LM686x0-Q1 70V, 8A/6A/4A, Automotive Buck Converters Optimized for Safety-Relevant Applications

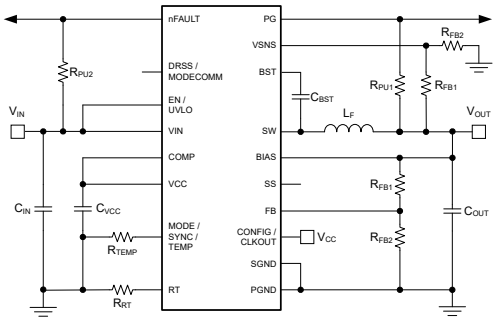
ADVANCE INFORMATION

1 Features

- AEC-Q100 qualified for automotive applications:
  - Temperature grade 1: –40°C to +125°C, T_A
- Functional Safety-Compliant
  - Developed for functional safety applications
  - Documentation available to aid ISO 26262 system design planned
  - Systematic capability up to ASIL D
  - Hardware capability up to ASIL C
  - Analog built-in-self-test at start-up
  - Redundant and fast (0.35µs) V_{OUT} monitor
  - Excellent pin FMEA and pin spacing
- Wide input voltage range: 3V to 70V
- 1% accurate, V_{OUT} from 0.8V to 60V
- Optimized for low EMI requirements
  - Facilitates CISPR 25 Class 5 compliance
  - Pin-configurable dual-random spread spectrum and slew-rate control reduce peak emissions
  - Enhanced HotRod™ QFN package with symmetrical pinout
  - Switching frequency from 300kHz to 2.2MHz
  - Pin-configurable AUTO or FPWM operation
- Low minimum on time: 36ns (typical)
  - Enables 36V to 3.3V conversion at 2.1MHz
- High-efficiency power conversion
  - > 95% peak efficiency, 12V_{IN} to 5V_{OUT}, 400kHz
  - No-load input current: 3.5µA
- High power density
  - Internal compensation, OCP, and TSD
  - 4.5mm × 4.5mm eQFN-26 with wettable flanks
  - Θ_{JA} = 18°C/W (EVM)
- VIN to PGND pin clearance: 1.1mm

2 Applications

- Advanced Driver Assistance Systems (ADAS)
- Automotive infotainment and cluster
- Hybrid, electric, and powertrain systems



Typical Application Circuit

3 Description

The LM686x0-Q1 are a family of stackable, automotive buck converters designed for high efficiency, high power density, and ultra-low electromagnetic interference (EMI). The converters operate over a wide input voltage range of 3V to 70V simplifying input surge protection design.

The low EMI operation is enabled with minimized loop inductance, internal bypass capacitors, pin-selectable SW node slew-rate control and dual-random spread spectrum (DRSS).

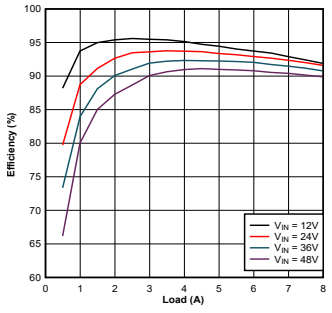
The current-mode control architecture with 36ns minimum on-time allows high conversion ratios at high frequencies, easy loop compensation, fast transient response, and excellent load and line regulation. Up to two converters can be set up in an interleaved mode (paralleled outputs) with accurate current sharing for supporting output current up to 16A.

The LM686x0-Q1 buck converters are specifically intended for functional safety relevant applications. An array of safety features including ABIST at start-up, redundant and fast V_{OUT} monitor, feedback path failure detection, redundant temperature sensor, thermal shutdown, and current limit significantly reduces residual failure-in-time (FIT).

Device Information

PART NUMBER(2)	PACKAGE(1)	OUTPUT CURRENT
LM68680-Q1	RZY (WQFN-FCRLF, 26)	8A
LM68660-Q1 (3)		6A
LM68640-Q1 (3)		4A

(1) For more information, see Section 7.
(2) See the *Device Comparison Table*.
(3) Preview information (not Advance Information).



Typical Efficiency V_{OUT} = 5V, f_{SW} = 400kHz

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ADVANCE INFORMATION

4 Device Comparison Table

Orderable Part Number	Input Voltage Rating	Current	Functional Safety	Level-Shifters for Inverting Buck-Boost Topology
LM65680RZYRQ1	70V	8A	Capable	No
LM65660RZYRQ1(1)	70V	6A	Capable	No
LM65640RZYRQ1(1)	70V	4A	Capable	No
LM68680FRZYRQ1	70V	8A	Compliant	No
LM68660FRZYRQ1(1)	70V	6A	Compliant	No
LM68640FRZYRQ1(1)	70V	4A	Compliant	No
LM68580FRZYRQ1(1)	42V	8A	Compliant	No
LM68560FRZYRQ1(1)	42V	6A	Compliant	No
LM67680RZYRQ1(1)	70V	8A	Capable	Yes
LM67660RZYRQ1(1)	70V	6A	Capable	Yes
LM67640RZYRQ1(1)	70V	4A	Capable	Yes

(1) Preview information (not Advance Information). For more information, please contact Texas Instruments.

