

BQ79656-Q1, BQ79654-Q1, BQ79652-Q1 Functional Safety-Compliant Automotive 16S/14S/12S Battery Monitor, Balancer and Integrated Hardware Protector with Integrated Current Sense

1 Features

- Qualified for automotive applications
- AEC-Q100 Qualified with the following results:
 - Device temperature grade 1: -40°C to $+125^{\circ}\text{C}$ ambient operating temperature range
 - Device HBM ESD classification level 2
 - Device CDM ESD classification level C4B
- **Functional Safety-Compliant**
 - Developed for functional safety applications
 - Documentation to aid ISO 26262 system design
 - Systematic capability up to ASIL D
 - Hardware capability up to ASIL D
- +/- 1.5mV ADC accuracy
- Pin-package and software compatible device family:
 - Stackable monitor 16S (BQ79616-Q1, BQ79656-Q1), 14S (BQ79614-Q1, BQ79654-Q1), and 12S (BQ79612-Q1, BQ79652-Q1)
 - Standalone monitor 48 V system (BQ75614-Q1)
- Supports current-sense measurement
- Built-in redundancy path for voltage and temperature and current diagnostics
- Highly accurate cell voltage measurements within 128 μs for all cell channels
- Integrated post-ADC configurable digital low-pass filters
- Supports bus bar connection and measurement
- Built-in host-controlled hardware reset to emulate POR-like device reset
- Supports internal cell balancing
 - Balancing current at 240 mA
 - Built-in balancing thermal management with automatic pause and resume control
- Isolated differential daisy chain communication with optional ring architecture
- Embedded fault signal and heartbeat through communication line
- 5 V LDO output to power external digital isolator
- UART/SPI host interface/communication bridge device BQ79600-Q1
- Built-in SPI master

2 Applications

- [Battery Management System \(BMS\) in hybrid and electric powertrain systems](#)
- [Energy storage battery packs with Battery Management Systems](#)
- E-bikes, E-Scooters

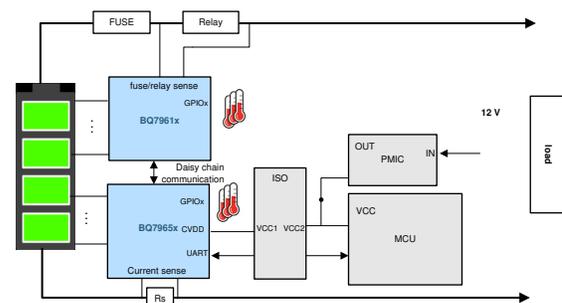
3 Description

The BQ7965x-Q1 family of devices provides high-accuracy cell voltage measurements for a minimum of 6S to a maximum of 12S (BQ79652-Q1), 14S (BQ79654-Q1), or 16S (BQ79656-Q1) battery modules in less than 200 μs while these devices also support shunt-resistor current sense measurement. The integrated front-end filters enable the system to implement with simple, low voltage raring, differential RC filters on the cell input channels. The integrated, post-ADC, low-pass filters enable filtered, DC-like, voltage measurements. This family of devices also supports integrated current sensing capabilities with option to synchronize with cell voltage measurements for better state of charge (SOC) calculation. The device supports autonomous internal cell balancing with temperature monitoring to auto-pause and resume balancing to avoid an overtemperature condition.

Device Information

| PART NUMBER (1) | PACKAGE | BODY SIZE (NOM) |
|-----------------|----------------|---------------------|
| BQ79652-Q1 | HTQFP (64-pin) | 10.00 mm × 10.00 mm |
| BQ79654-Q1 | | |
| BQ79656-Q1 | | |

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



Simplified System Diagram



4 Revision History

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

| Changes from Revision * (May 2021) to Revision A (June 2022) | Page |
|--|-------------|
| • Changed BQ79654-Q1 and BQ79652-Q1 from Product Preview to Production Data..... | 1 |

5 Description (continued)

The inclusion of the isolated, bidirectional, daisy chain ports supports both capacitor- and transformer-based isolation, allowing the use of the most effective components for centralized or distribution architectures commonly found in the xEV powertrain system. This device also includes eight GPIOs or auxiliary inputs that can be used for external thermistor measurements.

