

# TPS650332-Q1 Automotive Camera PMIC

## 1 Features

- Qualified for automotive applications
- Systematic capability of up to ASIL D and SIL 3 targeted
- Hardware integrity up to ASIL B and SIL 2 targeted
- Advanced diagnostics and protection
- AEC-Q100 grade 1 qualified
  - $-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$  ambient operating temperature range
- Three step-down converters:
  - BUCK1  $V_{\text{IN}}$  range from 4.0 V to 18.3 V
  - BUCK1  $V_{\text{OUT}}$  range from 2.5 V to 4.0 V
  - BUCK1 output current up to 1500-mA
  - BUCK2 and BUCK3  $V_{\text{IN}}$  range from 2.5 V to 5.5 V
  - BUCK2 and BUCK3  $V_{\text{OUT}}$  range from 0.9 V to 1.9 V
  - BUCK2 and BUCK3 output current up to 1200-mA
  - Spread-spectrum clock (SSC) generation for reduced EMI
  - 2.3-MHz forced fixed switching frequency PWM operation
- One low dropout (LDO) regulator:
  - $V_{\text{IN}}$  range from 2.5 V to 5.5 V
  - $V_{\text{OUT}}$  range from 1.8 V to 3.3 V
  - Low noise and high PSRR
  - Adjustable output voltage through  $I^2\text{C}$
  - Up to 300-mA output current
- 4.0-mm  $\times$  4.0-mm 24-pin VQFN with wettable flanks

## 2 Applications

- Automotive camera modules
  - Surround view camera modules
  - Rear view camera modules
  - Driver monitor camera modules
  - Power over coax (POC) camera modules
  - E-mirror camera modules
  - Front view camera modules

## 3 Description

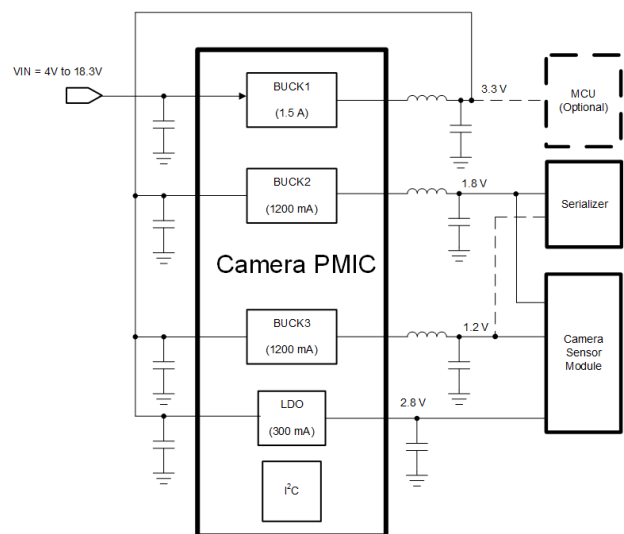
The TPS650332-Q1 device is a highly integrated power management IC for automotive camera modules. This device combines three step-down converters and one low-dropout (LDO) regulator. The BUCK1 step-down converter has an input voltage range up to 18.3 V for connections to power over coax (PoC). All converters operate in a forced fixed-frequency PWM mode. The LDO can supply 300 mA and operate with an input voltage range from 2.5 V to 5.5 V. The step-down converters and the LDO have separate voltage inputs that enable maximum design and sequencing flexibility.

The TPS650332-Q1 is available in a 24-pin VQFN package (4.00 mm  $\times$  4.00 mm).

### Device Information

PART NUMBER <sup>(1)</sup>	PACKAGE	BODY SIZE (NOM)
TPS650332-Q1	VQFN (24)	4.00 mm $\times$ 4.00 mm

- (1) For all available packages, see the orderable addendum at the end of the data sheet.



**TPS650332-Q1 Application Circuit**



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## 4 Revision History

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

DATE	REVISION	NOTES
September 2023	*	Initial Release

## 5 Device and Documentation Support

### 5.1 Device Support

#### 5.1.1 Third-Party Products Disclaimer

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#### 5.2 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on [ti.com](https://www.ti.com). Click on *Subscribe to updates* 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.