ADVANCE INFORMATION

5 Device and Documentation Support

5.1 Development Support

For development support, see the following:

- For TI's reference design library, visit TI Designs
- TI Designs:
  - *ADAS 8-Channel Sensor Fusion Hub Reference Design with Two 4-Gbps Quad Deserializers*
  - *Automotive EMI and Thermally Optimized Synchronous Buck Converter Reference Design*
  - *Automotive High Current, Wide V_{IN} Synchronous Buck Controller Reference Design Featuring LM5141-Q1*
  - *25W Automotive Start-Stop Reference Design Operating at 2.2 MHz*
  - *Synchronous Buck Converter for Automotive Cluster Reference Design*
  - *Automotive Synchronous Buck With 3.3V @ 12.0A Reference Design*
  - *Automotive Synchronous Buck Reference Design*
  - *Automotive Wide V_{IN} Front-end Reference Design for Digital Cockpit Processing Units*
- Technical articles:
  - *High-Density PCB Layout of DC/DC Converters*
  - *Synchronous Buck Controller Solutions Support Wide V_{IN} Performance and Flexibility*
  - *How to Use Slew Rate for EMI Control*

5.2 Documentation Support

5.2.1 Related Documentation

For related documentation, see the following:

- Application notes:
  - Texas Instruments, *Improve High-current DC/DC Regulator Performance for Free with Optimized Power Stage Layout*
  - Texas Instruments, *AN-2162 Simple Success with Conducted EMI from DC-DC Converters*
  - Texas Instruments, *Multiphase Buck Design From Start to Finish.*
- Analog design journal:
  - Texas Instruments, *Reduce Buck Converter EMI and Voltage Stress by Minimizing Inductive Parasitics*
  - Texas Instruments, *Benefits of a Multiphase Buck Converter*
- White papers:
  - Texas Instruments, *An Overview of Conducted EMI Specifications for Power Supplies*
  - Texas Instruments, *An Overview of Radiated EMI Specifications for Power Supplies*
  - Texas Instruments, *Valuing Wide V_{IN}, Low EMI Synchronous Buck Circuits for Cost-driven, Demanding Applications*

5.2.1.1 PCB Layout Resources

- Application notes:
  - Texas Instruments, *Improve High-current DC/DC Regulator Performance for Free with Optimized Power Stage Layout*
  - Texas Instruments, *AN-1149 Layout Guidelines for Switching Power Supplies*
  - Texas Instruments, *AN-1229 Simple Switcher PCB Layout Guidelines*
  - Texas Instruments, *Low Radiated EMI Layout Made SIMPLE with LM4360x and LM4600x*
- Seminars:
  - Texas Instruments, *Constructing Your Power Supply – Layout Considerations*

5.2.1.2 Thermal Design Resources

- Application notes:
  - Texas Instruments, *AN-2020 Thermal Design by Insight, Not Hindsight*
  - *AN-1520 A Guide to Board Layout for Best Thermal Resistance for Exposed Pad Packages*
  - Texas Instruments, *Semiconductor and IC Package Thermal Metrics*

- Texas Instruments, *Thermal Design Made Simple with LM43603 and LM43602*
- Texas Instruments, *PowerPAD™ Thermally Enhanced Package*
- Texas Instruments, *PowerPAD Made Easy*
- Texas Instruments, *Using New Thermal Metrics*

5.3 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.

5.4 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.

5.5 Trademarks

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5.6 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.