Host communication to the BQ7965x-Q1 family of devices can be connected via the device's dedicated UART interface or through a communication bridge device, BQ79600. Additionally, an isolated, differential daisy-chain communication interface allows the host to communicate with the entire battery stack over a single interface. In the event of a communication line break, the daisy-chain communication interface is configurable to a ring architecture that allows the host to talk to devices at either end of the stack.

6 Device and Documentation Support

6.1 Device Support

6.1.1 Third-Party Products Disclaimer

TI'S PUBLICATION OF INFORMATION REGARDING THIRD-PARTY PRODUCTS OR SERVICES DOES NOT CONSTITUTE AN ENDORSEMENT REGARDING THE SUITABILITY OF SUCH PRODUCTS OR SERVICES OR A WARRANTY, REPRESENTATION OR ENDORSEMENT OF SUCH PRODUCTS OR SERVICES, EITHER ALONE OR IN COMBINATION WITH ANY TI PRODUCT OR SERVICE.

6.2 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on 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.

6.3 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.

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](#).

6.4 Trademarks

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

6.5 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.

6.6 Glossary

[TI Glossary](#) This glossary lists and explains terms, acronyms, and definitions.

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 |
|------------------|---------------|--------------|-----------------|------|-------------|-----------------|--------------------------------------|----------------------|--------------|-------------------------|-------------------------|
| BQ79652PAPRQ1 | ACTIVE | HTQFP | PAP | 64 | 1000 | RoHS & Green | NIPDAU | Level-3-260C-168 HR | -40 to 125 | BQ79652 | Samples |
| BQ79654PAPRQ1 | ACTIVE | HTQFP | PAP | 64 | 1000 | RoHS & Green | NIPDAU | Level-3-260C-168 HR | -40 to 125 | BQ79654 | Samples |
| BQ79656PAPRQ1 | ACTIVE | HTQFP | PAP | 64 | 1000 | RoHS & Green | NIPDAU | Level-3-260C-168 HR | -40 to 125 | BQ79656 | 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.

OBSOLETE: 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.

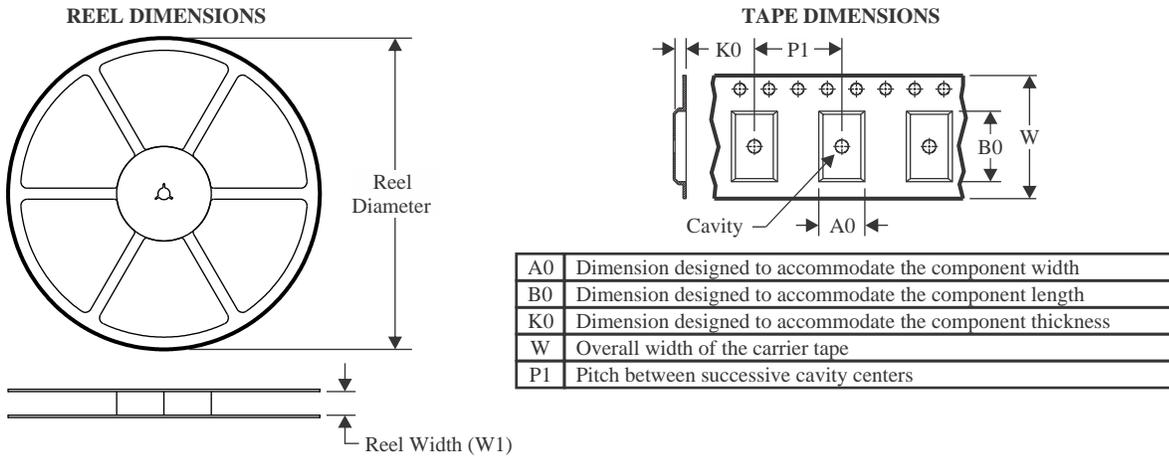
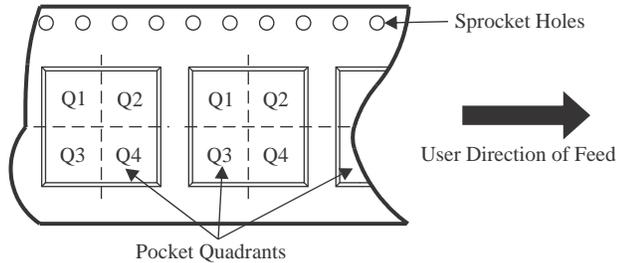
(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(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.

