LMS3635/55-Q1, 3.5-A /5.5-A, 36-V Synchronous, 400-kHz, Step-Down Converter

1 Features

- AEC-Q100 Qualified for Automotive Applications
  - Device Temperature Grade 1: –40°C to +125°C Ambient Operating Temperature
  - Device HBM Classification Level 2
  - Device CDM Classification Level C6
- 96% Peak Efficiency While Converting 12 V to 5 V
- Low EMI and Switch Noise
  - Minimized Switch Node Ringing
  - Pseudo-Random Spread Spectrum
- 400-kHz (±10%) Fixed Switching Frequency
- –40°C to +150°C Junction Temperature Range
- External Frequency Synchronization
- $\overline{\text{RESET}}$ Output With Internal Filter and 3-ms Release Timer
- Automatic Light Load Mode for Improved Efficiency
- Pin-Selectable Forced PWM Mode
- Built-In Compensation, Soft Start, Current Limit, Thermal Shutdown, and UVLO
- 0.35-V Dropout With 3.5-A Load at 25°C (Typical)
- 15-µA I_q – Quiescent Current at No Load (Typical)
- 3.5-A or 5.5-A Continuous Load Current
- Output Voltage Options: 5 V, 3.3 V, and ADJ (1 V to 15 V)
- ±2% Output Voltage Tolerance
- 4-mm × 5-mm, 0.5-mm Pitch SON Package

2 Applications

- Automotive Systems
- Industrial Performance
- In-Dash Instrumentation
- Battery-Powered Applications

3 Description

The LMS3635-Q1 and LMS3655-Q1 synchronous buck regulators are optimized for high performance applications, providing an output voltage of 3.3 V, 5 V, or an adjustable output of 1 V to 15 V. Seamless transition between PWM and PFM modes, along with a low quiescent current, ensures high efficiency and superior transient responses at all loads.

Advanced high-speed circuitry allows the LMS3635-Q1 and LMS3655-Q1 to regulate an input of 24 V to an output of 3.3 V at a fixed frequency of 400 kHz. An innovative frequency foldback architecture allows this device to regulate a 3.3-V output from an input voltage of only 3.5 V. The input voltage can range up to 36 V, with transient tolerance up to 42 V, easing input surge protection design. The LMS3655-Q1 enables a continuous load current of 5.5 A across the wide input voltage range.

An open-drain reset output, with built-in filtering and delay, provides a true indication of system status. This feature negates the requirement for an additional supervisory component, saving cost and board space.

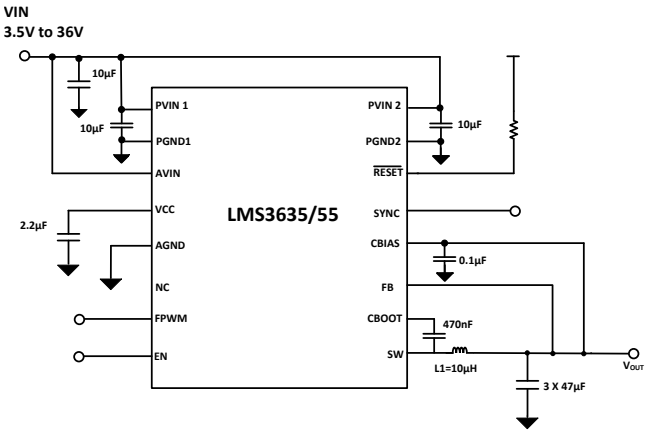
Device Information(1)

