AFE1598 Low-Power, 8-Channel, 24-Bit Analog Front-Ends for Bio-Potential Measurements

1 Features

- Integrated Signal Chain for ECG, Pace Detection, and Respiration Measurement
- **ECG Receiver**
  - Eight high resolution channels at low power of 0.37mW/channel
  - Flexible eight leads selectable from ten electrodes
  - Programmable gain: 1.25 to 9
  - Noise: 4.7μV_{PP} in 150Hz with Gain = 4
  - Differential input range: ±1V with Gain = 4
  - CMRR: -140dB
  - Data rate: 125SPS to 128kSPS
- **Pace Detection**
  - On-chip digital pace detection algorithm on programmable four leads
  - High-speed 128kSPS pace output on four channels for software pace detection
- **Respiration**
  - Low-noise of 16mΩ_{PP} with 2kΩ body impedance and 1kΩ defibrillator protection resistor on each electrode
  - Supports Sine and Square wave excitation
- **Other Features**
  - Built-in right leg drive amplifier steerable to any electrode
  - DC lead-off detection, AC lead impedance detection, Wilson Center Terminal (WCT), Goldberger Central Terminals (GCT), test signals
  - Battery voltage monitoring
  - Flexible power-down and standby modes
  - Built-in oscillator, PLL, and reference
  - 1k sample main FIFO and 2k sample pace FIFO
  - SPI-compatible serial interface
  - Analog supply voltage 1: 3.15V to 5.25V
  - Analog supply voltage 2: 1.7V to 1.9V
  - I/O supply voltage: 1.65V to 3.6V
- Supports systems meeting AAMI EC11, AMI EC13, AMI EC38, IEC60601-1, IEC60601-2-25, IEC60601-2-27, and IEC60601-2-51 standards

2 Applications

- Medical instrumentation (ECG, EMG, and EEG):
  - Bedside patient monitoring and diagnostic ECG
  - Portable telemetry
  - Holter monitor and multi-lead patch
- Event, stress, and vital sign monitors:
  - ECGs
  - AEDs
  - Telemedicine Bispectral Index (BIS)
  - Evoked Audio Potential (EAP)
  - Sleep study monitor

3 Description

The AFE1598 is a family of multichannel, simultaneous sampling, 24-bit, delta-sigma (ΔΣ) analog-to-digital converters (ADCs) with built-in programmable gain Instrumentation Amplifiers (INAs), internal reference, and an on-chip PLL. The AFE supports digital pace pulse detection, thoracic impedance measurement and incorporates all of the features that are commonly required in medical electrocardiogram (ECG) and electroencephalogram (EEG) applications. Multiple AFE159x devices can be cascaded in high channel count systems. With high levels of integration and exceptional performance, the AFE159x enables the development of scalable medical instrumentation systems at significantly reduced size, power, and overall cost.

Package Information

PART NUMBER	PACKAGE(1)	PACKAGE SIZE(2)
AFE1598	QFN	8mm × 8mm
AFE1598	WCSP	3.6mm × 5.2mm

(1) For all available packages, see Mechanical, Packaging, and Orderable Information.
(2) The package size (length × width) is a nominal value and includes pins, where applicable.

Table of Contents

4 Device Comparison

Table 4-1. Comparison of the features between the AFE159x variants

	AFE159RP8	AFE159P8	AFE1598
Number of ECG electrode pins	10	10	10
Number of ECG channels	8	8	8
Number of Respiration electrode pins	4	4(1)	4(1)
Number of Respiration receiver channel	1	-	-
Number of internal Pace detect channels	4	4	-

(1) Only RESP_OUT pins available, RESP_IN pins are NC.

5 Revision History

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

DATE	REVISION	NOTES
December 2025	*	Production Data

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.

6.1 Package Option Addendum

Packaging Information

Orderable Device	Status(1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan(2)	Lead/Ball Finish(6)	MSL Peak Temp(3)	Op Temp (°C)	Device Marking(4) (5)
AFE159RP8RTQR	Preview	VQFN	RTQ	56	2000	Green (RoHS & no Sn/Br)	NIPDAU	Level-2-260C-1 YEAR	-20 to 85	AFE159RP8
AFE159RP8RTQT	Preview	VQFN	RTQ	56	250	Green (RoHS & no Sn/Br)	NIPDAU	Level-2-260C-1 YEAR	-20 to 85	AFE159RP8
AFE159P8RTQR	Preview	VQFN	RTQ	56	2000	Green (RoHS & no Sn/Br)	NIPDAU	Level-2-260C-1 YEAR	-20 to 85	AFE159P8
AFE159P8RTQT	Preview	VQFN	RTQ	56	250	Green (RoHS & no Sn/Br)	NIPDAU	Level-2-260C-1 YEAR	-20 to 85	AFE159P8
AFE1598RTQR	Preview	VQFN	RTQ	56	2000	Green (RoHS & no Sn/Br)	NIPDAU	Level-2-260C-1 YEAR	-20 to 85	AFE1598
AFE1598RTQT	Preview	VQFN	RTQ	56	250	Green (RoHS & no Sn/Br)	NIPDAU	Level-2-260C-1 YEAR	-20 to 85	AFE1598
AFE159RP8YAFR	Preview	DSBGA	YAF	70	6000	Green (RoHS & no Sn/Br)	SNAGCU	Level-1-260C-UNLIM	-20 to 85	AFE159RP8
AFE159RP8YAFT	Preview	DSBGA	YAF	70	250	Green (RoHS & no Sn/Br)	SNAGCU	Level-1-260C-UNLIM	-20 to 85	AFE159RP8
AFE159P8YAFR	Preview	DSBGA	YAF	70	6000	Green (RoHS & no Sn/Br)	SNAGCU	Level-1-260C-UNLIM	-20 to 85	AFE159P8
AFE159P8YAFT	Preview	DSBGA	YAF	70	250	Green (RoHS & no Sn/Br)	SNAGCU	Level-1-260C-UNLIM	-20 to 85	AFE159P8
AFE159P8YAFR	Preview	DSBGA	YAF	70	6000	Green (RoHS & no Sn/Br)	SNAGCU	Level-1-260C-UNLIM	-20 to 85	AFE159P8
AFE159P8YAFT	Preview	DSBGA	YAF	70	250	Green (RoHS & no Sn/Br)	SNAGCU	Level-1-260C-UNLIM	-20 to 85	AFE159P8

(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.
PRE_PROD Unannounced device, not in production, not available for mass market, nor on the web, samples not available.
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 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.