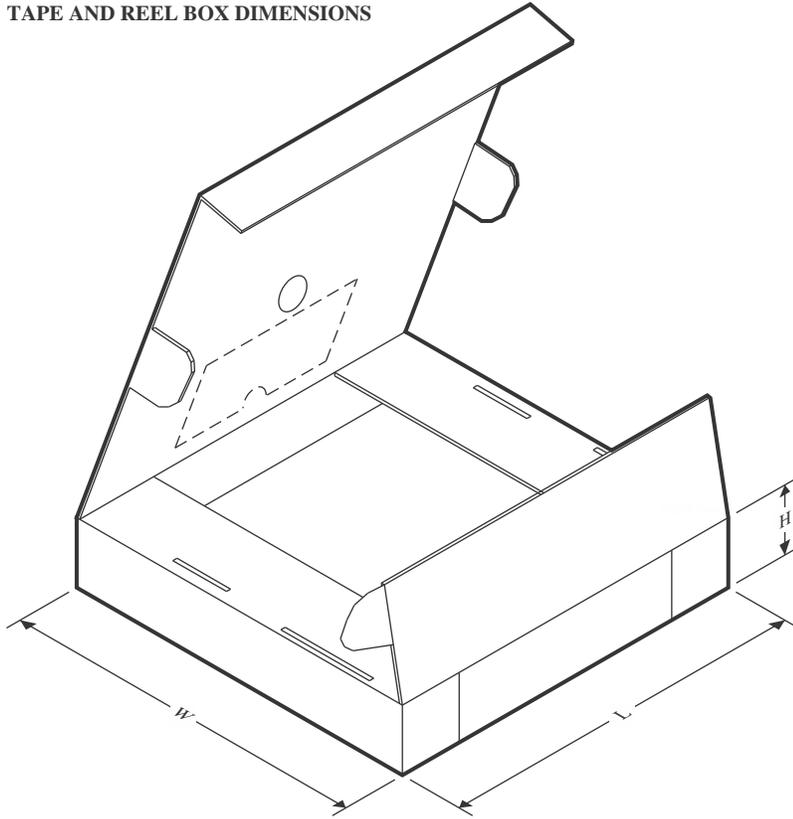
Important Information and Disclaimer:The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

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 |
|---------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| BQ79652PAPRQ1 | HTQFP | PAP | 64 | 1000 | 330.0 | 24.4 | 13.0 | 13.0 | 1.5 | 16.0 | 24.0 | Q2 |
| BQ79654PAPRQ1 | HTQFP | PAP | 64 | 1000 | 330.0 | 24.4 | 13.0 | 13.0 | 1.5 | 16.0 | 24.0 | Q2 |
| BQ79656PAPRQ1 | HTQFP | PAP | 64 | 1000 | 330.0 | 24.4 | 13.0 | 13.0 | 1.5 | 16.0 | 24.0 | Q2 |