DEVICE NAME	PACKAGE	BODY SIZE
LMS3635-Q1	SON (22)	4.00 mm × 5.00 mm
LMS3655-Q1		

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

ADVANCE INFORMATION

Typical Application Circuit



LMS3635 and LMS3655 Efficiency: V_{OUT} = 5 V

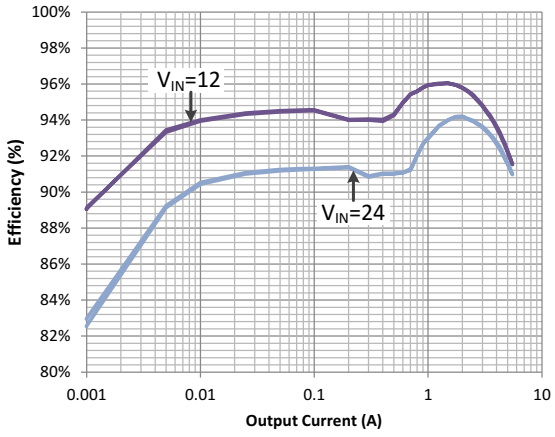


Table of Contents

4 Revision History

DATE	REVISION	NOTES
September 2016	*	Initial release.

ADVANCE INFORMATION

5 Device and Documentation Support

5.1 Documentation Support

5.1.1 Related Documentation

For additional information, see the following:

- *Optimizing Transient Response of Internally Compensated DC-DC Converters With Feedforward Capacitor* (SLVA289)
- *Output Ripple Voltage for Buck Switching Regulator* (SLVA630)
- *AN-1149 Layout Guidelines for Switching Power Supplies* (SNVA021)
- *AN-1229 Simple Switcher® PCB Layout Guidelines* (SNVA054)
- *Constructing Your Power Supply- Layout Considerations* (SLUP230)
- *AN-2020 Thermal Design By Insight, Not Hindsight* (SNVA419)
- *Semiconductor and IC Package Thermal Metrics* (SPRA953)

5.2 Related Links

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

Table 1. Related Links

PARTS	PRODUCT FOLDER	SAMPLE & BUY	TECHNICAL DOCUMENTS	TOOLS & SOFTWARE	SUPPORT & COMMUNITY
LMS3655-Q1	Click here	Click here	Click here	Click here	Click here
LMS5335-Q1	Click here	Click here	Click here	Click here	Click here

5.3 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. In the upper right corner, click on *Alert me* 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 Community Resources

The following links connect to TI community resources. Linked contents are 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.

TI E2E™ Online Community ***TI's Engineer-to-Engineer (E2E) Community.*** Created to foster collaboration among engineers. At e2e.ti.com, you can ask questions, share knowledge, explore ideas and help solve problems with fellow engineers.

Design Support ***TI's Design Support*** Quickly find helpful E2E forums along with design support tools and contact information for technical support.

5.5 Trademarks

E2E is a trademark of Texas Instruments.
All other trademarks are the property of their respective owners.

5.6 Electrostatic Discharge Caution

These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

5.7 Glossary

SLYZ022 — *TI Glossary*.

