

LM686x5-Q1 High Performance, Functional Safety Power Converter, 3V to 70V, Pin-Compatible, 2.5A/3.5A/4.5A, Automotive, Low EMI, Synchronous Buck Converter

1 Features

- AEC-Q100 qualified for automotive applications:
 - Temperature grade 1: -40°C to $+125^{\circ}\text{C}$, T_A
- **Functional Safety-Compliant**
 - Developed for functional safety applications
 - Documentation to aid with ISO26262 compliant designs planned
 - Systematic capability up to ASIL-D
 - Hardware capability up to ASIL-C
 - Analog built-in-self-test at start-up
 - Redundant and fast ($0.35\mu\text{s}$) V_{OUT} monitor
 - Feedback path failure detection
 - Redundant temperature sensor
 - Excellent pin FMEA and pin spacing
- Wide input voltage range: 3V to 70V
- Designed for low EMI requirements
 - Facilitates CISPR 25 class 5 compliance
 - $\pm 5\%$ dual-random spread spectrum
 - Enhanced HotRod™ QFN package with symmetrical pinout
 - Switching frequency from 300kHz to 2.2MHz
 - Pin-configurable 400kHz and 2.2MHz
 - Pin-configurable AUTO or FPWM operation
- Low minimum on time: 40ns (maximum)
 - Enables 36V to 3.3V conversion at 2.2MHz
- High-efficiency power conversion at all loads
 - $> 94\%$ peak efficiency at $24V_{\text{IN}}$, $5V_{\text{OUT}}$, 400kHz
 - $2.5\mu\text{A}$ PFM no-load input current
- High power density
 - Internal compensation, current limit, and TSD
 - $3.6\text{mm} \times 2.6\text{mm}$, wettable flank, 20-pin package
 - Pin compatible with LM656x5-Q1
 - $\Theta_{\text{JA}} = 25.5^{\circ}\text{C}/\text{W}$ (LM65645-Q1EVM)
- Create a custom design using the with the [WEBENCH® Power Designer](#)

2 Applications

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

3 Description

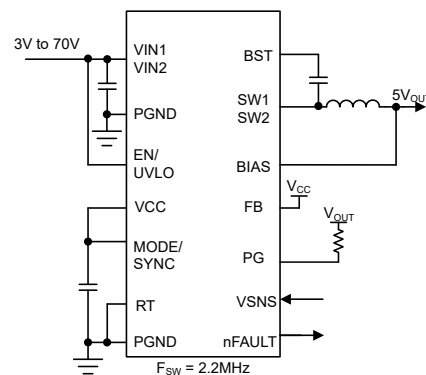
The LM686x5-Q1 are a family of automotive buck converters designed for high efficiency, high power density, and ultra-low electromagnetic interference (EMI). The converters operate over a wide input voltage range of 3V to 70V (75V tolerant) reducing the need for external input surge protection. The LM686x5-Q1 comes with pin selectable fixed output voltages of 3.3V and 5V or in adjustable configuration. The low EMI operation is enabled with minimized loop inductance and optimized switch node slew rate. The current-mode control architecture with a 30ns typical minimum on-time allows high conversion ratios at high frequencies coupled with a fast transient response and excellent load and line regulation.

The LM686x5-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} monitoring, feedback path failure detection, redundant temperature sensor, thermal shutdown, and current limiting significantly reduce the residual failure-in-time (FIT).

Device Information

PART NUMBER ⁽³⁾	PACKAGE ⁽¹⁾	PACKAGE SIZE ⁽²⁾
LM68625-Q1 ⁽⁴⁾ , LM68635-Q1 ⁽⁴⁾ , LM68645-Q1	RZT (WQFN-FCRLF, 20)	2.60mm × 3.60mm

- (1) For more information, see [Section 7](#).
- (2) The package size (length × width) is a nominal value and includes pins, where applicable.
- (3) See the [Device Comparison table](#).
- (4) Preview information (not Advance Information).