TAPE AND REEL BOX DIMENSIONS


*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|---------------|--------------|-----------------|------|------|-------------|------------|-------------|
| BQ79652PAPRQ1 | HTQFP | PAP | 64 | 1000 | 367.0 | 367.0 | 55.0 |
| BQ79654PAPRQ1 | HTQFP | PAP | 64 | 1000 | 367.0 | 367.0 | 55.0 |
| BQ79656PAPRQ1 | HTQFP | PAP | 64 | 1000 | 367.0 | 367.0 | 55.0 |

GENERIC PACKAGE VIEW

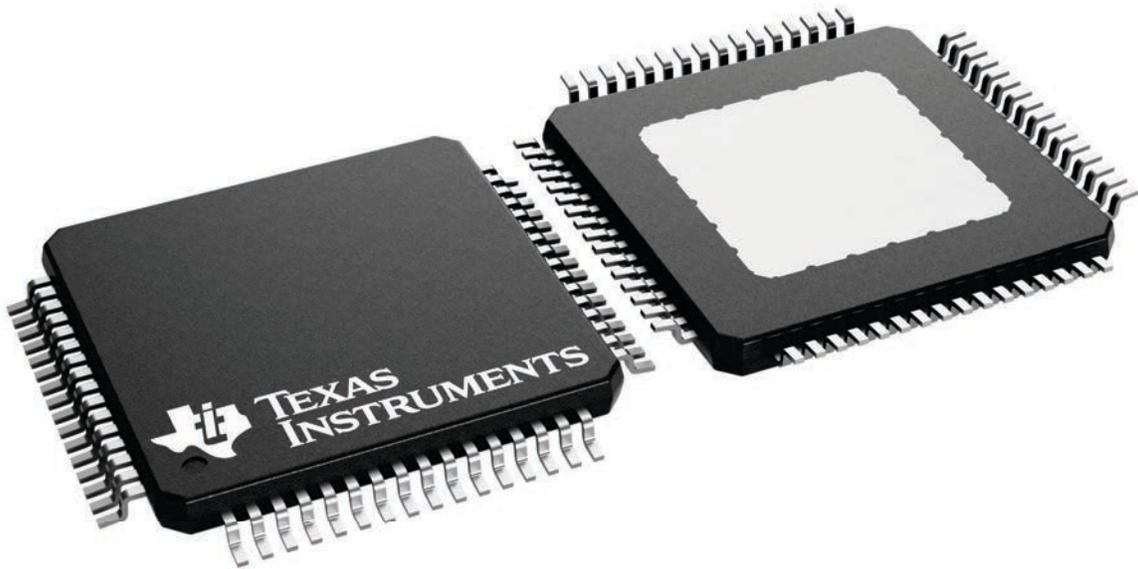
PAP 64

HTQFP - 1.2 mm max height

10 x 10, 0.5 mm pitch

QUAD FLATPACK

This image is a representation of the package family, actual package may vary.
Refer to the product data sheet for package details.