5.7 Glossary

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

6 Revision History

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

DATE	REVISION	NOTES
October 2024	*	Initial Release

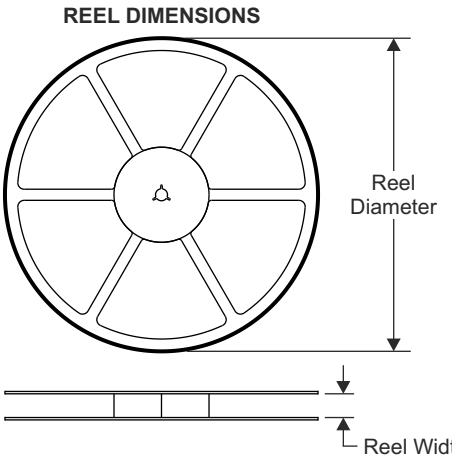
ADVANCE INFORMATION

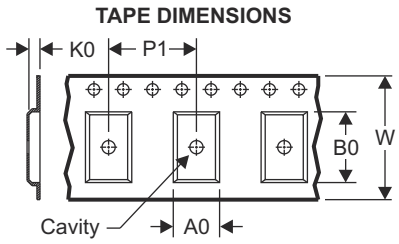
ADVANCE INFORMATION

7 Mechanical, Packaging, and Orderable Information

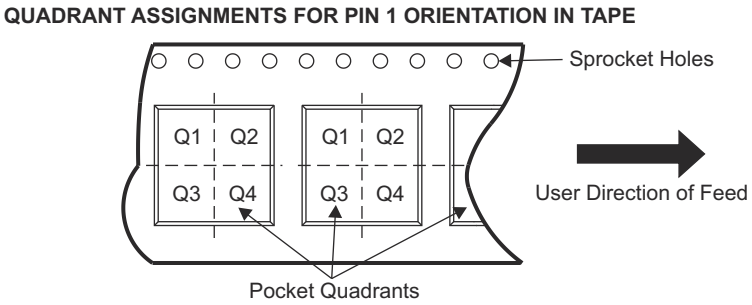
The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

7.1 Tape and Reel Information



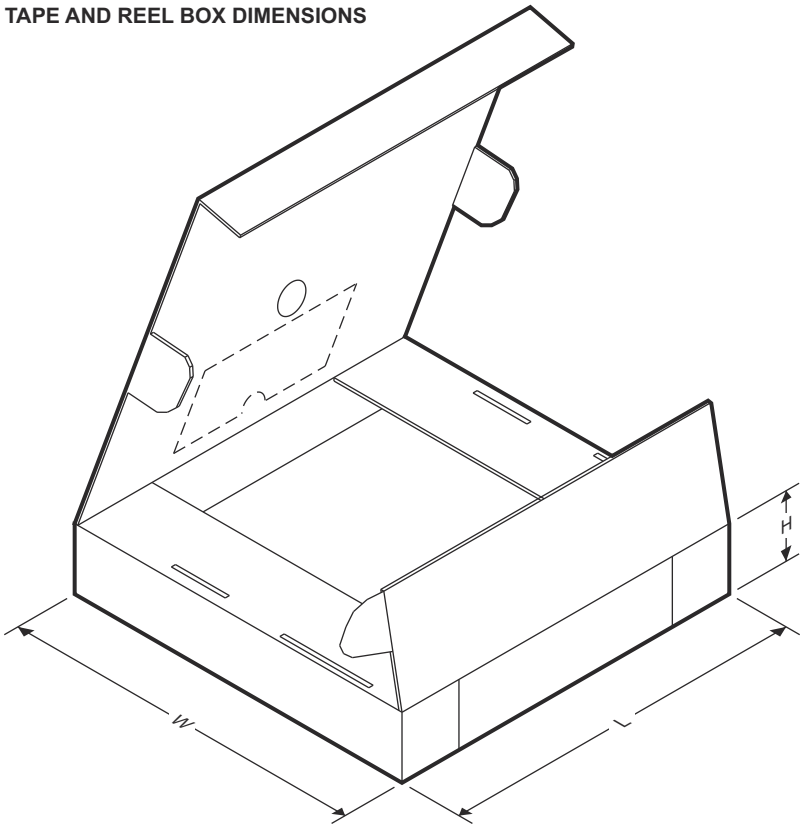


A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers



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
PLM68680FRZYRQ1	VQFN-FCRLF	RZY	26	3000	330	12.4	3.79	3.79	0.71	8.0	12.0	Q1

TAPE AND REEL BOX DIMENSIONS



Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
PLM68680FRZYRQ1	VQFN-FCRLF	RZY	26	3000	367	367	35

