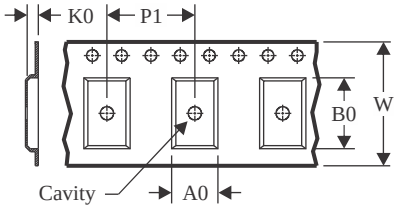
Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

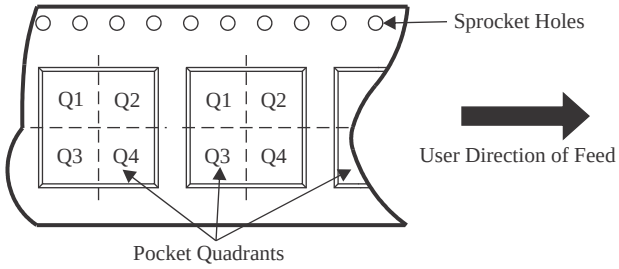


TAPE DIMENSIONS



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

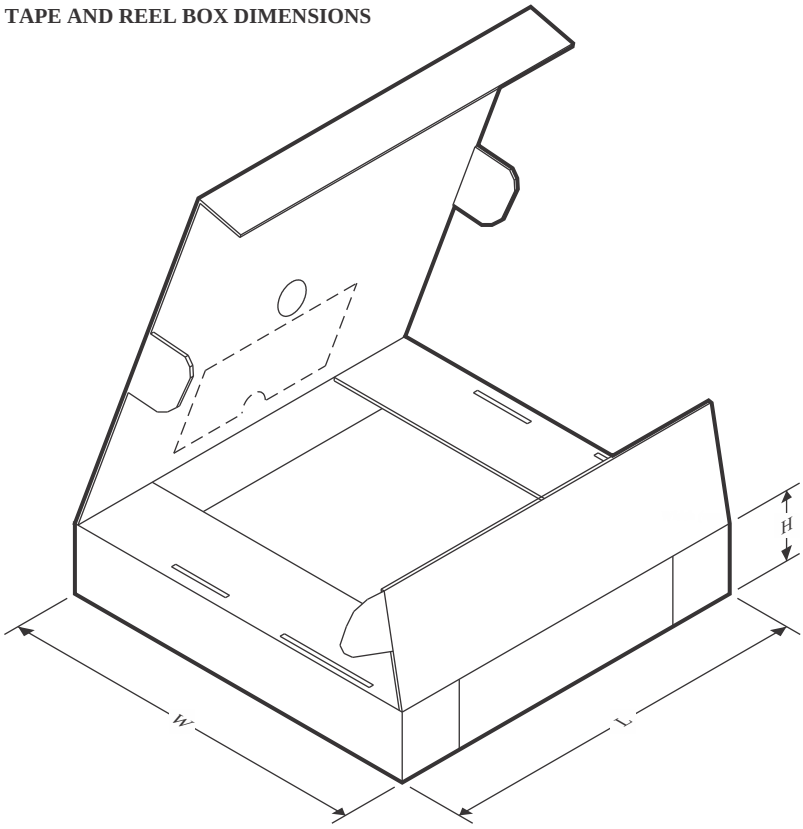
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
O386000QDCARQ1	HTSSOP	DCA	48	2500	330.0	24.4	8.6	13.0	1.8	12.0	24.0	Q1
O386001QDCARQ1	HTSSOP	DCA	48	2500	330.0	24.4	8.6	13.0	1.8	12.0	24.0	Q1
O386003QDCARQ1	HTSSOP	DCA	48	2500	330.0	24.4	8.6	13.0	1.8	12.0	24.0	Q1
O386005QDCARQ1	HTSSOP	DCA	48	2500	330.0	24.4	8.6	13.0	1.8	12.0	24.0	Q1
O386027QDCARQ1	HTSSOP	DCA	48	2500	330.0	24.4	8.6	13.0	1.8	12.0	24.0	Q1
O386050EDCARQ1	HTSSOP	DCA	48	2500	330.0	24.4	8.6	13.0	1.8	12.0	24.0	Q1

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
O386000QDCARQ1	HTSSOP	DCA	48	2500	350.0	350.0	43.0
O386001QDCARQ1	HTSSOP	DCA	48	2500	350.0	350.0	43.0
O386003QDCARQ1	HTSSOP	DCA	48	2500	350.0	350.0	43.0
O386005QDCARQ1	HTSSOP	DCA	48	2500	350.0	350.0	43.0
O386027QDCARQ1	HTSSOP	DCA	48	2500	350.0	350.0	43.0
O386050EDCARQ1	HTSSOP	DCA	48	2500	350.0	350.0	43.0