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

ADVANCE INFORMATION

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/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
LMS36353QRNLRQ1	PREVIEW	VQFN-HR	RNL	22	3000	TBD	Call TI	Call TI	-40 to 150		
LMS36353QRNLTQ1	PREVIEW	VQFN-HR	RNL	22	250	TBD	Call TI	Call TI	-40 to 150		
LMS36355QRNLRQ1	PREVIEW	VQFN-HR	RNL	22	3000	TBD	Call TI	Call TI	-40 to 150		
LMS36355QRNLTQ1	PREVIEW	VQFN-HR	RNL	22	250	TBD	Call TI	Call TI	-40 to 150		
LMS3635AQRNLRQ1	PREVIEW	VQFN-HR	RNL	22	3000	TBD	Call TI	Call TI	-40 to 150		
LMS3635AQRNLTQ1	PREVIEW	VQFN-HR	RNL	22	250	TBD	Call TI	Call TI	-40 to 150		
LMS3635LQRNLRQ1	PREVIEW	VQFN-HR	RNL	22	3000	TBD	Call TI	Call TI	-40 to 150		
LMS3635LQRNLTQ1	PREVIEW	VQFN-HR	RNL	22	250	TBD	Call TI	Call TI	-40 to 150		
LMS3635MQRNLRQ1	PREVIEW	VQFN-HR	RNL	22	3000	TBD	Call TI	Call TI	-40 to 150		
LMS3635MQRNLTQ1	PREVIEW	VQFN-HR	RNL	22	250	TBD	Call TI	Call TI	-40 to 150		
LMS3635NQRNLRQ1	PREVIEW	VQFN-HR	RNL	22	3000	TBD	Call TI	Call TI	-40 to 150		
LMS3635NQRNLTQ1	PREVIEW	VQFN-HR	RNL	22	250	TBD	Call TI	Call TI	-40 to 150		
LMS36553QRNLRQ1	PREVIEW	VQFN-HR	RNL	22	3000	TBD	Call TI	Call TI	-40 to 150		
LMS36553QRNLTQ1	PREVIEW	VQFN-HR	RNL	22	250	TBD	Call TI	Call TI	-40 to 150		
LMS36555QRNLRQ1	PREVIEW	VQFN-HR	RNL	22	3000	TBD	Call TI	Call TI	-40 to 150		
LMS36555QRNLTQ1	PREVIEW	VQFN-HR	RNL	22	250	TBD	Call TI	Call TI	-40 to 150		
LMS3655AQRNLRQ1	PREVIEW	VQFN-HR	RNL	22	3000	TBD	Call TI	Call TI	-40 to 150		
LMS3655AQRNLTQ1	PREVIEW	VQFN-HR	RNL	22	250	TBD	Call TI	Call TI	-40 to 150		
LMS3655LQRNLRQ1	PREVIEW	VQFN-HR	RNL	22	3000	TBD	Call TI	Call TI	-40 to 150		
LMS3655LQRNLTQ1	PREVIEW	VQFN-HR	RNL	22	250	TBD	Call TI	Call TI	-40 to 150		
LMS3655MQRNLRQ1	PREVIEW	VQFN-HR	RNL	22	3000	TBD	Call TI	Call TI	-40 to 150		
LMS3655MQRNLTQ1	PREVIEW	VQFN-HR	RNL	22	250	TBD	Call TI	Call TI	-40 to 150		
LMS3655NQRNLRQ1	PREVIEW	VQFN-HR	RNL	22	3000	TBD	Call TI	Call TI	-40 to 150		
LMS3655NQRNLTQ1	PREVIEW	VQFN-HR	RNL	22	250	TBD	Call TI	Call TI	-40 to 150		
XMS3655MQRNLTQ1	PREVIEW	VQFN-HR	RNL	22	250	TBD	Call TI	Call TI	-40 to 150		

(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.
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 http://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.