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#### 5.4 Trademarks

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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 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
TPS65033201RGERQ1	ACTIVE	VQFN	RGE	24	3000	RoHS & Green	NIPDAU   SN	Level-3-260C-168 HR	-40 to 125	TPS6503 3201-Q1	<a href="#">Samples</a>
TPS65033203RGERQ1	ACTIVE	VQFN	RGE	24	3000	RoHS & Green	NIPDAU   SN	Level-3-260C-168 HR	-40 to 125	TPS6503 3203-Q1	<a href="#">Samples</a>
TPS65033205QRGERQ1	ACTIVE	VQFN	RGE	24	3000	RoHS & Green	NIPDAU   SN	Level-3-260C-168 HR	-40 to 125	TPS6503 3205-Q1	<a href="#">Samples</a>
TPS65033206RGERQ1	ACTIVE	VQFN	RGE	24	3000	RoHS & Green	NIPDAU   SN	Level-3-260C-168 HR	-40 to 125	TPS6503 3206-Q1	<a href="#">Samples</a>
TPS65033207RGERQ1	ACTIVE	VQFN	RGE	24	3000	RoHS & Green	NIPDAU   SN	Level-3-260C-168 HR	-40 to 125	TPS6503 3207-Q1	<a href="#">Samples</a>
TPS65033208RGERQ1	ACTIVE	VQFN	RGE	24	3000	RoHS & Green	NIPDAU   SN	Level-3-260C-168 HR	-40 to 125	TPS6503 3208-Q1	<a href="#">Samples</a>
TPS65033209QRGERQ1	ACTIVE	VQFN	RGE	24	3000	RoHS & Green	NIPDAU   SN	Level-3-260C-168 HR	-40 to 125	TPS6503 3209-Q1	<a href="#">Samples</a>
TPS6503320AARGERQ1	ACTIVE	VQFN	RGE	24	3000	RoHS & Green	NIPDAU   SN	Level-3-260C-168 HR	-40 to 125	TPS6503 320AAQ1	<a href="#">Samples</a>
TPS6503320CRGERQ1	ACTIVE	VQFN	RGE	24	3000	RoHS & Green	SN	Level-3-260C-168 HR	-40 to 125	TPS6503 320C-Q1	<a href="#">Samples</a>
TPS6503320DRGERQ1	ACTIVE	VQFN	RGE	24	3000	RoHS & Green	NIPDAU   SN	Level-3-260C-168 HR	-40 to 125	TPS6503 320D-Q1	<a href="#">Samples</a>
TPS6503320FRGERQ1	ACTIVE	VQFN	RGE	24	3000	RoHS & Green	NIPDAU   SN	Level-3-260C-168 HR	-40 to 125	TPS6503 320F-Q1	<a href="#">Samples</a>
TPS6503320GRGERQ1	ACTIVE	VQFN	RGE	24	3000	RoHS & Green	NIPDAU   SN	Level-3-260C-168 HR	-40 to 125	TPS6503 320G-Q1	<a href="#">Samples</a>
TPS6503320HARGERQ1	ACTIVE	VQFN	RGE	24	3000	RoHS & Green	NIPDAU   SN	Level-3-260C-168 HR	-40 to 125	TPS6503 320HAQ1	<a href="#">Samples</a>
TPS6503320KRGERQ1	ACTIVE	VQFN	RGE	24	3000	RoHS & Green	NIPDAU   SN	Level-3-260C-168 HR	-40 to 125	TPS6503 320K-Q1	<a href="#">Samples</a>
TPS6503320MRGERQ1	ACTIVE	VQFN	RGE	24	3000	RoHS & Green	NIPDAU   SN	Level-3-260C-168 HR	-40 to 125	TPS6503 320M-Q1	<a href="#">Samples</a>

<sup>(1)</sup> 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.

**OBSOLETE:** TI has discontinued the production of the device.

<sup>(2)</sup> **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  $\leq 1000$ ppm threshold. Antimony trioxide based flame retardants must also meet the  $\leq 1000$ ppm threshold requirement.

<sup>(3)</sup> **MSL, Peak Temp.** - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

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

<sup>(5)</sup> 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.

<sup>(6)</sup> **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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## TAPE AND REEL INFORMATION