Simplified Schematic



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4 Device Comparison Table

ORDERABLE PART NUMBER	CURRENT	SAMPLING
LM68645SRZTRQ1	4.5A	Yes
LM68635SRZTRQ1 ⁽²⁾	3.5A ⁽¹⁾	No
LM68625SRZTRQ1 ⁽²⁾	2.5A	No

- (1) For more information about sampling requests, please contact Texas Instruments.
(2) Preview information (not Advance Information).

5 Device and Documentation Support

5.1 Device Support

5.1.1 Third-Party Products Disclaimer

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5.1.2 Development Support

5.1.2.1 Custom Design With WEBENCH® Tools

[Click here](#) to create a custom design using the LM686x5-Q1 device with the WEBENCH Power Designer.

1. Start by entering the input voltage (V_{IN}), output voltage (V_{OUT}), and output current (I_{OUT}) requirements.
2. Optimize the design for key parameters such as efficiency, footprint, and cost using the optimizer dial.
3. Compare the generated design with other possible solutions from Texas Instruments.

The WEBENCH Power Designer provides a customized schematic along with a list of materials with real-time pricing and component availability.

In most cases, these actions are available:

- Run electrical simulations to see important waveforms and circuit performance
- Run thermal simulations to understand board thermal performance
- Export customized schematic and layout into popular CAD formats
- Print PDF reports for the design, and share the design with colleagues

Get more information about WEBENCH tools at www.ti.com/WEBENCH.

5.2 Documentation Support

5.2.1 Related Documentation

For related documentation, see the following:

- Texas Instruments, [Thermal Design by Insight not Hindsight application report](#)
- Texas Instruments, [A Guide to Board Layout for Best Thermal Resistance for Exposed Pad Packages application report](#)
- Texas Instruments, [How to Properly Evaluate Junction Temperature with Thermal Metrics application report](#)
- Texas Instruments, [Layout Guidelines for Switching Power Supplies application report](#)
- Texas Instruments, [Simple Switcher PCB Layout Guidelines application report](#)
- Texas Instruments, [Construction Your Power Supply- Layout Considerations seminar](#)
- Texas Instruments, [Low Radiated EMI Layout Made Simple with LM4360x and LM4600x application report](#)
- Texas Instruments, [Semiconductor and IC Package Thermal Metrics application note](#)

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.

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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

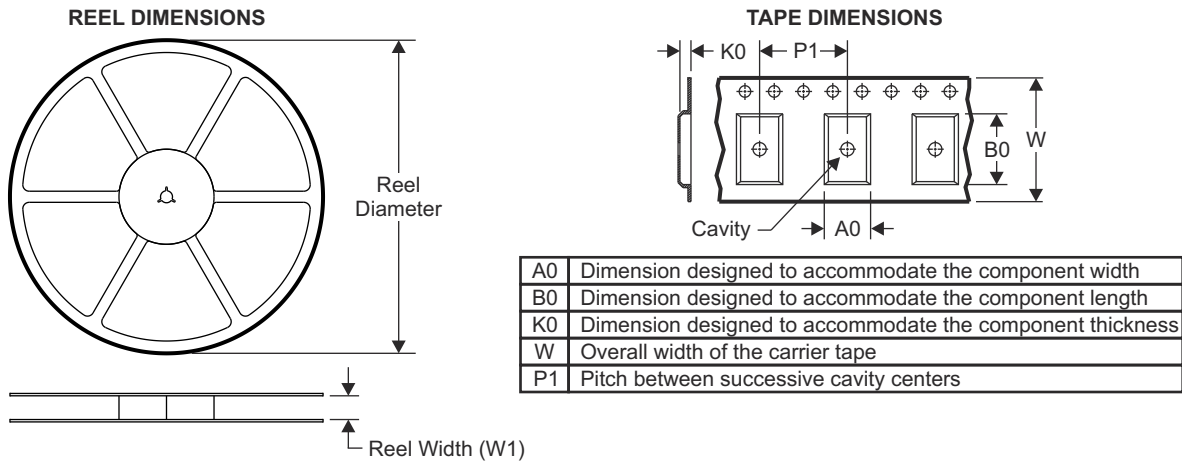
NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