GENERIC PACKAGE VIEW

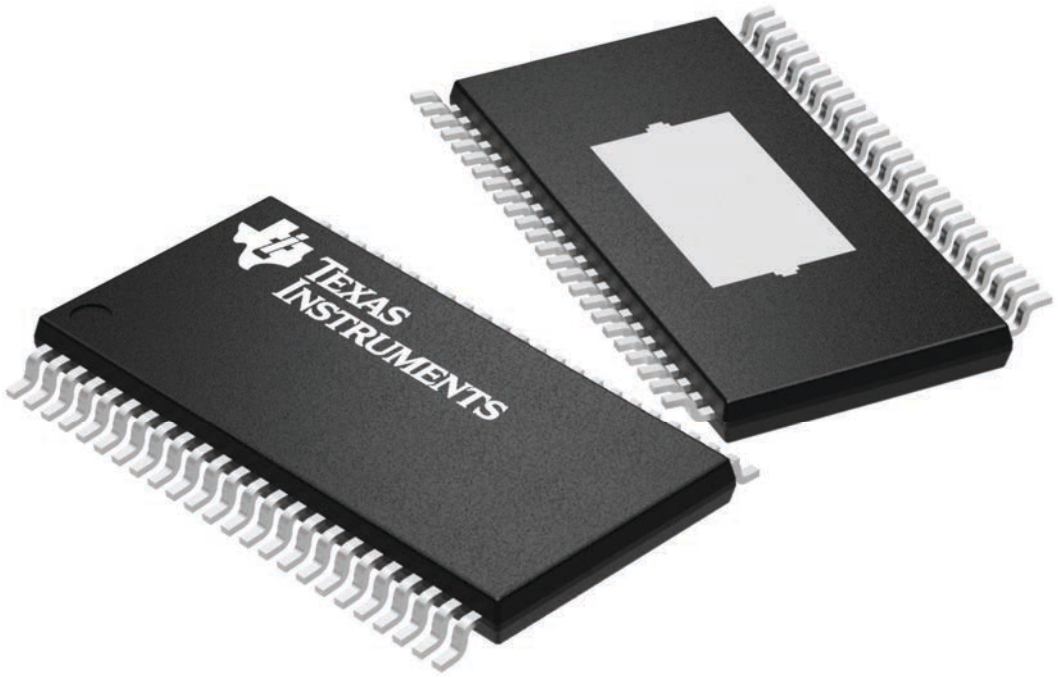
DCA 48

HTSSOP - 1.2 mm max height

12.5 x 6.1, 0.5 mm pitch

SMALL OUTLINE PACKAGE

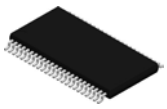
This image is a representation of the package family, actual package may vary.
Refer to the product data sheet for package details.