### 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
TPS65033201RGERQ1	VQFN	RGE	24	3000	330.0	12.4	4.3	4.3	1.1	8.0	12.0	Q2
TPS65033203RGERQ1	VQFN	RGE	24	3000	330.0	12.4	4.3	4.3	1.1	8.0	12.0	Q2
TPS65033205QRGERQ1	VQFN	RGE	24	3000	330.0	12.4	4.3	4.3	1.1	8.0	12.0	Q2
TPS65033206RGERQ1	VQFN	RGE	24	3000	330.0	12.4	4.3	4.3	1.1	8.0	12.0	Q2
TPS65033207RGERQ1	VQFN	RGE	24	3000	330.0	12.4	4.3	4.3	1.1	8.0	12.0	Q2
TPS65033208RGERQ1	VQFN	RGE	24	3000	330.0	12.4	4.3	4.3	1.1	8.0	12.0	Q2
TPS65033209QRGERQ1	VQFN	RGE	24	3000	330.0	12.4	4.3	4.3	1.1	8.0	12.0	Q2
TPS6503320AARGERQ1	VQFN	RGE	24	3000	330.0	12.4	4.3	4.3	1.1	8.0	12.0	Q2
TPS6503320CRGERQ1	VQFN	RGE	24	3000	330.0	12.4	4.3	4.3	1.1	8.0	12.0	Q2
TPS6503320DRGERQ1	VQFN	RGE	24	3000	330.0	12.4	4.3	4.3	1.1	8.0	12.0	Q2
TPS6503320FRGERQ1	VQFN	RGE	24	3000	330.0	12.4	4.3	4.3	1.1	8.0	12.0	Q2
TPS6503320GRGERQ1	VQFN	RGE	24	3000	330.0	12.4	4.3	4.3	1.1	8.0	12.0	Q2
TPS6503320HARGERQ1	VQFN	RGE	24	3000	330.0	12.4	4.3	4.3	1.1	8.0	12.0	Q2
TPS6503320KRGERQ1	VQFN	RGE	24	3000	330.0	12.4	4.3	4.3	1.1	8.0	12.0	Q2
TPS6503320MRGERQ1	VQFN	RGE	24	3000	330.0	12.4	4.3	4.3	1.1	8.0	12.0	Q2

**TAPE AND REEL BOX DIMENSIONS**


\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TPS65033201RGERQ1	VQFN	RGE	24	3000	367.0	367.0	38.0
TPS65033203RGERQ1	VQFN	RGE	24	3000	367.0	367.0	38.0
TPS65033205QRGERQ1	VQFN	RGE	24	3000	367.0	367.0	38.0
TPS65033206RGERQ1	VQFN	RGE	24	3000	367.0	367.0	38.0
TPS65033207RGERQ1	VQFN	RGE	24	3000	367.0	367.0	38.0
TPS65033208RGERQ1	VQFN	RGE	24	3000	367.0	367.0	38.0
TPS65033209QRGERQ1	VQFN	RGE	24	3000	367.0	367.0	38.0
TPS6503320AARGERQ1	VQFN	RGE	24	3000	367.0	367.0	38.0
TPS6503320CRGERQ1	VQFN	RGE	24	3000	367.0	367.0	38.0
TPS6503320DRGERQ1	VQFN	RGE	24	3000	367.0	367.0	38.0
TPS6503320FRGERQ1	VQFN	RGE	24	3000	367.0	367.0	38.0
TPS6503320GRGERQ1	VQFN	RGE	24	3000	367.0	367.0	38.0
TPS6503320HARGERQ1	VQFN	RGE	24	3000	367.0	367.0	38.0
TPS6503320KRGERQ1	VQFN	RGE	24	3000	367.0	367.0	38.0
TPS6503320MRGERQ1	VQFN	RGE	24	3000	367.0	367.0	38.0