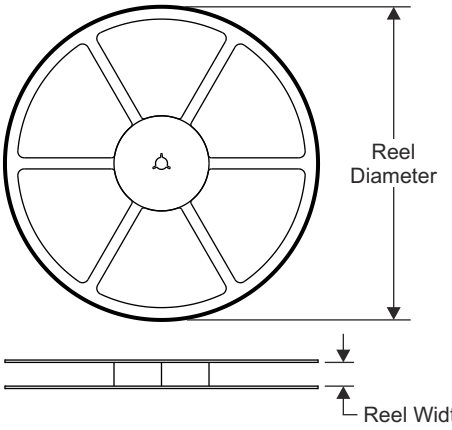
(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(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.

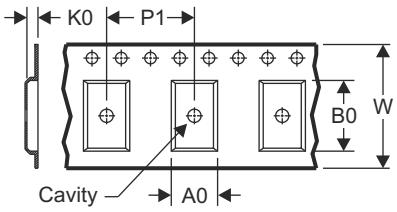
(6) Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

6.2 Tape and Reel Information

REEL DIMENSIONS

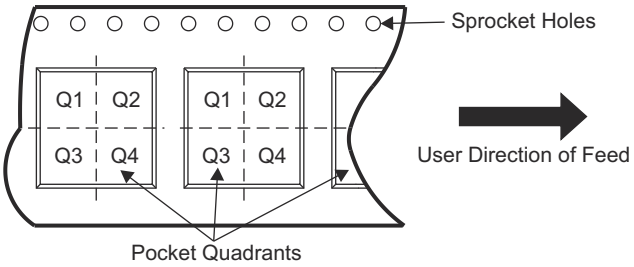


TAPE DIMENSIONS



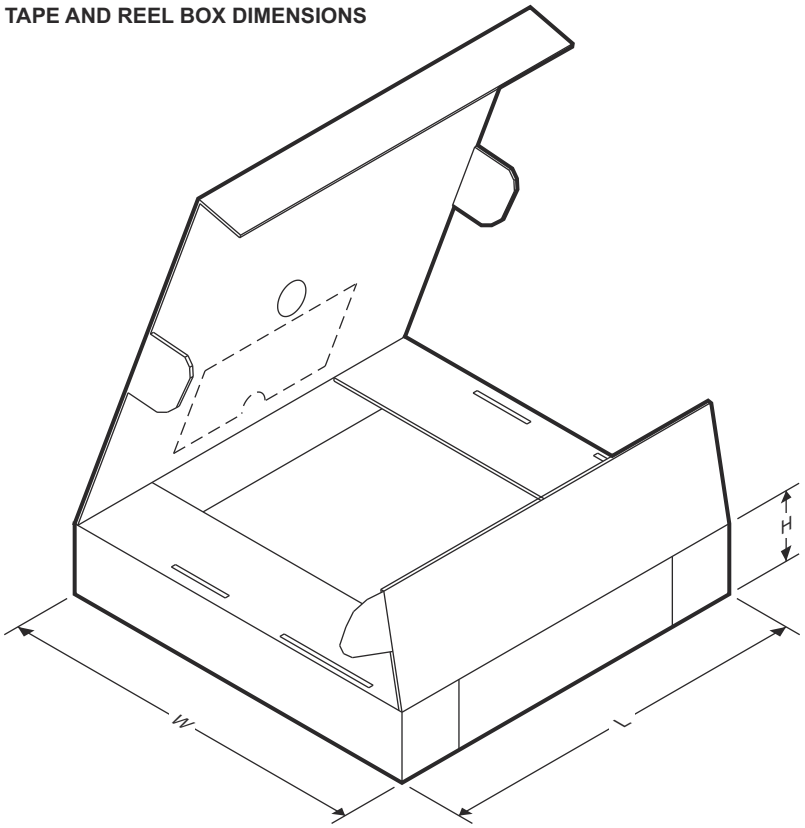
A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



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
AFE159RP8RTQR	VQFN	RTQ	56	2000	330.0	16.4	8.3	8.3	1.1	12.0	16.0	Q2
AFE159RP8RTQT	VQFN	RTQ	56	250	180.0	16.4	8.3	8.3	1.1	12.0	16.0	Q2
AFE159P8RTQR	VQFN	RTQ	56	2000	330.0	16.4	8.3	8.3	1.1	12.0	16.0	Q2
AFE159P8RTQT	VQFN	RTQ	56	250	180.0	16.4	8.3	8.3	1.1	12.0	16.0	Q2
AFE1598RTQR	VQFN	RTQ	56	2000	330.0	16.4	8.3	8.3	1.1	12.0	16.0	Q2
AFE1598RTQT	VQFN	RTQ	56	250	180.0	16.4	8.3	8.3	1.1	12.0	16.0	Q2
AFE159RP8YAFR	DSBGA	YAF	70	6000	330.0	16.4	4.36	5.56	0.81	8.0	12.0	Q1
AFE159RP8YAFT	DSBGA	YAF	70	250	180.0	16.4	4.36	5.56	0.81	8.0	12.0	Q1
AFE159P8YAFR	DSBGA	YAF	70	6000	330.0	16.4	4.36	5.56	0.81	8.0	12.0	Q1
AFE159P8YAFT	DSBGA	YAF	70	250	180.0	16.4	4.36	5.56	0.81	8.0	12.0	Q1
AFE159P8YAFR	DSBGA	YAF	70	6000	330.0	16.4	4.36	5.56	0.81	8.0	12.0	Q1
AFE159P8YAFT	DSBGA	YAF	70	250	180.0	16.4	4.36	5.56	0.81	8.0	12.0	Q1