4224608/A

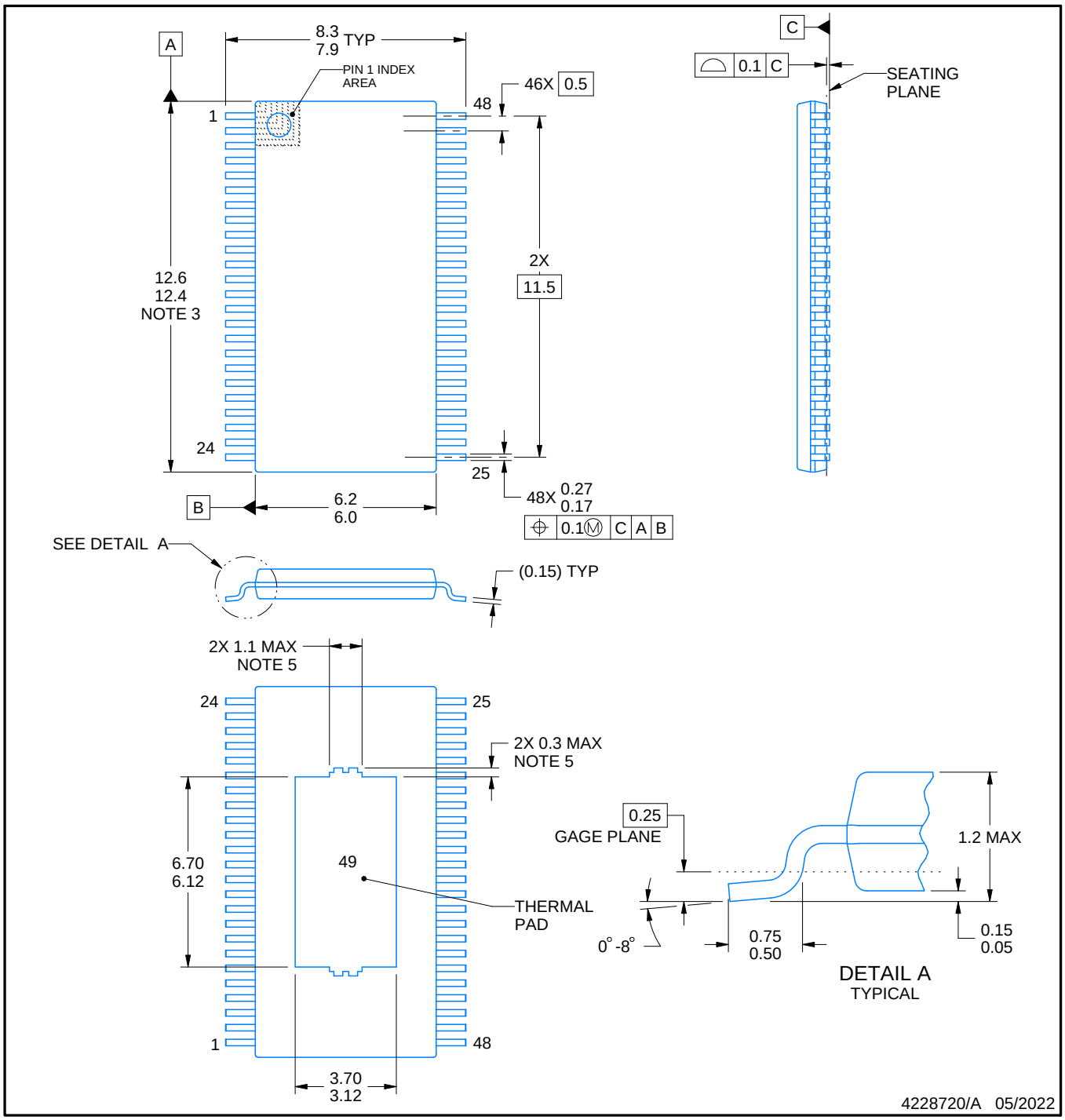
PACKAGE OUTLINE

DCA0048J



PowerPAD™ TSSOP - 1.2 mm max height

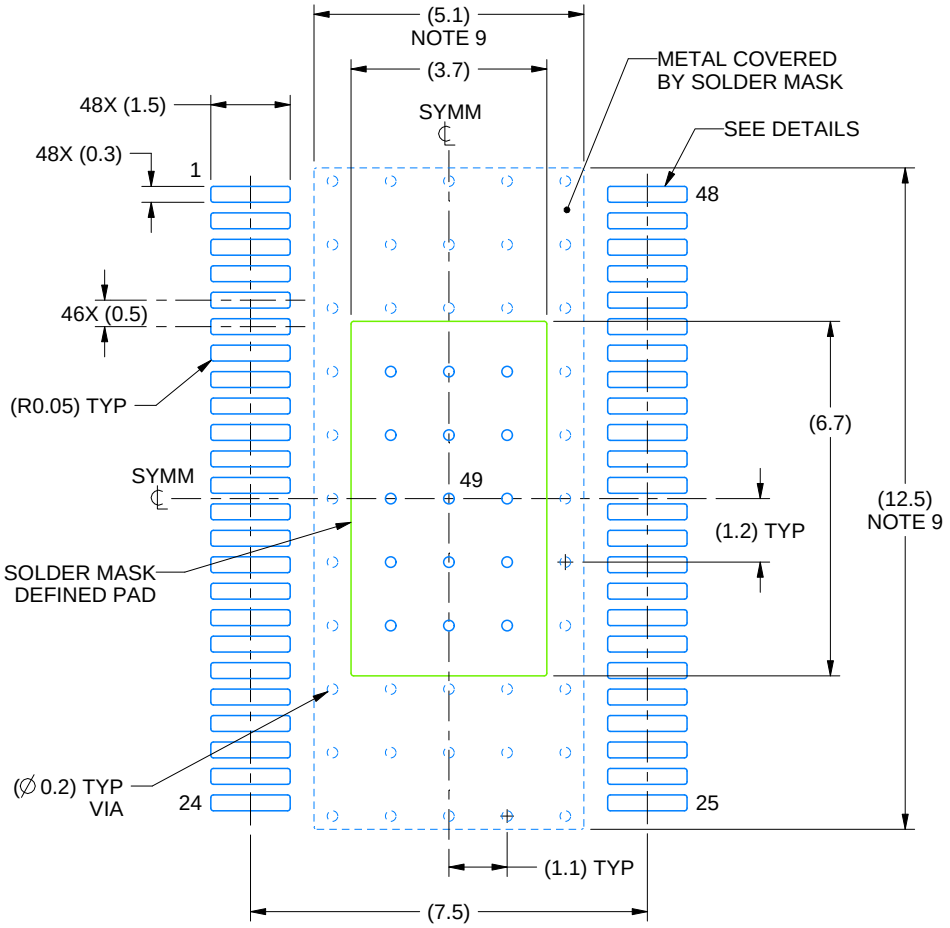
SMALL OUTLINE PACKAGE



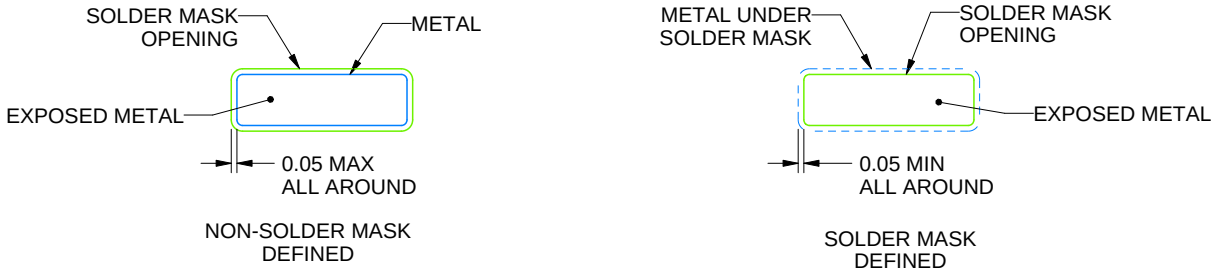
PowerPAD is a trademark of Texas Instruments.

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.



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 7X



SOLDER MASK DETAILS