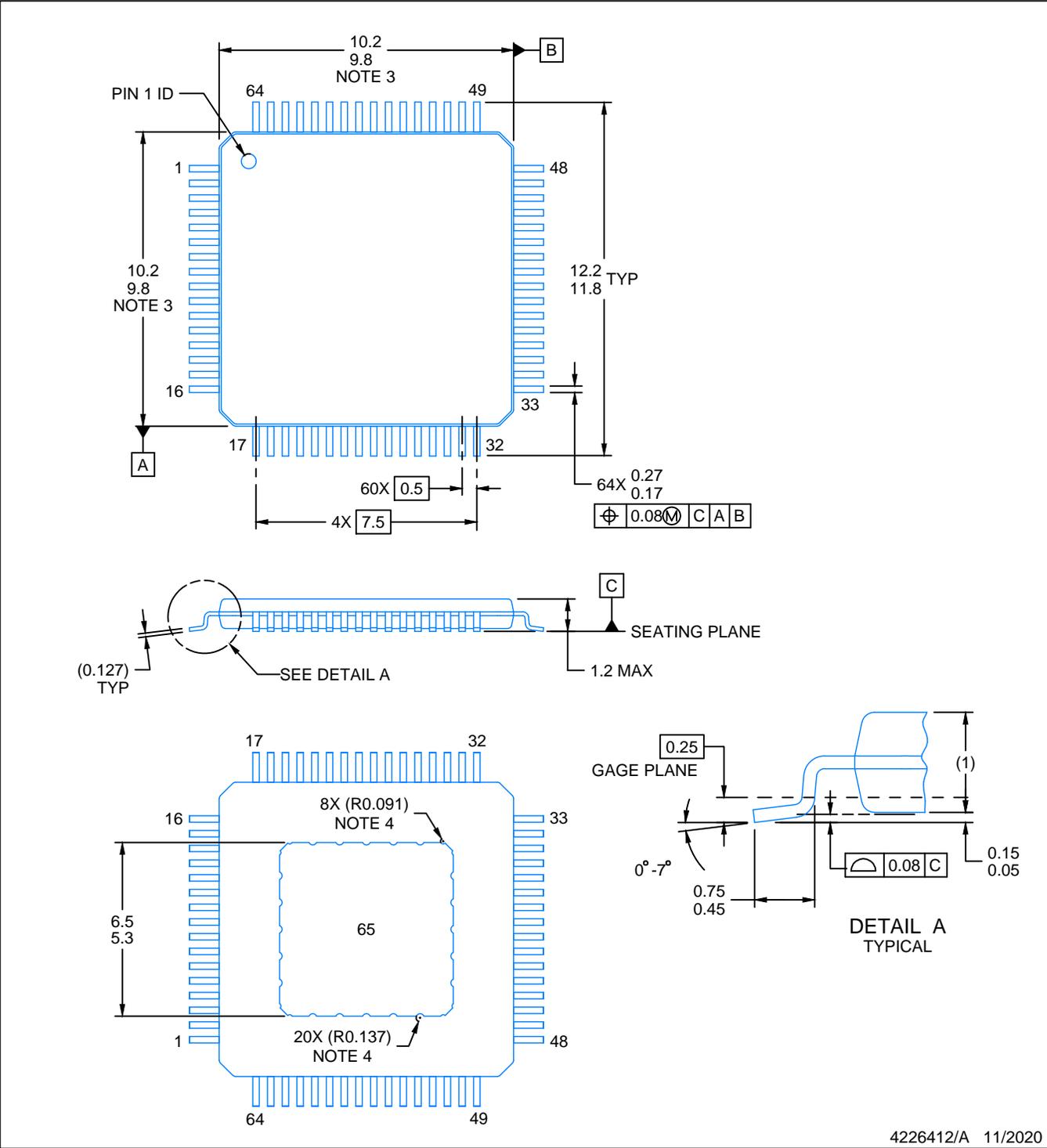
4226442/A

PACKAGE OUTLINE

PAP0064F

PowerPAD™ TQFP - 1.2 mm max height

PLASTIC QUAD FLATPACK



4226412/A 11/2020

NOTES:

PowerPAD is a trademark of Texas Instruments.