TAPE AND REEL BOX DIMENSIONS



Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
AFE159RP8RTQR	VQFN	RTQ	56	2000	367.0	367.0	35.0
AFE159RP8RTQT	VQFN	RTQ	56	250	210.0	185.0	35.0
AFE159P8RTQR	VQFN	RTQ	56	2000	367.0	367.0	35.0
AFE159P8RTQT	VQFN	RTQ	56	250	210.0	185.0	35.0
AFE1598RTQR	VQFN	RTQ	56	2000	367.0	367.0	35.0
AFE1598RTQT	VQFN	RTQ	56	250	210.0	185.0	35.0
AFE159RP8YAFR	DSBGA	YAF	70	6000	335.0	335.0	25.0
AFE159RP8YAFT	DSBGA	YAF	70	250	182.0	182.0	20.0
AFE159P8YAFR	DSBGA	YAF	70	6000	335.0	335.0	25.0
AFE159P8YAFT	DSBGA	YAF	70	250	182.0	182.0	20.0
AFE159P8YAFR	DSBGA	YAF	70	6000	335.0	335.0	25.0
AFE159P8YAFT	DSBGA	YAF	70	250	182.0	182.0	20.0

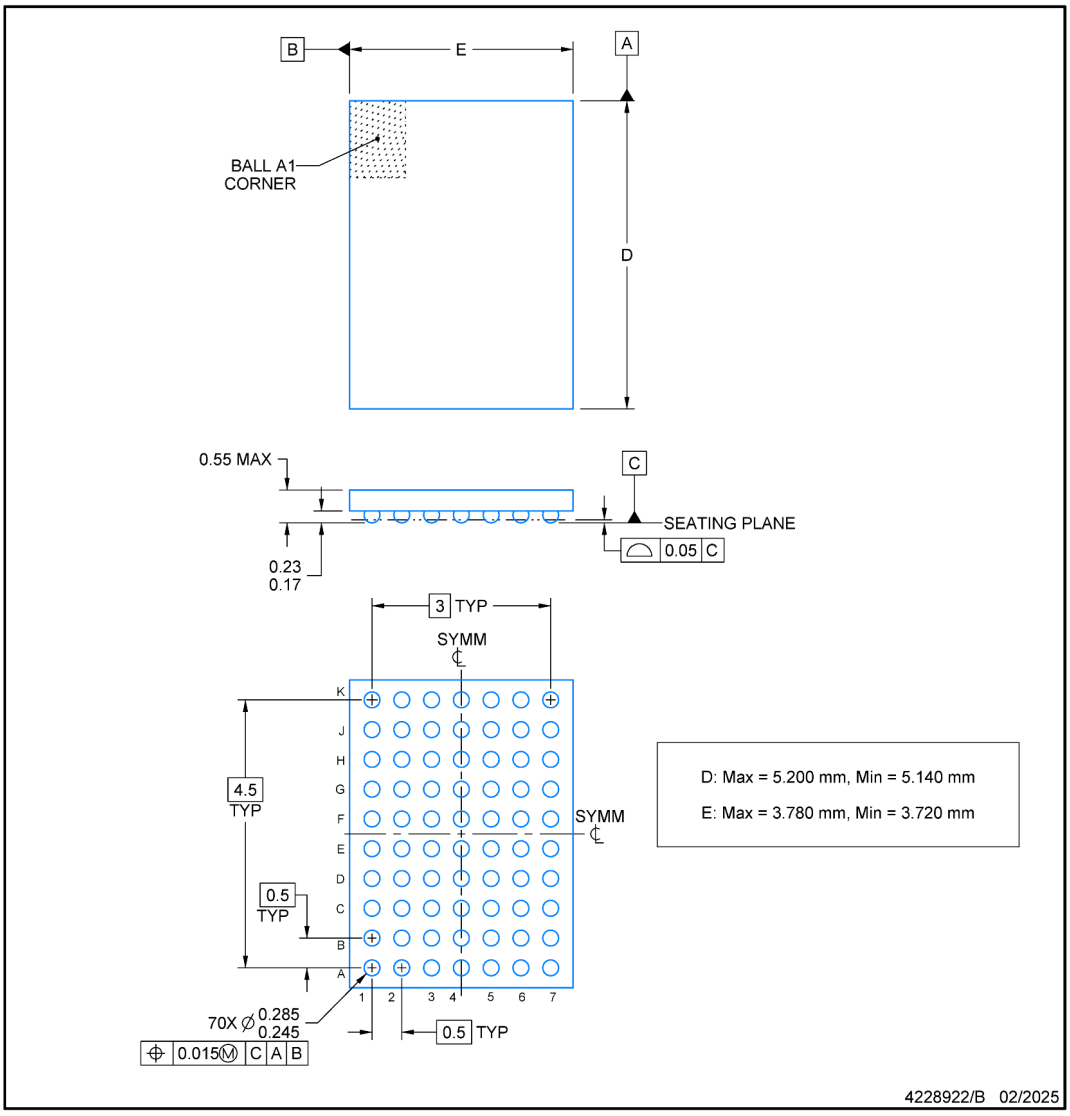
6.3 Mechanical Data

YAF0070-C01

PACKAGE OUTLINE

DSBGA - 0.55 mm max height

DIE SIZE BALL GRID ARRAY



NOTES:

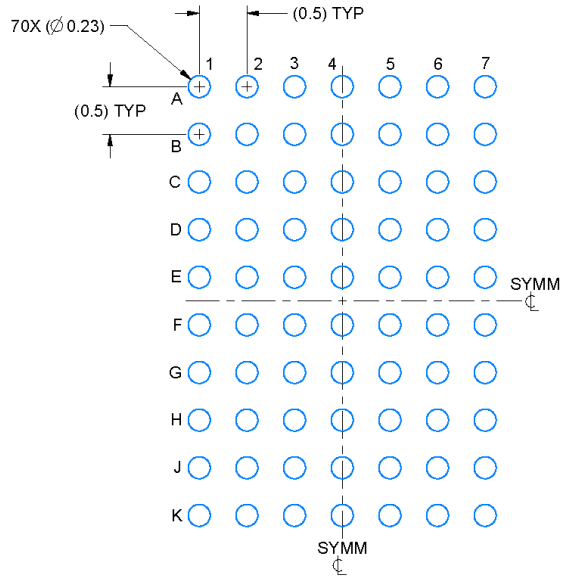
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.

EXAMPLE BOARD LAYOUT

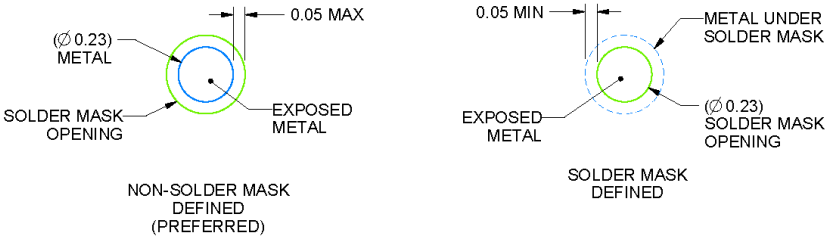
YAF0070-C01

DSBGA - 0.55 mm max height

DIE SIZE BALL GRID ARRAY



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 16X



SOLDER MASK DETAILS
NOT TO SCALE

4228922/B 02/2025

NOTES: (continued)

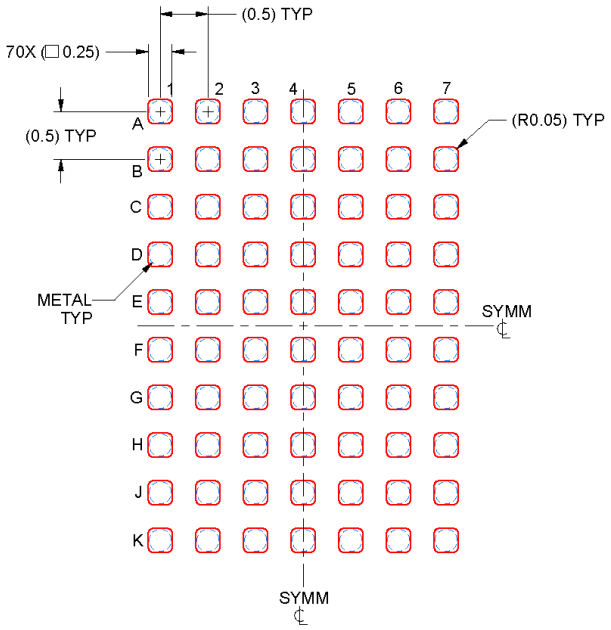
3. Final dimensions may vary due to manufacturing tolerance considerations and also routing constraints. See Texas Instruments Literature No. SNVA009 (www.ti.com/lit/snva009).

EXAMPLE STENCIL DESIGN

YAF0070-C01

DSBGA - 0.55 mm max height

DIE SIZE BALL GRID ARRAY



SOLDER PASTE EXAMPLE
BASED ON 0.1 mm THICK STENCIL
SCALE: 16X

4228922/B 02/2025

NOTES: (continued)