DATE	REVISION	NOTES
October 2024	*	Initial Release

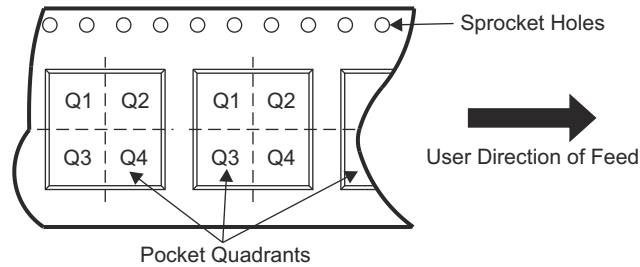
7 Mechanical, Packaging, and Orderable Information

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

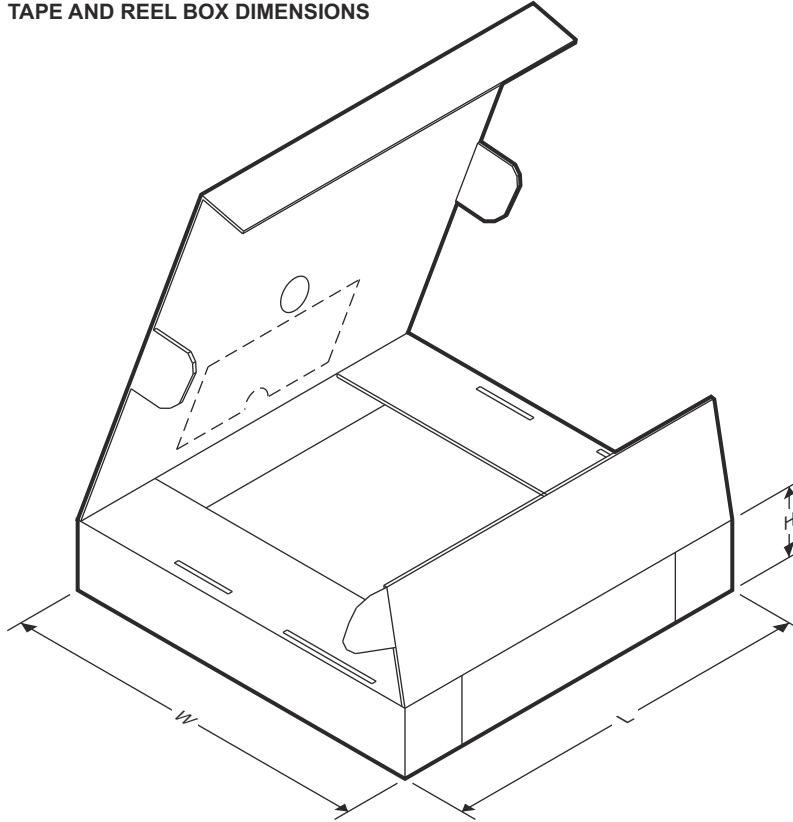


QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



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
PLM68645SRZT RQ1	QFN	RZT	20	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)
PLM68645SRZTRQ1	QFN	RZT	20	3000	367	367	35