**RGE 24**

**GENERIC PACKAGE VIEW**

**VQFN - 1 mm max height**

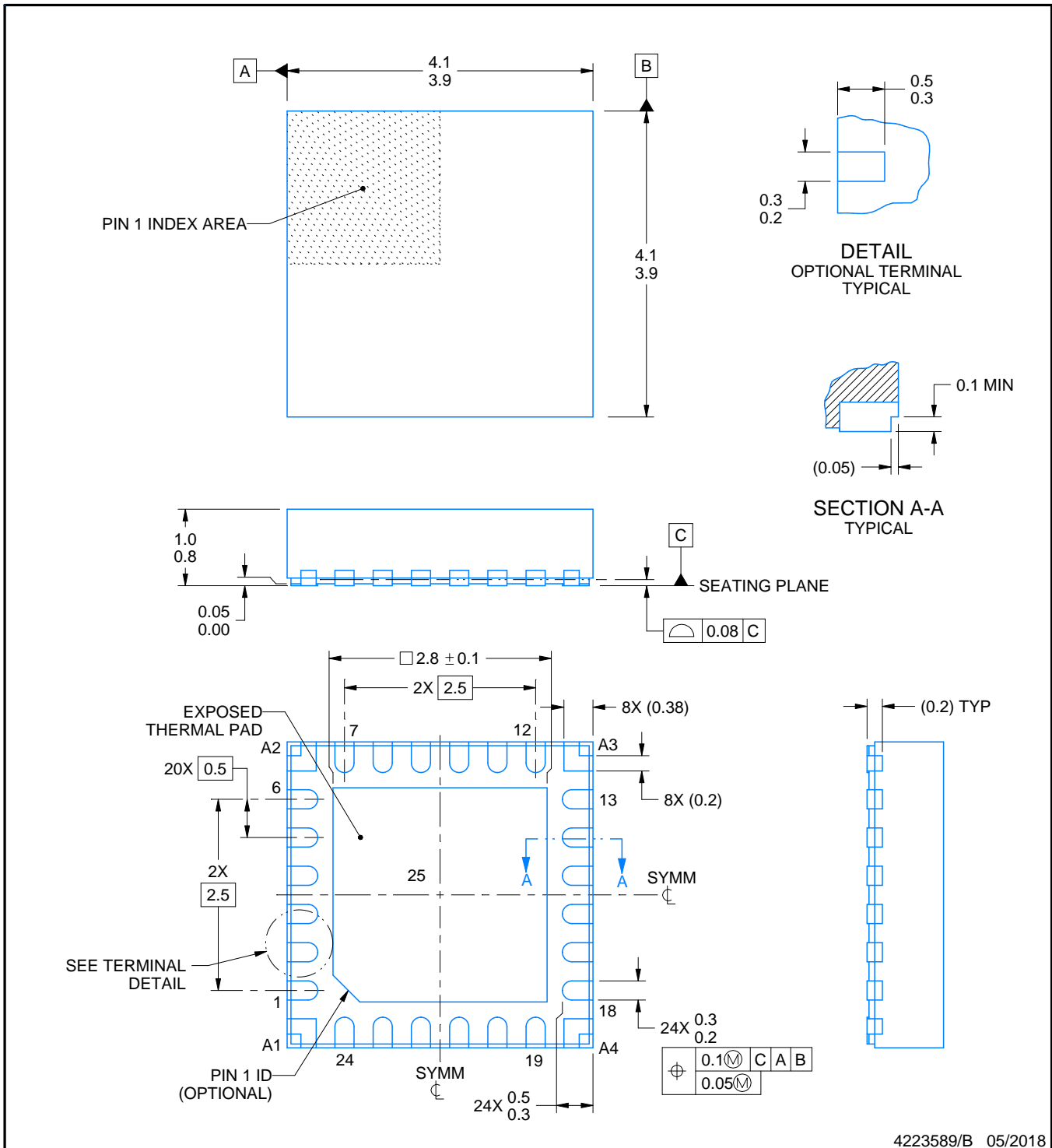
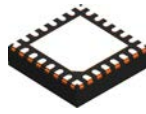
PLASTIC QUAD FLATPACK - NO LEAD



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

4204104/H





4223589/B 05/2018

NOTES:

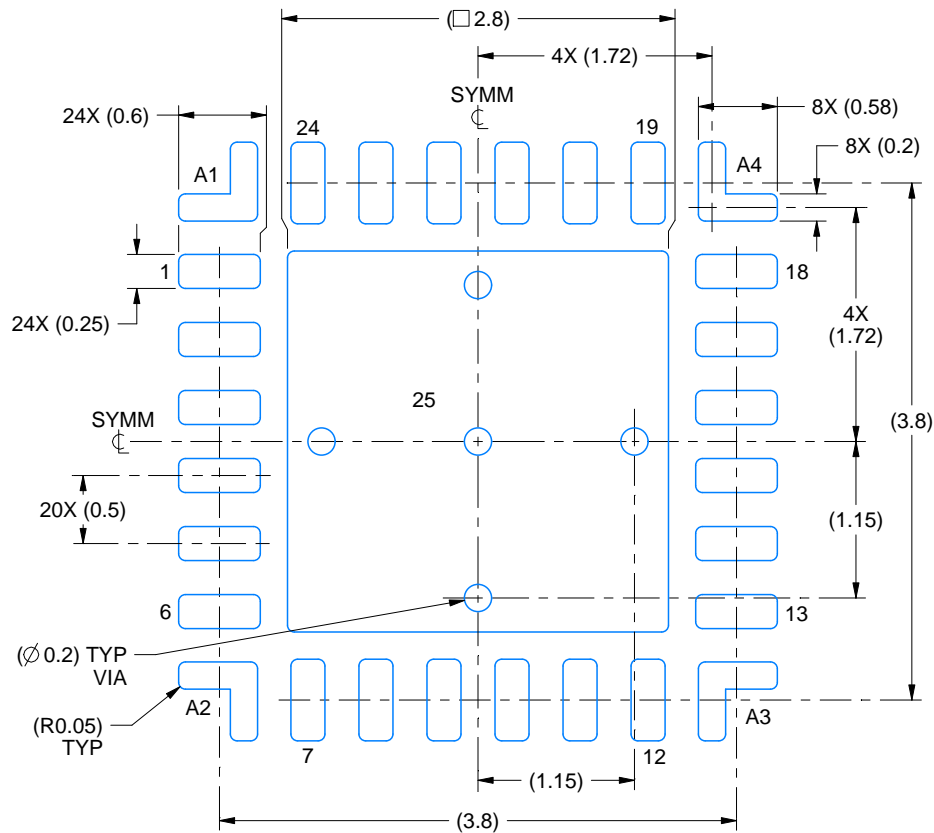
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. The package thermal pad must be soldered to the printed circuit board for thermal and mechanical performance.