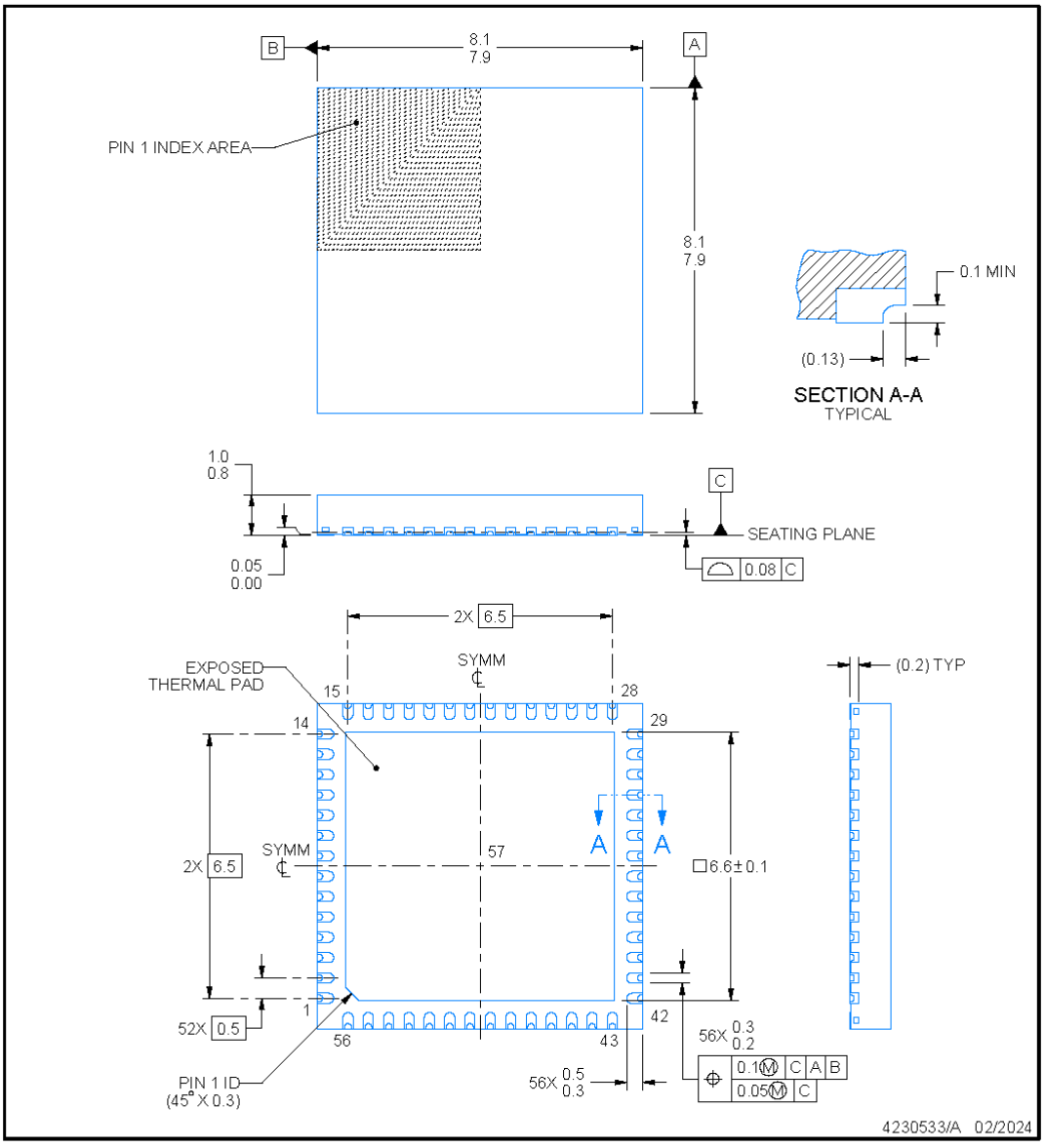
4. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release.

RTQ0056K

PACKAGE OUTLINE

VQFN - 1 mm max height

PLASTIC QUAD FLATPACK - NO LEAD



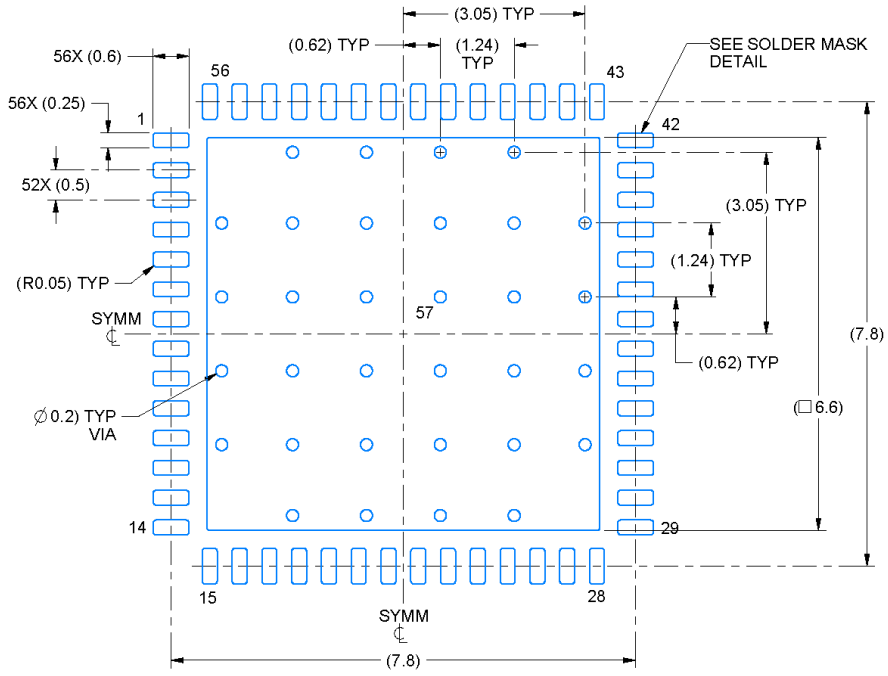
NOTES:

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. The package thermal pad must be soldered to the printed circuit board for thermal and mechanical performance.