ADVANCE INFORMATION

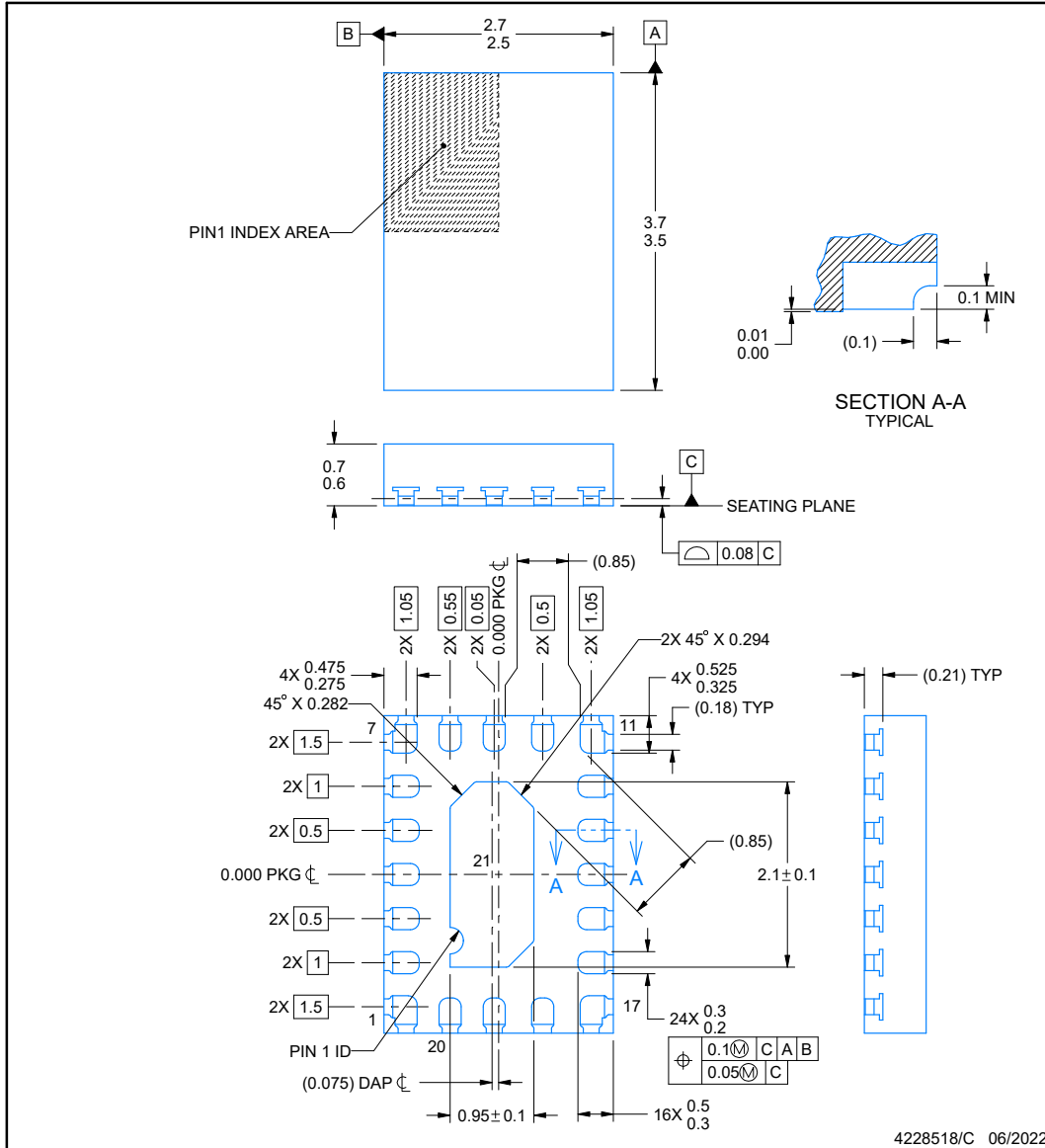


PACKAGE OUTLINE

RZT0020A

WQFN-FCRLF - 0.7 mm max height

PLASTIC QUAD FLATPACK - NO LEAD



NOTES:

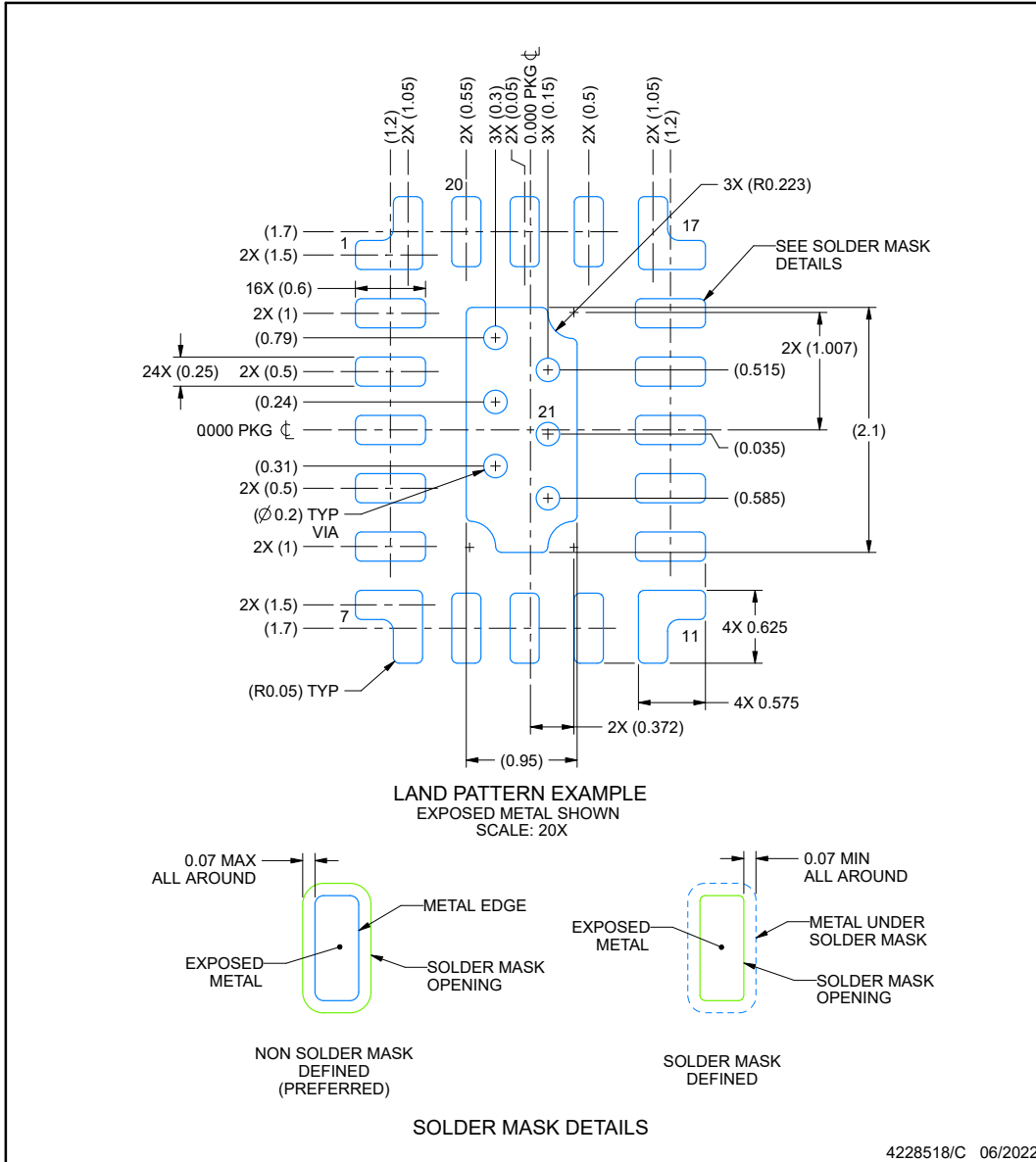
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. The package thermal pad must be soldered to the printed circuit board for thermal and mechanical performance.

EXAMPLE BOARD LAYOUT

RZT0020A

WQFN-FCRLF - 0.7 mm max height

PLASTIC QUAD FLATPACK - NO LEAD



NOTES: (continued)