ADVANCE INFORMATION

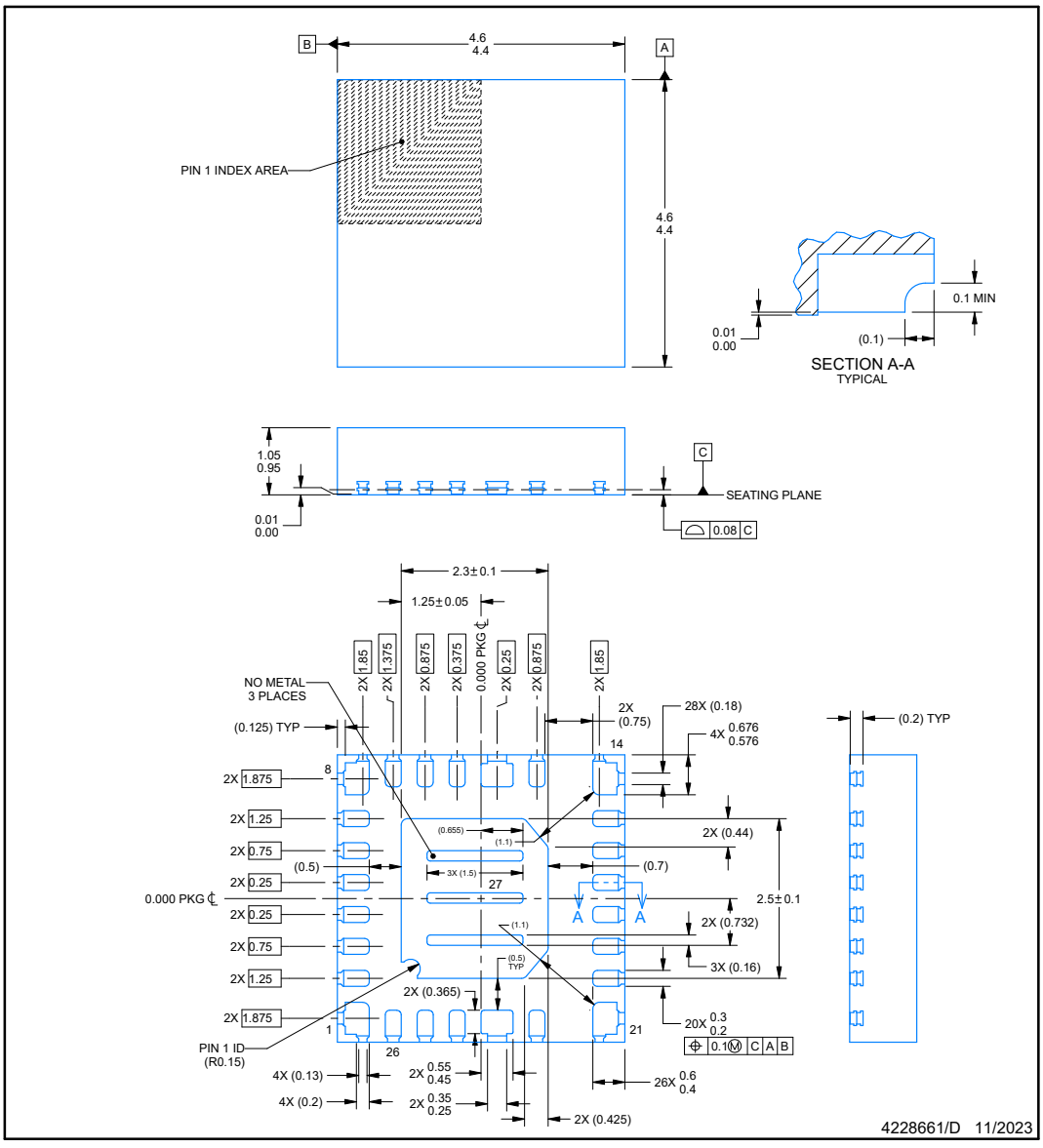
ADVANCE INFORMATION

PACKAGE OUTLINE

RZY0026A

VQFN-FCRLF - 1.05 mm max height

PLASTIC QUAD FLATPACK - NO LEAD



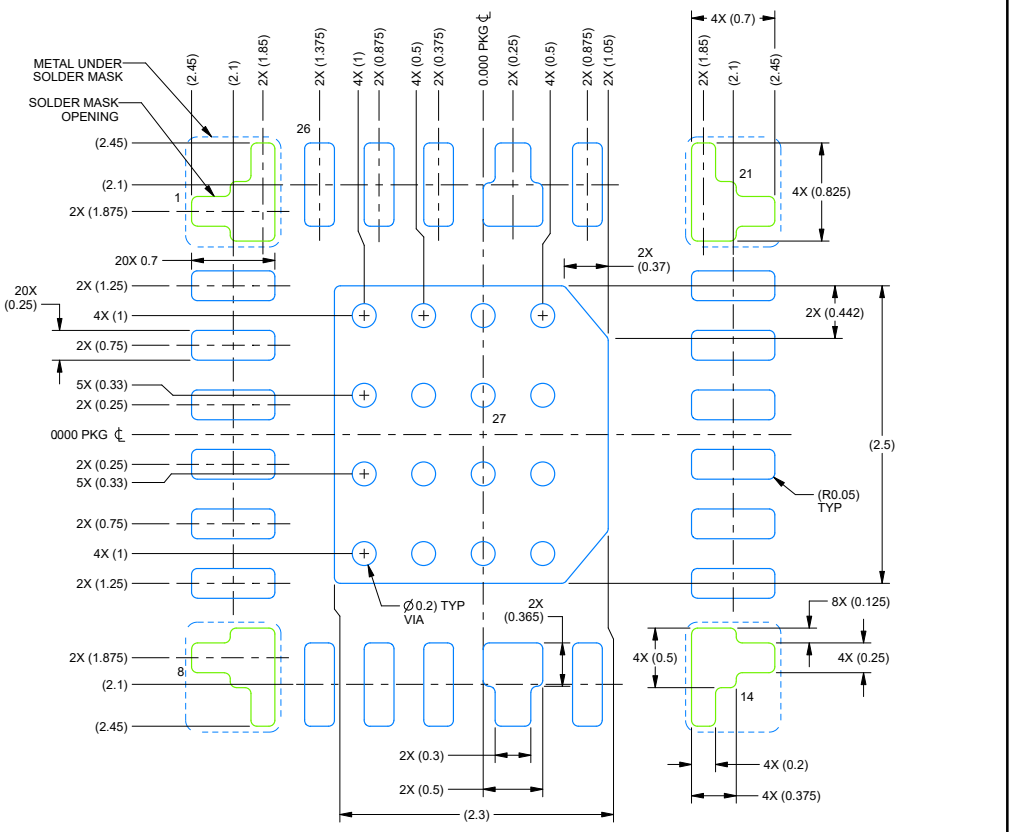
NOTES:

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

RZY0026A — **VQFN-FCRLF - 1.05 mm max height**

PLASTIC QUAD FLATPACK - NO LEAD



NOTES: (continued)

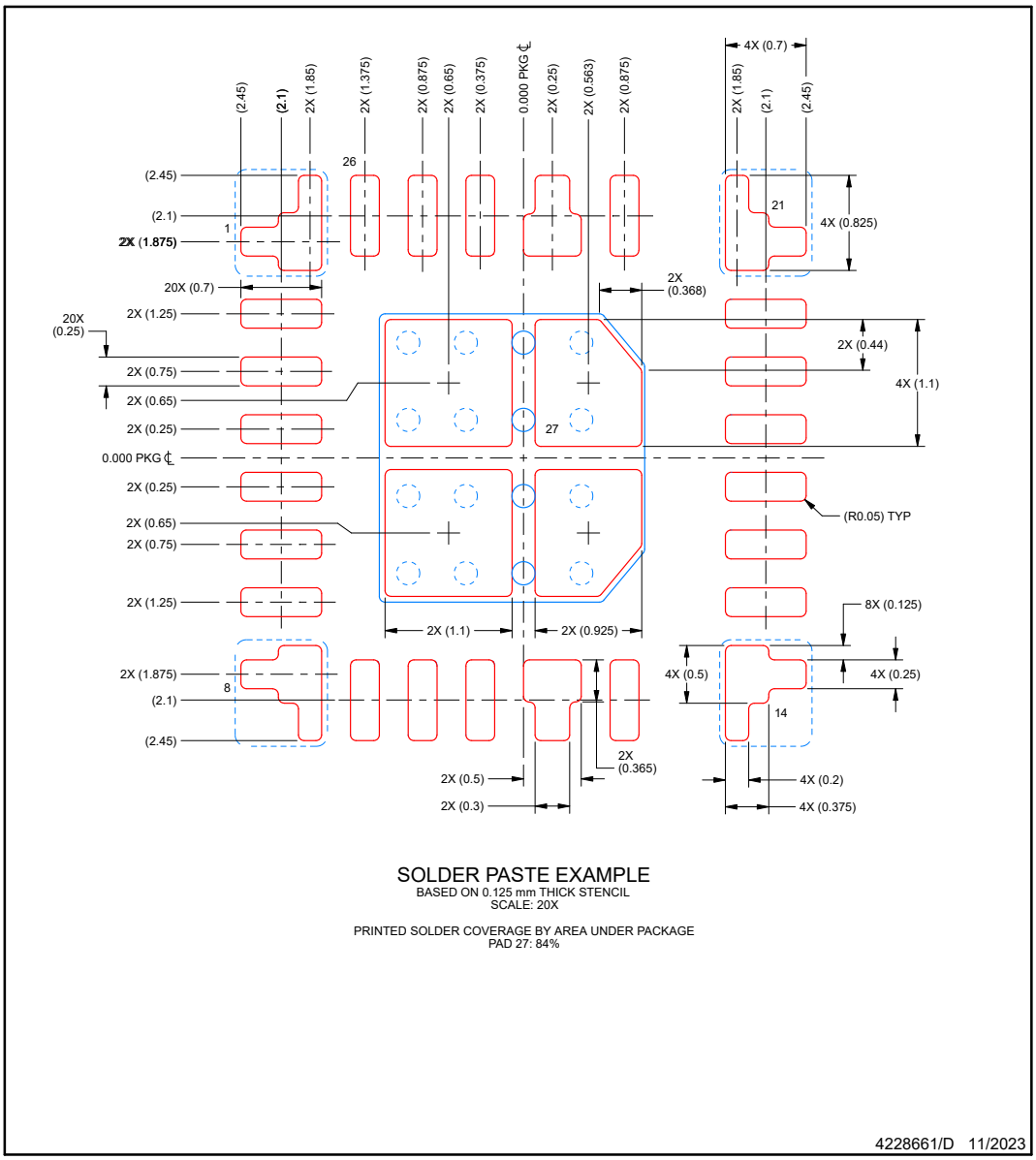
4. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 (www.ti.com/lit/slua271).
5. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown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