# EXAMPLE BOARD LAYOUT

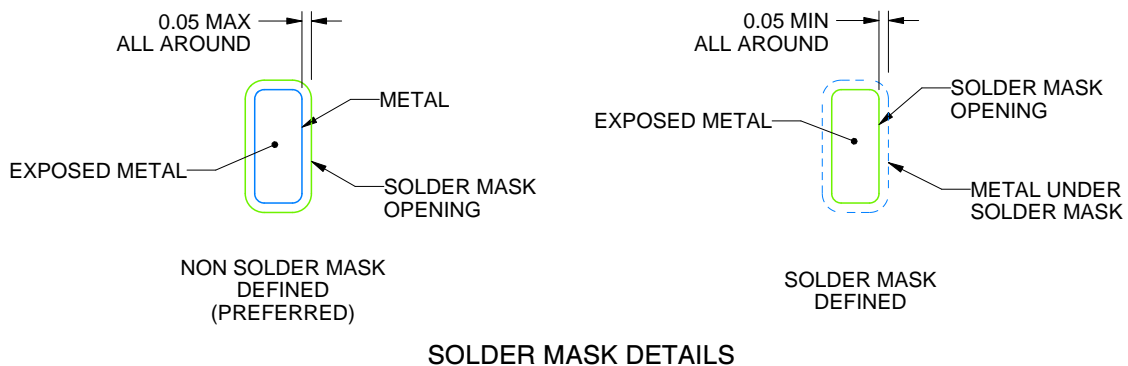
RGE0024K

VQFN - 1 mm max height

PLASTIC QUAD FLATPACK - NO LEAD



LAND PATTERN EXAMPLE  
EXPOSED METAL SHOWN  
SCALE:18X



4223589/B 05/2018

NOTES: (continued)

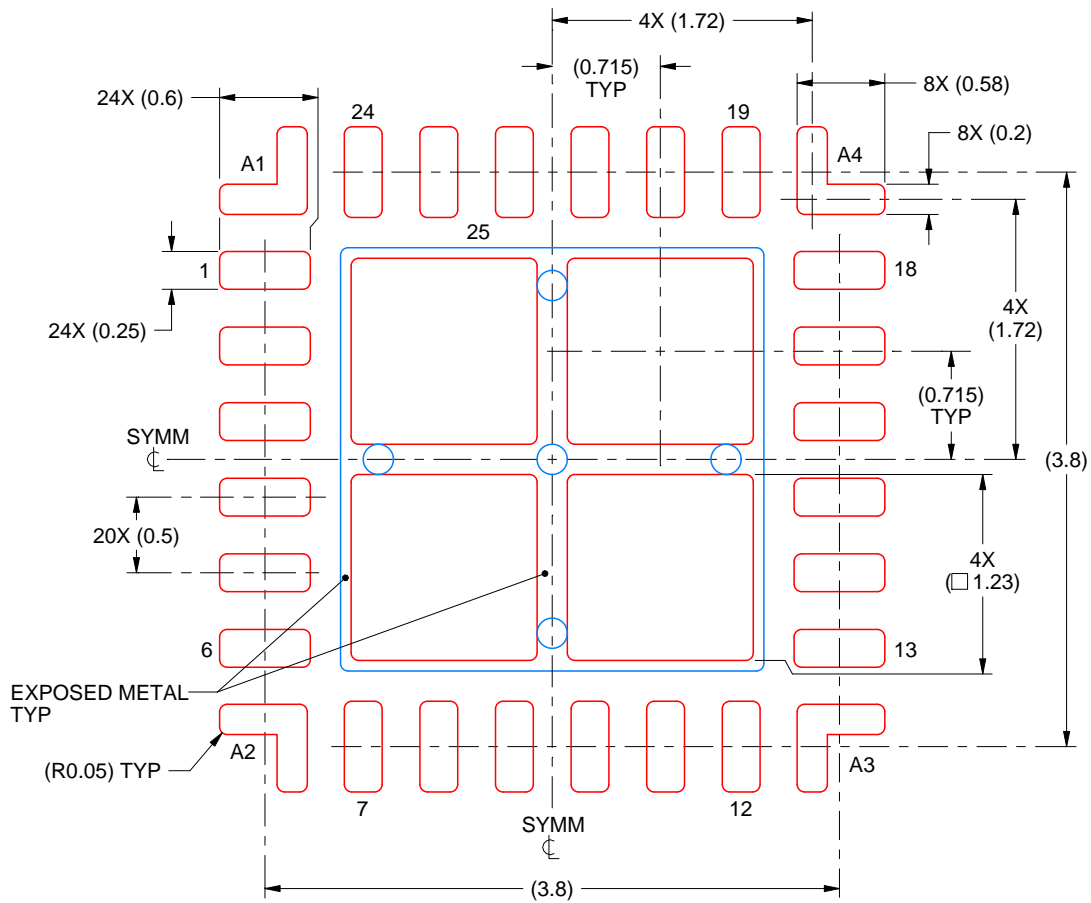
- This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 ([www.ti.com/lit/sluea271](http://www.ti.com/lit/sluea271)).
- Vias are optional depending on application, refer to device data sheet. If any vias are implemented,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