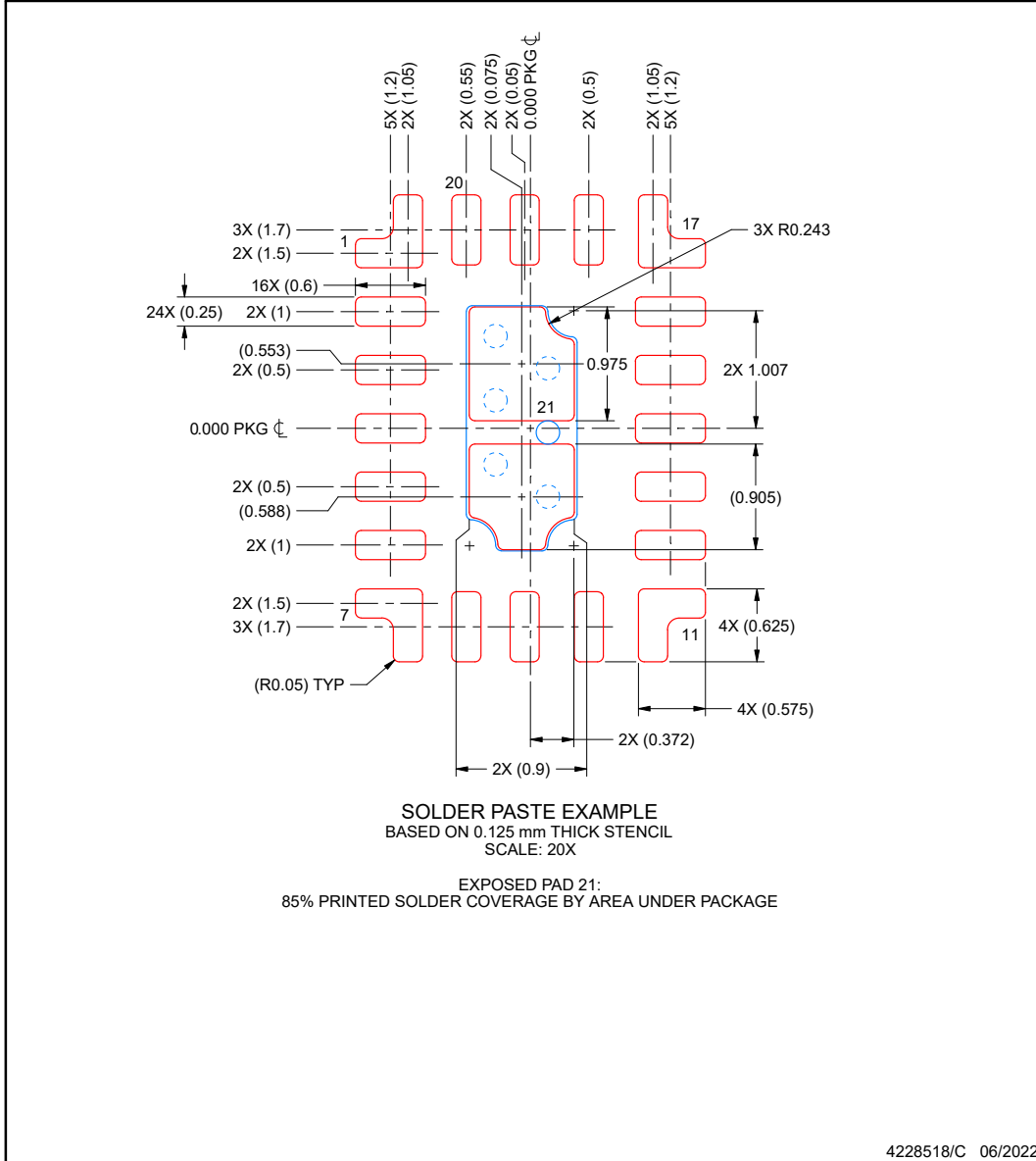
4. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 (www.ti.com/lit/sluea271).
5. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It is recommended that vias under paste be filled, plugged or tented.

EXAMPLE STENCIL DESIGN

RZT0020A

WQFN-FCRLF - 0.7 mm max height

PLASTIC QUAD FLATPACK - NO LEAD



NOTES: (continued)

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

ADVANCE INFORMATION

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
PLM68645SFRZTRQ1	ACTIVE	WQFN-FCRLF	RZT	20	2500	TBD	Call TI	Call TI	-40 to 150		Samples

(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.

PREVIEW: Device has been announced but is not in production. Samples may or may not be available.

OBSELETE: TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".

RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.

Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(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 finish/Ball material - Orderable Devices 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.

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Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
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