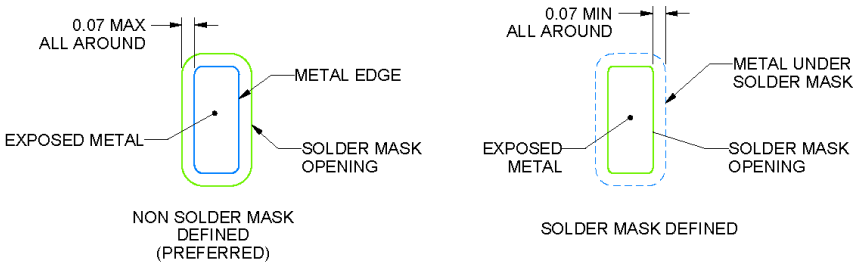
EXAMPLE BOARD LAYOUT

RTQ0056K — **VQFN - 1 mm max height**

PLASTIC QUAD FLATPACK - NO LEAD



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 10X



SOLDER MASK DETAILS

4230533/A 02/2024

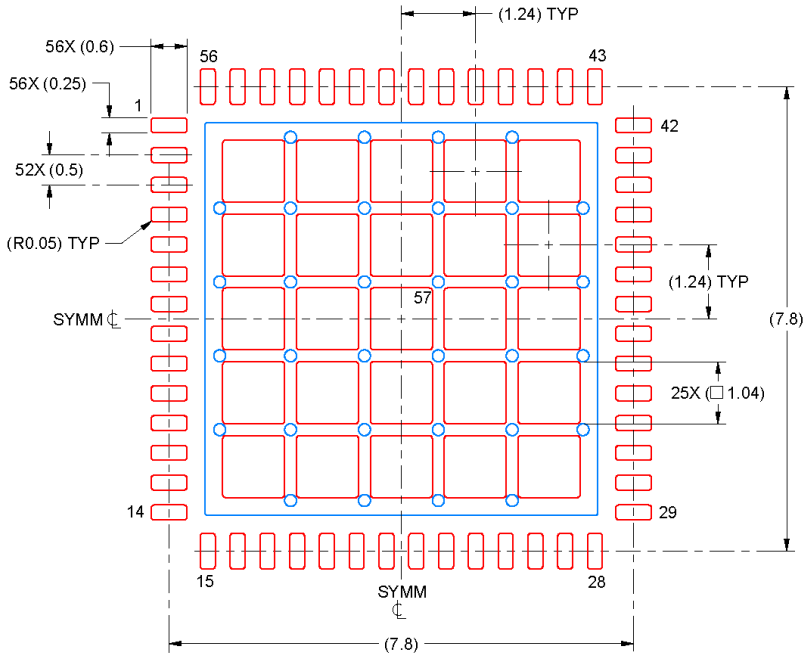
NOTES: (continued)

4. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 (www.ti.com/lit/slua271).
5. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It is recommended that vias under paste be filled, plugged or tented.

EXAMPLE STENCIL DESIGN

RTQ0056K — **VQFN - 1 mm max height**

PLASTIC QUAD FLATPACK - NO LEAD



SOLDER PASTE EXAMPLE
BASED ON 0.125 MM THICK STENCIL
SCALE: 10X

EXPOSED PAD 57
62% PRINTED SOLDER COVERAGE BY AREA UNDER PACKAGE

4230533/A 02/2024

NOTES: (continued)

6. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.

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)
AFE159RP8RTQR	Active	Production	QFN (RTQ) | 56	2000 | LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-20 to 85	AFE159RP8
AFE159RP8RTQT	Active	Production	QFN (RTQ) | 56	250 | SMALL T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-20 to 85	AFE159RP8

(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.