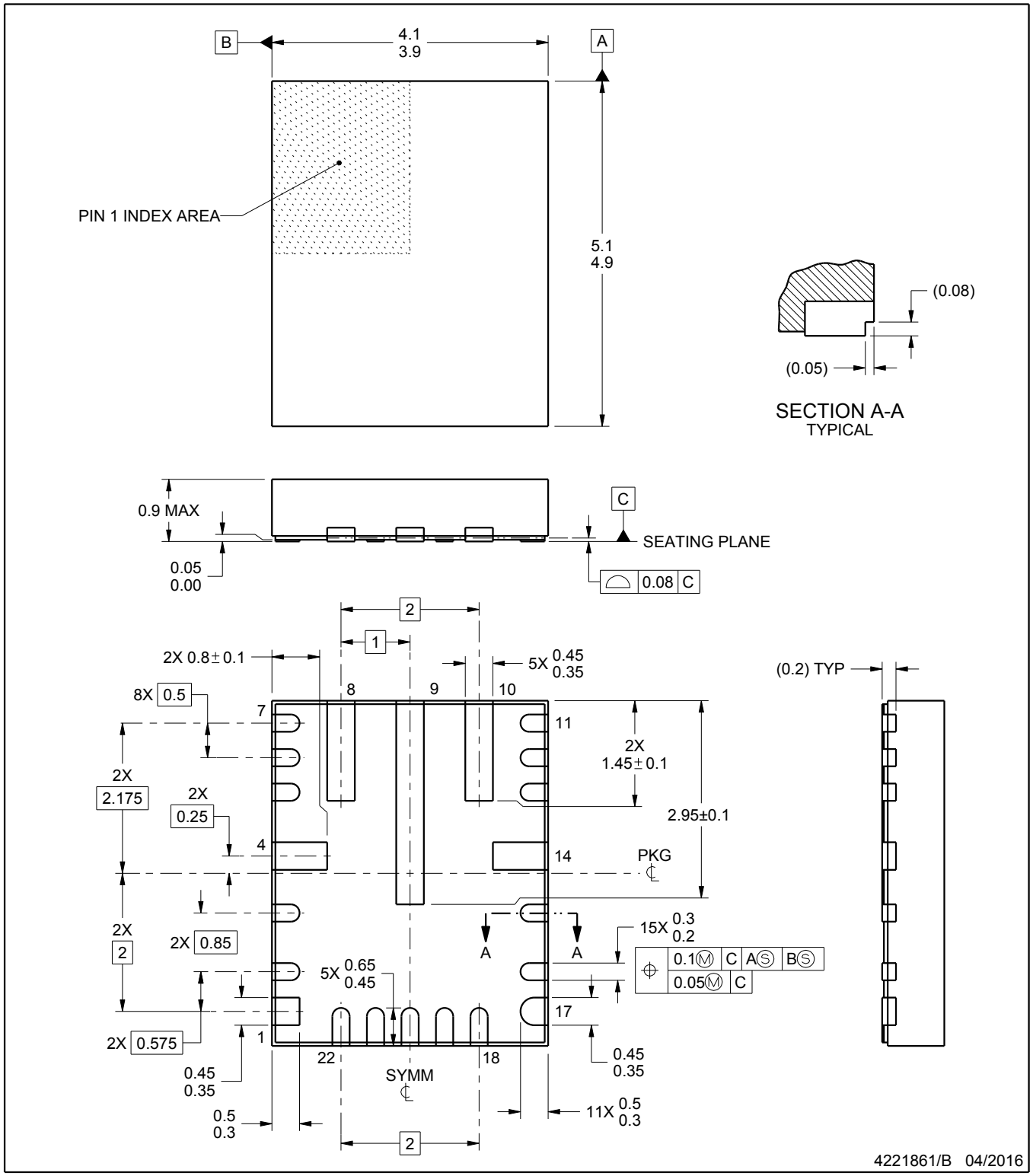
(6) Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