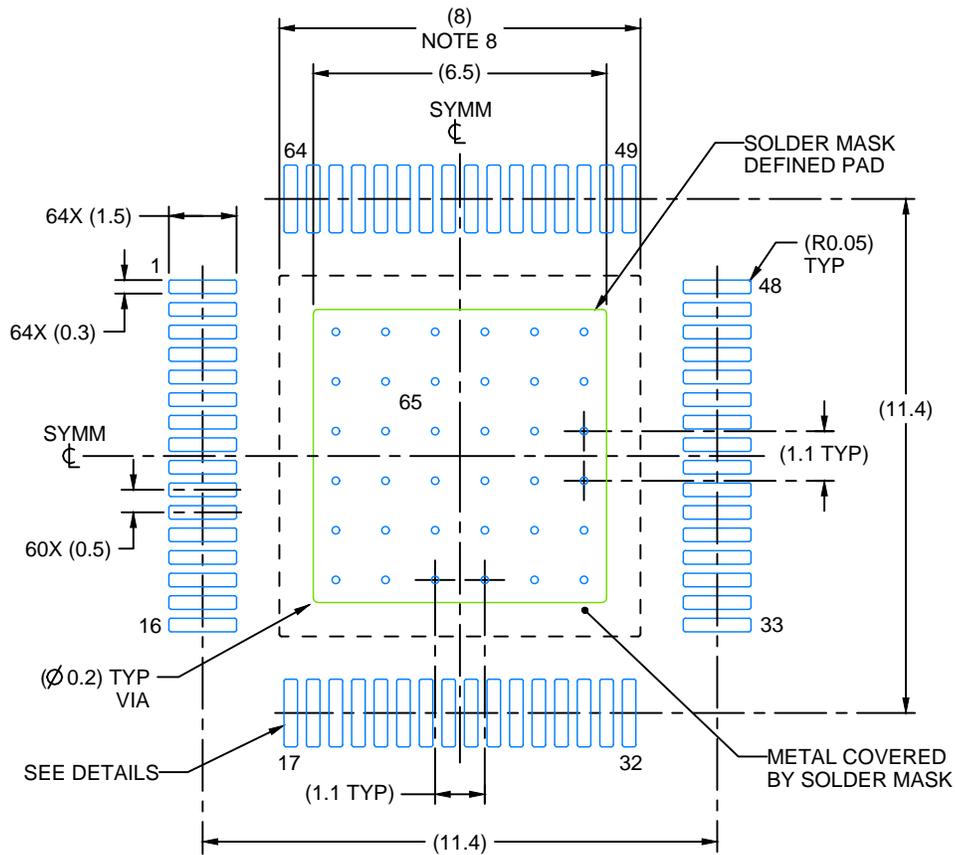
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs.
4. Strap features may not be present.
5. Reference JEDEC registration MS-026.

EXAMPLE BOARD LAYOUT

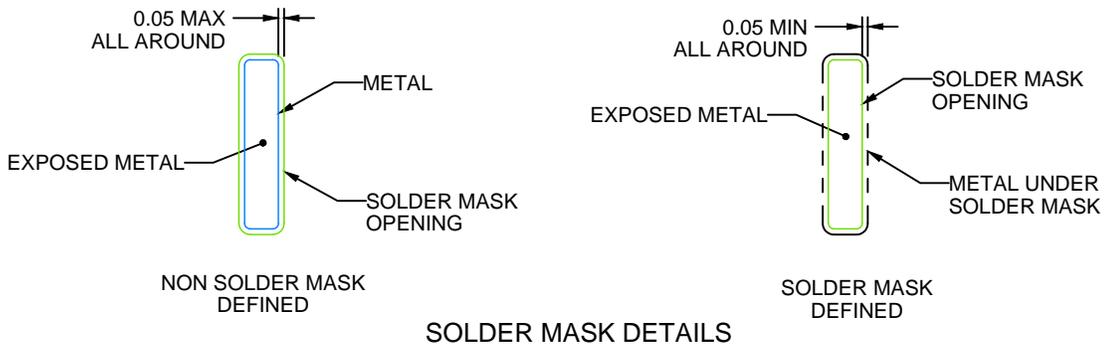
PAP0064F

PowerPAD™ TQFP - 1.2 mm max height

PLASTIC QUAD FLATPACK



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:6X



SOLDER MASK DETAILS

4226412/A 11/2020

NOTES: (continued)