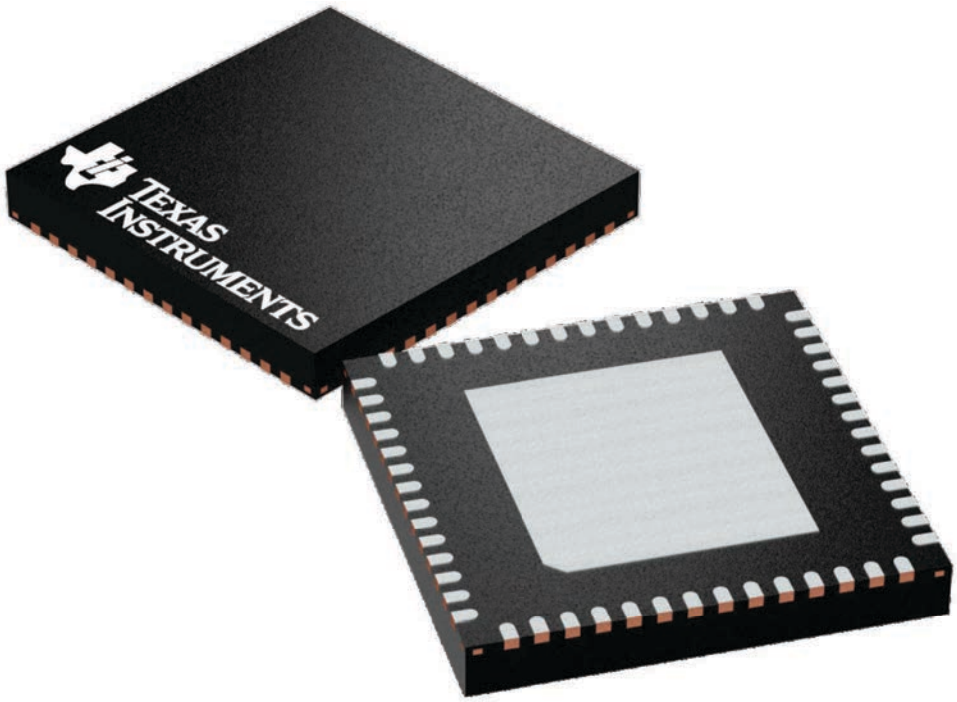
GENERIC PACKAGE VIEW

RTQ 56

VQFN - 1 mm max height

8 x 8, 0.5 mm pitch

PLASTIC QUAD FLATPACK - NO LEAD



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

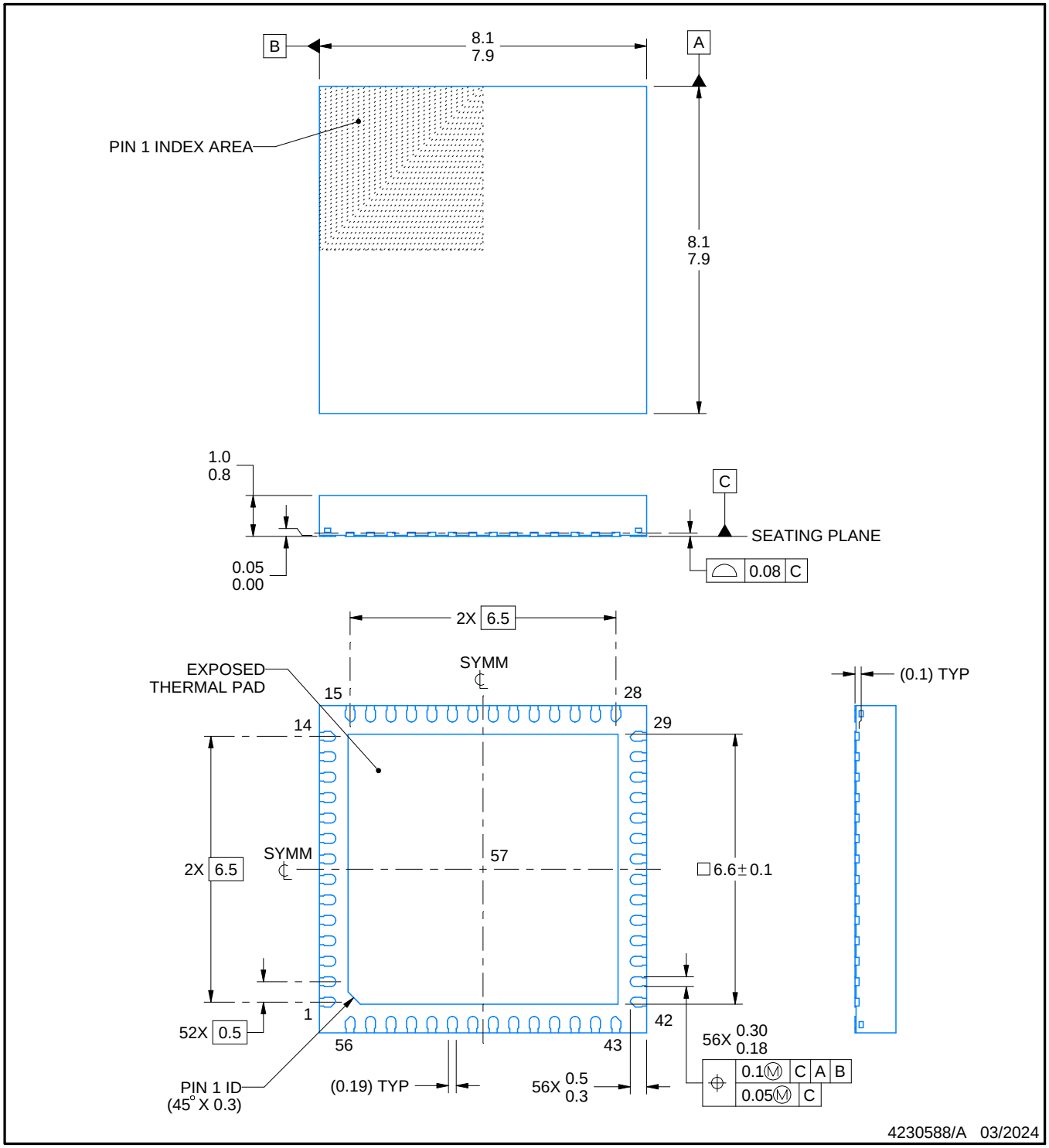
4224653/A

PACKAGE OUTLINE

RTQ0056L

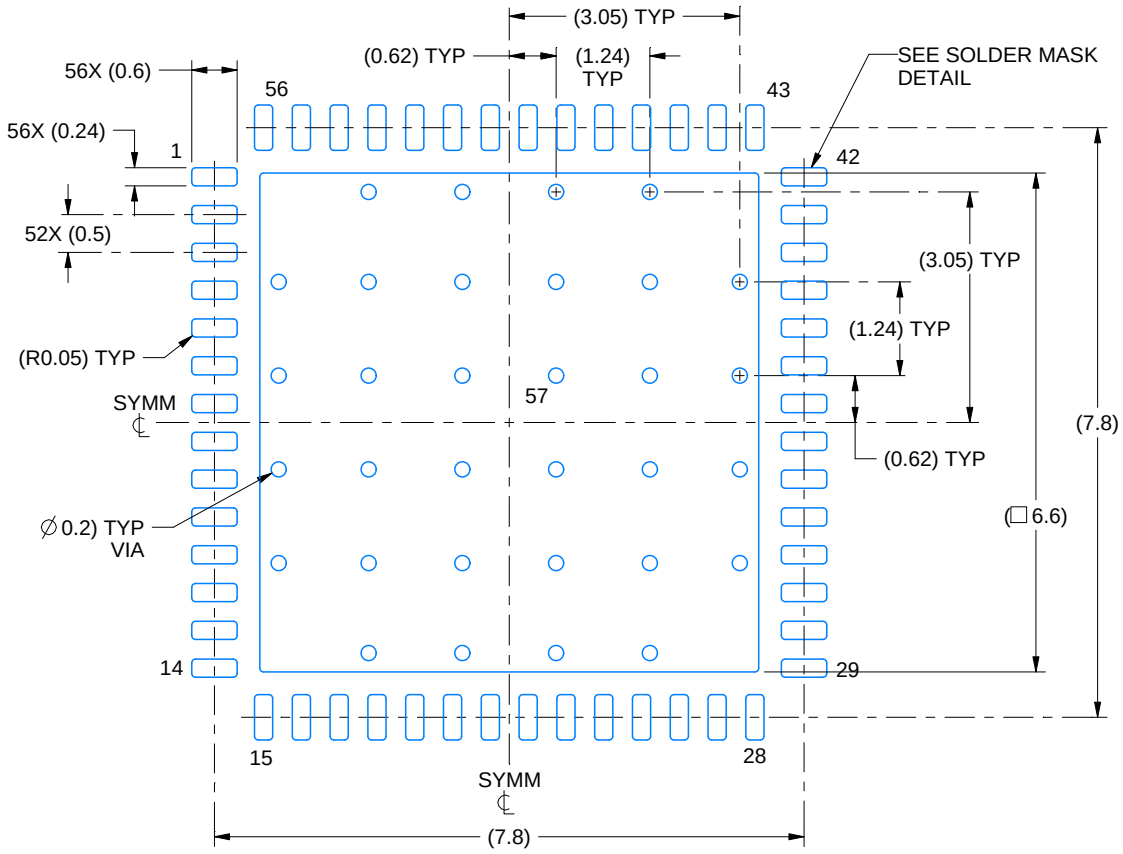
VQFN - 1 mm max height

PLASTIC QUAD FLATPACK - NO LEAD

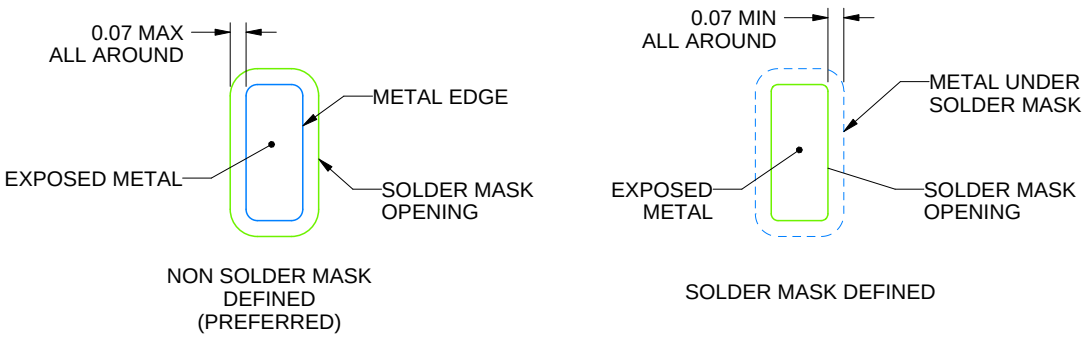


NOTES:

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. The package thermal pad must be soldered to the printed circuit board for thermal and mechanical performance.



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 10X