ADVANCE INFORMATION

EXAMPLE STENCIL DESIGN

RZY0026A — **VQFN-FCRLF - 1.05 mm max height**

PLASTIC QUAD FLATPACK - NO LEAD



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL
SCALE: 20X

PRINTED SOLDER COVERAGE BY AREA UNDER PACKAGE
PAD 27: 84%

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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)
PLM68680FRZYRQ1	Active	Preproduction	WQFN-FCRLF (RZY) | 26	3000 | LARGE T&R	-	Call TI	Call TI	-40 to 150	
PLM68680FRZYRQ1.A	Active	Preproduction	WQFN-FCRLF (RZY) | 26	3000 | LARGE T&R	-	Call TI	Call TI	-40 to 150	

(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.

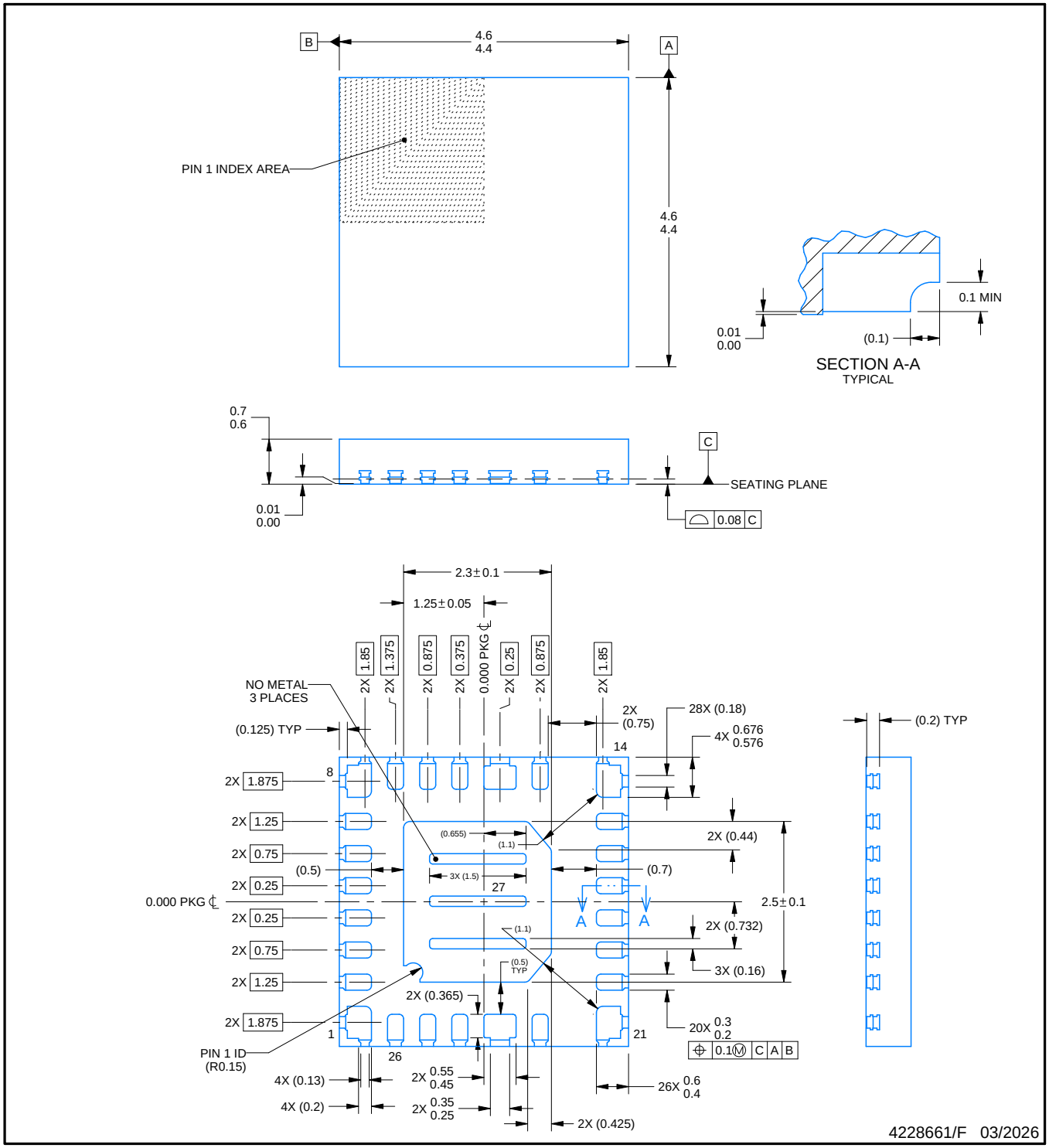
Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