PACKAGE OUTLINE

RNL0022A

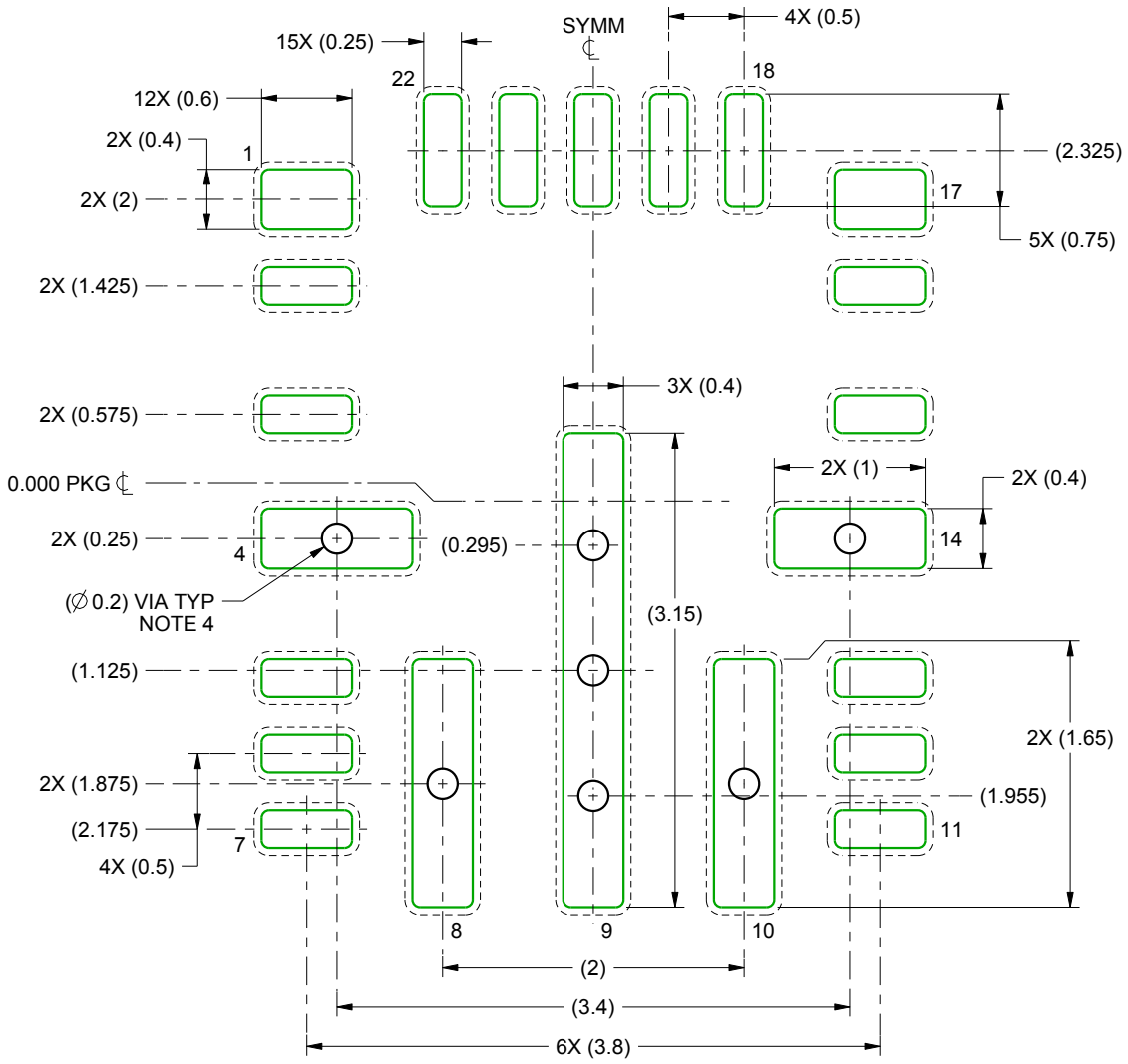
VQFN - 0.9 mm max height

PLASTIC QUAD FLATPACK - NO LEAD

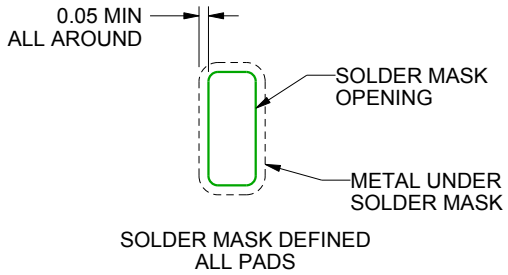


NOTES:

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.



LAND PATTERN EXAMPLE
SCALE:20X



SOLDER MASK DEFINED
ALL PADS

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NOTES: (continued)