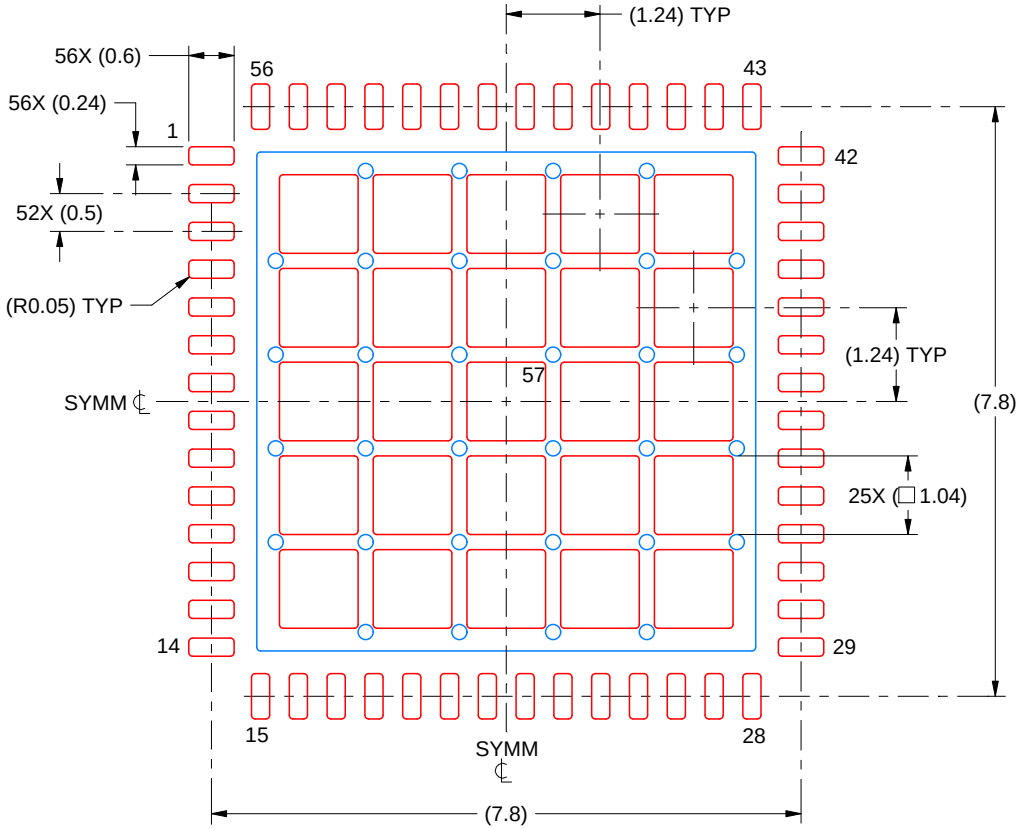


SOLDER MASK DETAILS

4230588/A 03/2024

NOTES: (continued)

4. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 (www.ti.com/lit/slua271).
5. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It is recommended that vias under paste be filled, plugged or tented.



SOLDER PASTE EXAMPLE
BASED ON 0.125 MM THICK STENCIL
SCALE: 10X

EXPOSED PAD 57
62% PRINTED SOLDER COVERAGE BY AREA UNDER PACKAGE

4230588/A 03/2024

NOTES: (continued)

6. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.

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Last updated 10/2025