PACKAGE OUTLINE

RZY0026A

WQFN-FCRLF - 0.7 mm max height

PLASTIC QUAD FLATPACK - NO LEAD



NOTES:

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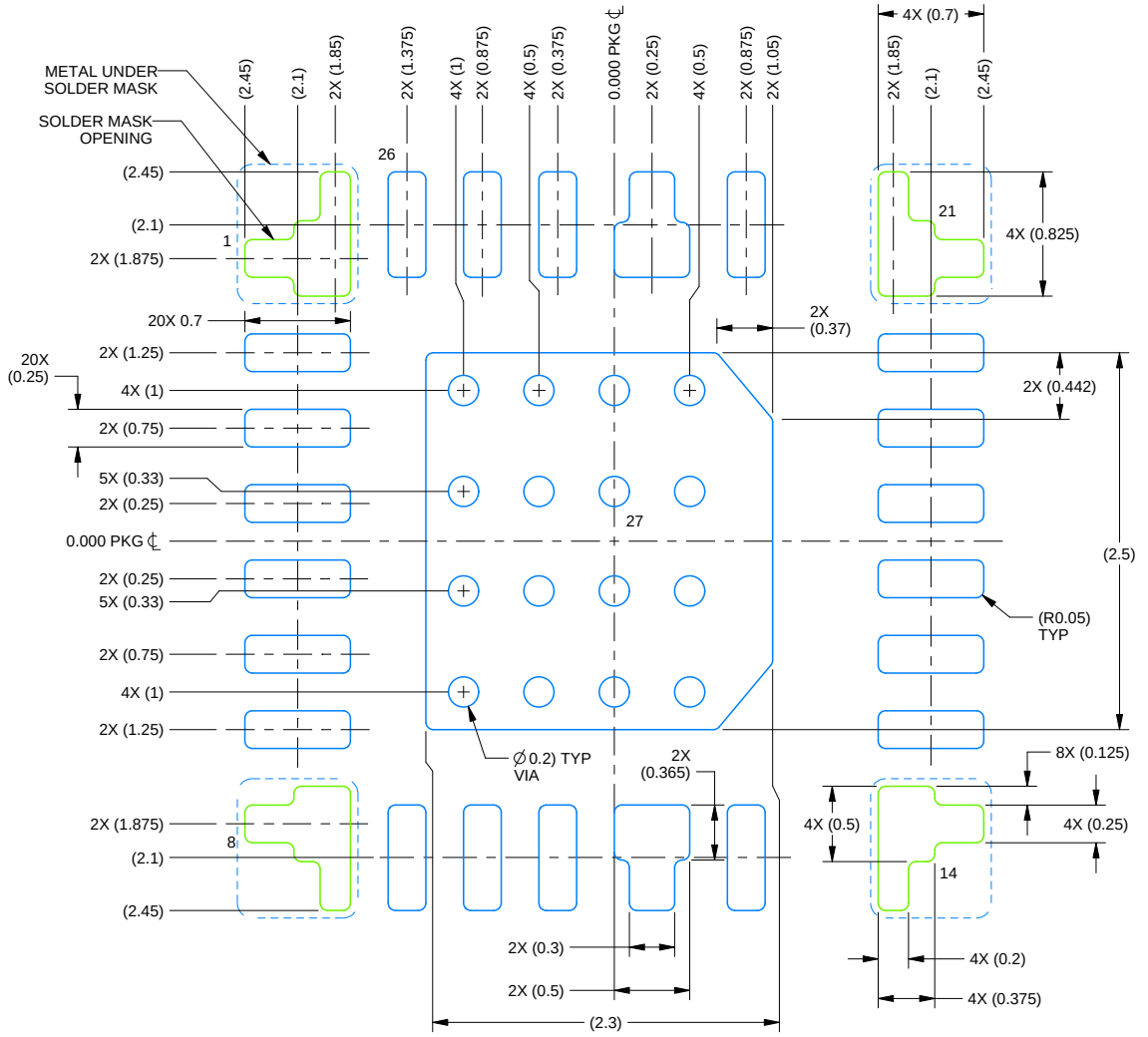
RZY0026A

WQFN-FCRLF - 0.7 mm max height

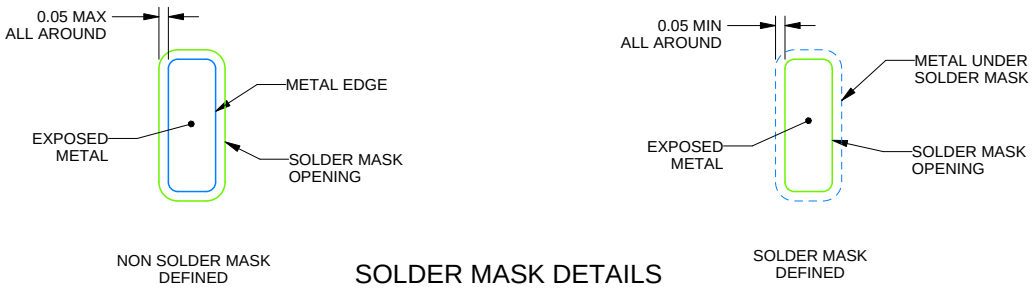
PLASTIC QUAD FLATPACK - NO LEAD



LAND PATTERN EXAMPLE

EXPOSED METAL SHOWN

SCALE: 20X



NON SOLDER MASK DEFINED

SOLDER MASK DETAILS

SOLDER MASK DEFINED

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NOTES: (continued)