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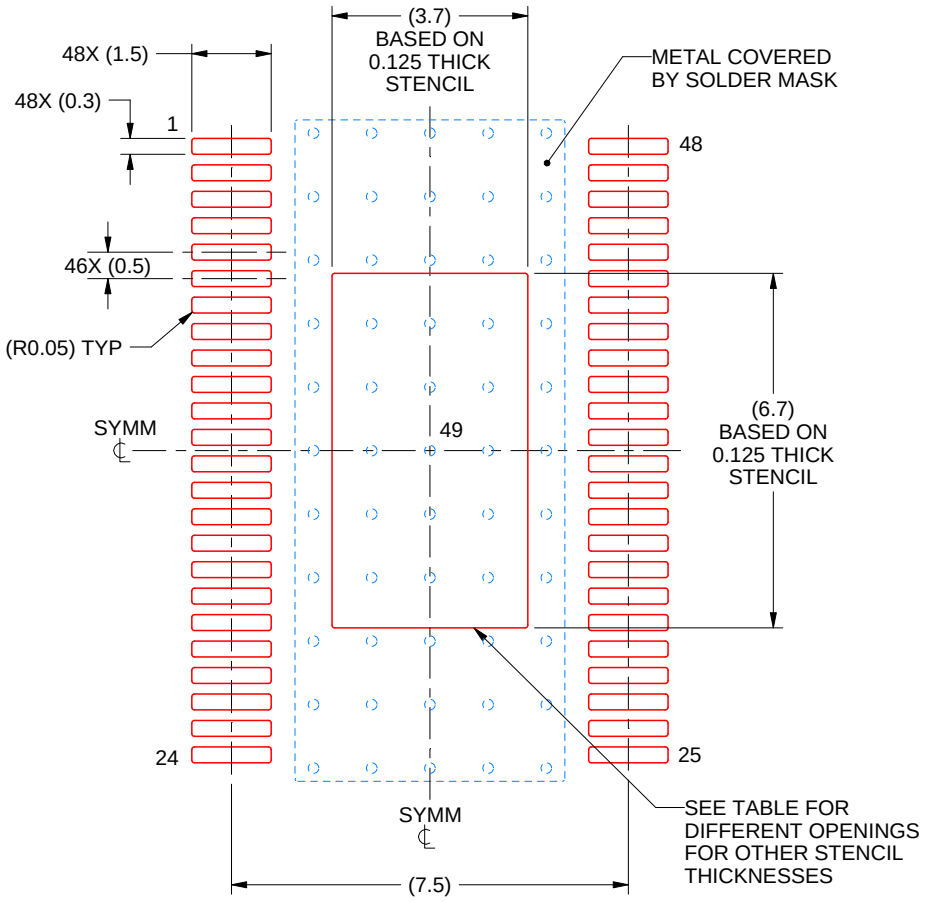
NOTES: (continued)

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. 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	4.14 X 7.49
0.125	3.70 X 6.70 (SHOWN)
0.15	3.38 X 6.12
0.175	3.13 X 5.66

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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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