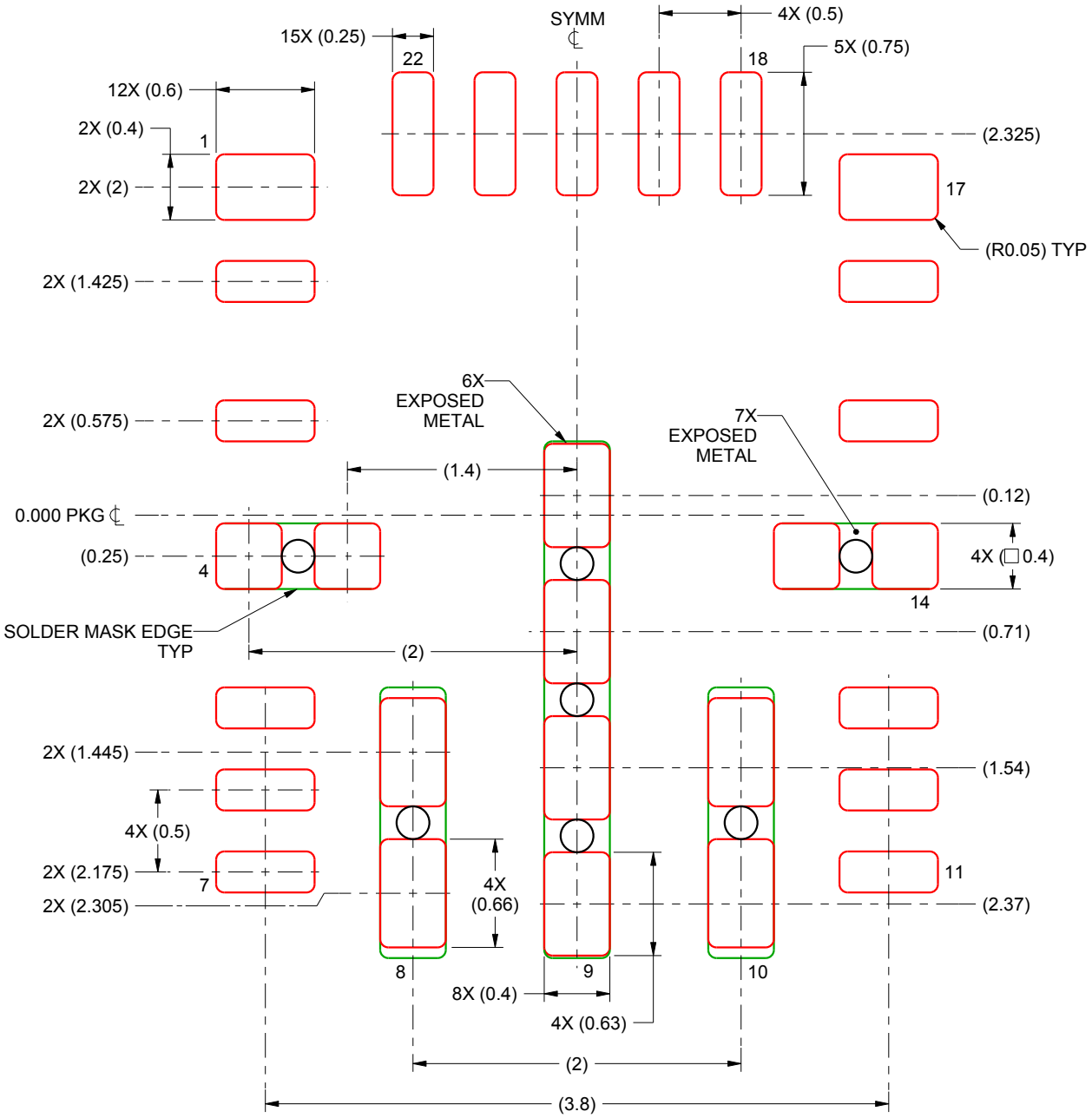
3. This package is designed to be soldered to thermal pads on the board. For more information, see Texas Instruments literature number SLUA271 (www.ti.com/lit/slua271).
4. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown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

EXAMPLE STENCIL DESIGN

RNL0022A

VQFN - 0.9 mm max height

PLASTIC QUAD FLATPACK - NO LEAD



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL

FOR PADS 4,8,9,10 & 14
80% PRINTED SOLDER COVERAGE BY AREA
SCALE:25X

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NOTES: (continued)

5. 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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