# EXAMPLE STENCIL DESIGN

RGE0024K

VQFN - 1 mm max height

PLASTIC QUAD FLATPACK - NO LEAD



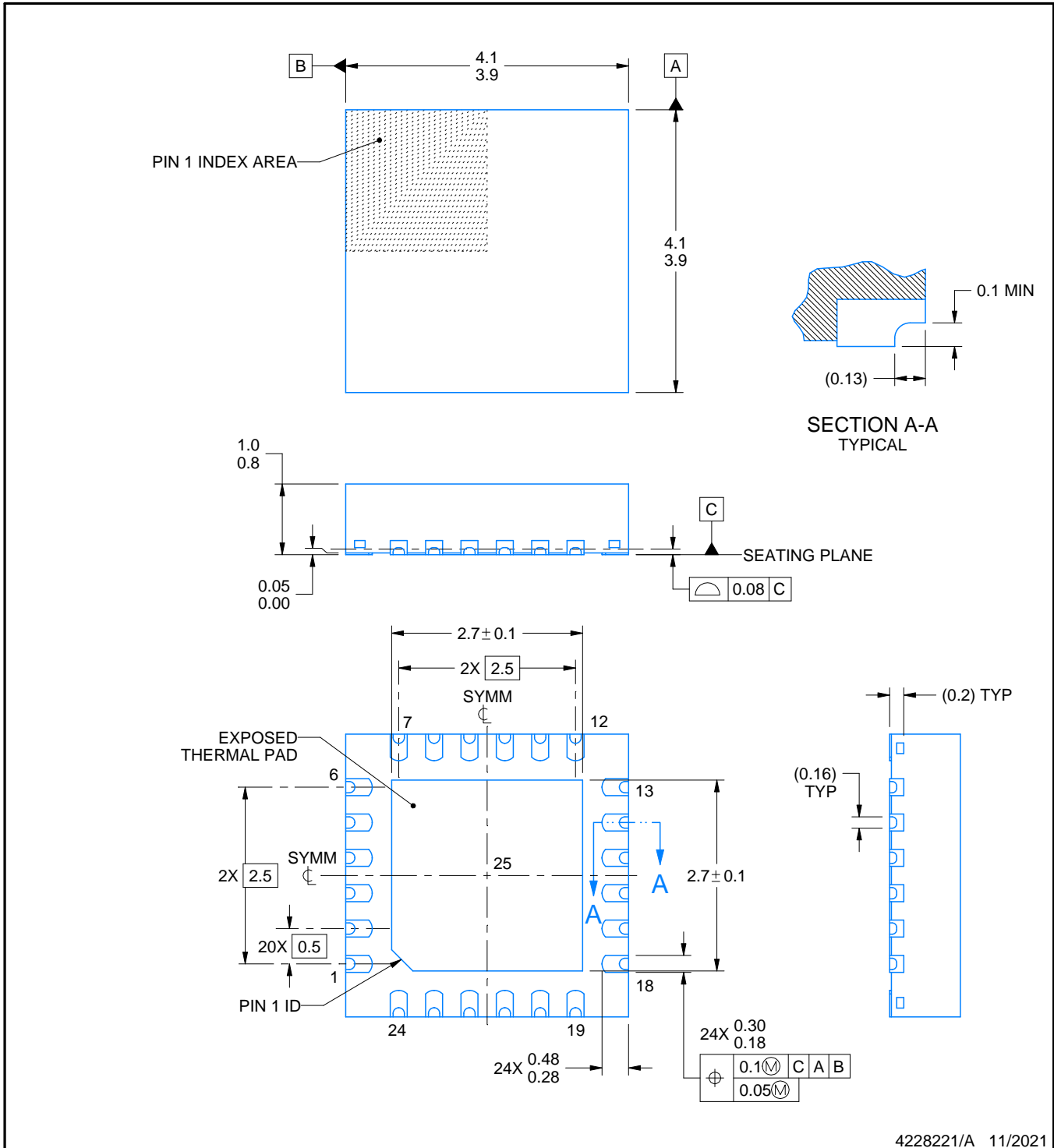
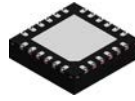
**SOLDER PASTE EXAMPLE**  
 BASED ON 0.1 mm THICK STENCIL