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EXAMPLE STENCIL DESIGN

RZY0026A

WQFN-FCRLF - 0.7 mm max height

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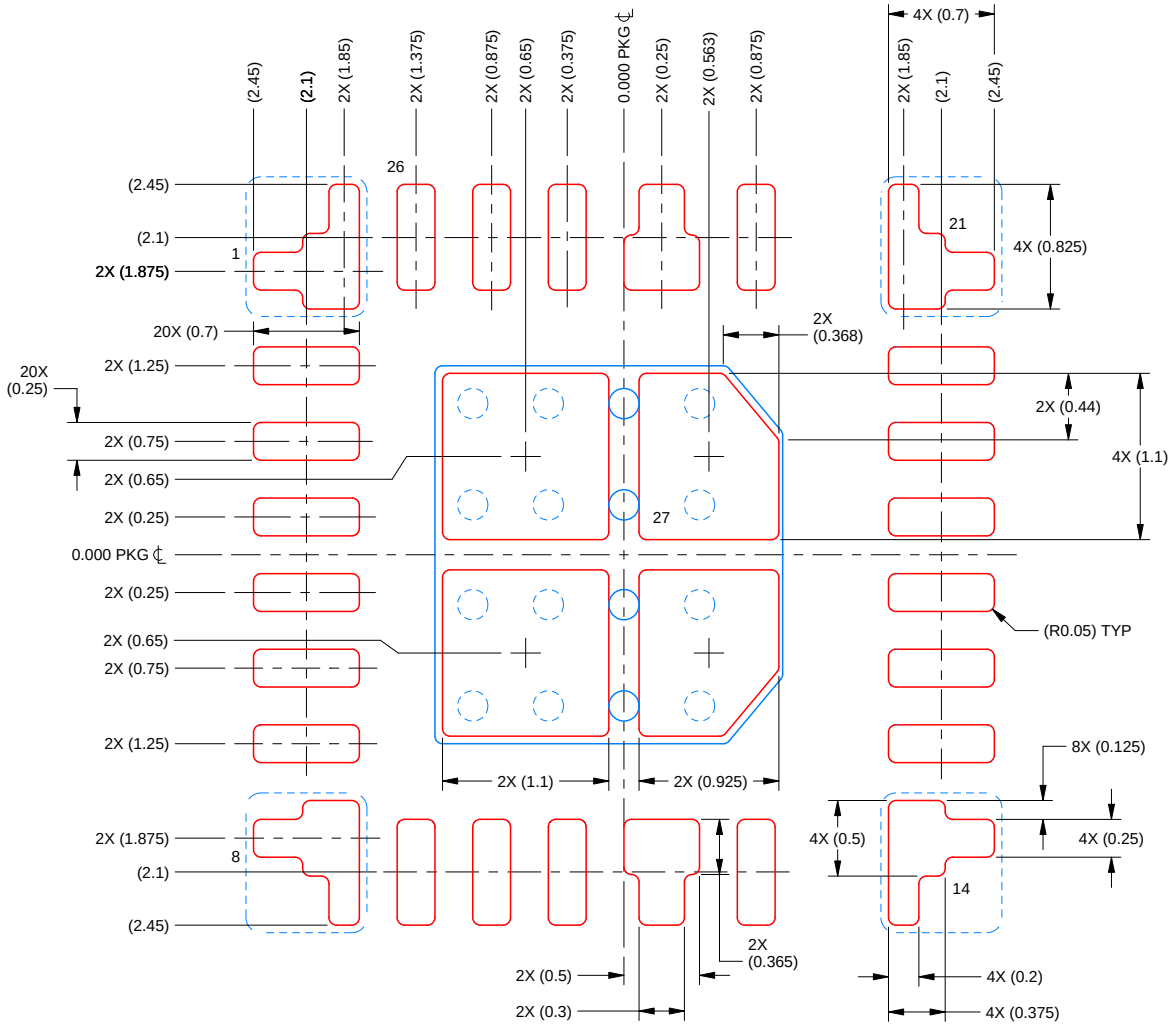

SOLDER PASTE EXAMPLE

BASED ON 0.125 mm THICK STENCIL

SCALE: 20X

PRINTED SOLDER COVERAGE BY AREA UNDER PACKAGE

PAD 27: 84%

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NOTES: (continued)

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