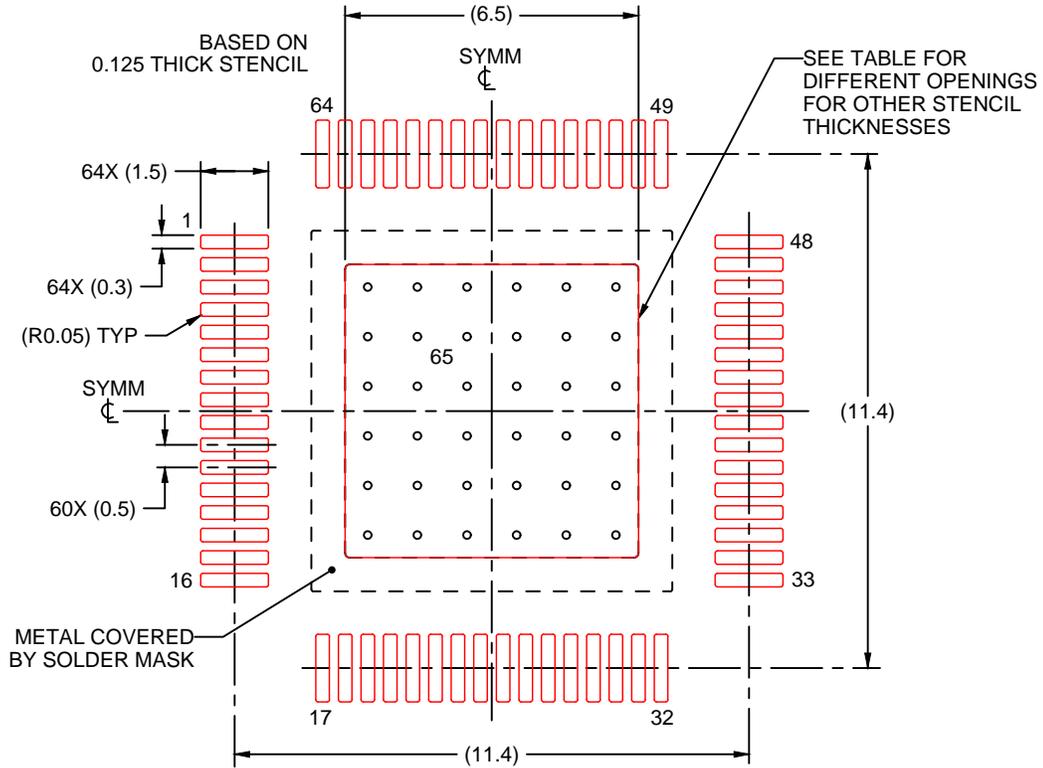
6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.
8. This package is designed to be soldered to a thermal pad on the board. See technical brief, Powerpad thermally enhanced package, Texas Instruments Literature No. SLMA002 (www.ti.com/lit/slma002) and SLMA004 (www.ti.com/lit/slma004).
9. Vias are optional depending on application, refer to device data sheet. It is recommended that vias under paste be filled, plugged or tented.
10. Size of metal pad may vary due to creepage requirement.

EXAMPLE STENCIL DESIGN

PAP0064F

PowerPAD™ TQFP - 1.2 mm max height

PLASTIC QUAD FLATPACK



SOLDER PASTE EXAMPLE
EXPOSED PAD
100% PRINTED SOLDER COVERAGE BY AREA
SCALE:6X

| STENCIL THICKNESS | SOLDER STENCIL OPENING |
|-------------------|------------------------|
| 0.1 | 7.27 X 7.27 |
| 0.125 | 6.5 X 6.5 (SHOWN) |
| 0.15 | 5.93 X 5.93 |
| 0.175 | 5.49 X 5.49 |

4226412/A 11/2020

NOTES: (continued)

11. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
12. Board assembly site may have different recommendations for stencil design.

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATA SHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES "AS IS" AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI's products are provided subject to [TI's Terms of Sale](#) or other applicable terms available either on ti.com or provided in conjunction with such TI products. TI's provision of these resources does not expand or otherwise alter TI's applicable warranties or warranty disclaimers for TI products.

TI objects to and rejects any additional or different terms you may have proposed.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2022, Texas Instruments Incorporated