THERMAL PAD 25:  
 77% PRINTED SOLDER COVERAGE BY AREA UNDER PACKAGE  
 SCALE:20X

4223589/B 05/2018

NOTES: (continued)

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



4228221/A 11/2021

NOTES:

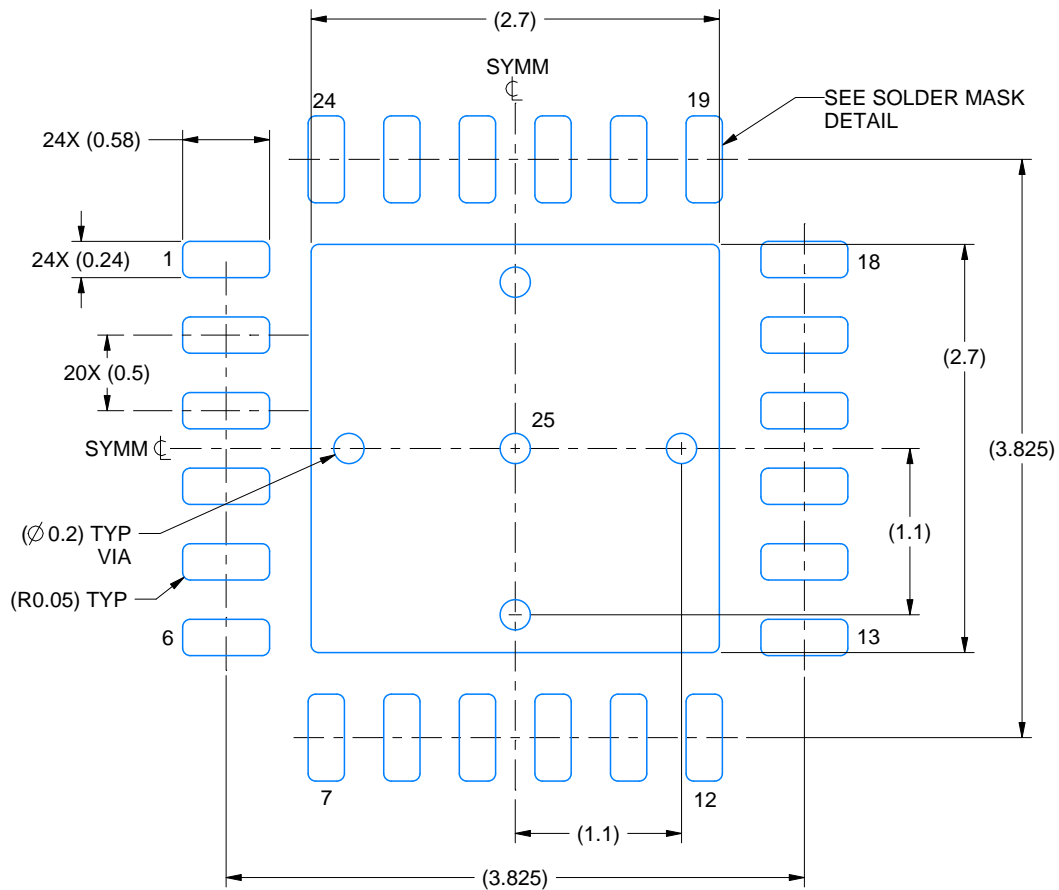
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. The package thermal pad must be soldered to the printed circuit board for thermal and mechanical performance.

# EXAMPLE BOARD LAYOUT

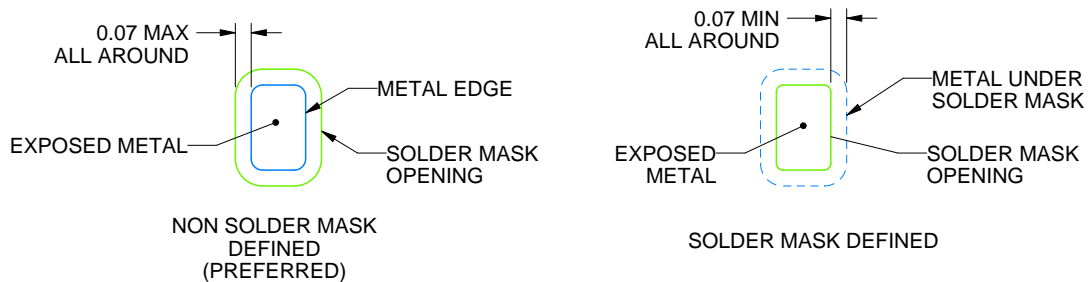
RGE0024U

VQFN - 1 mm max height

PLASTIC QUAD FLATPACK - NO LEAD



LAND PATTERN EXAMPLE  
EXPOSED METAL SHOWN  
SCALE: 20X



SOLDER MASK DETAILS

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NOTES: (continued)

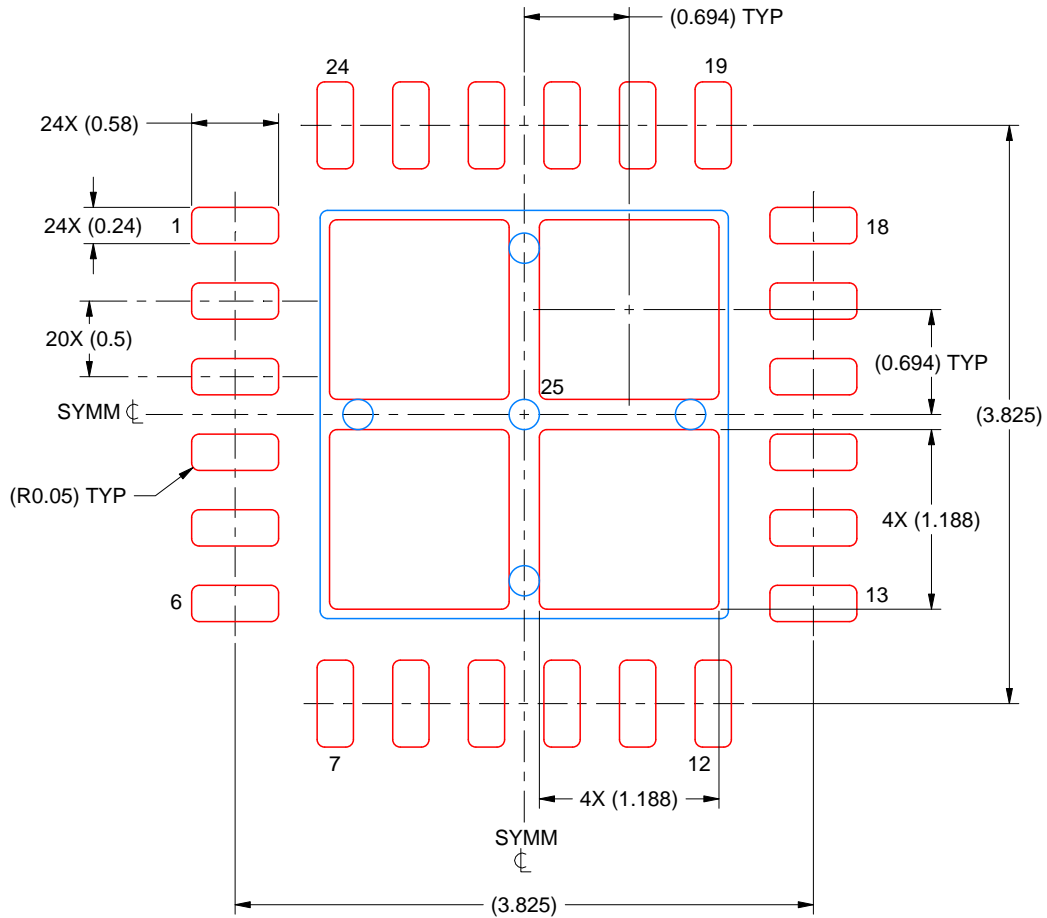
4. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 ([www.ti.com/lit/slua271](http://www.ti.com/lit/slua271)).
5. Vias are optional depending on application, refer to device data sheet. If any vias are implemented,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

# EXAMPLE STENCIL DESIGN

RGE0024U

VQFN - 1 mm max height

PLASTIC QUAD FLATPACK - NO LEAD



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

EXPOSED PAD 25  
 77% PRINTED SOLDER COVERAGE BY AREA UNDER PACKAGE

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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.

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