TPS65903x-Q1 Automotive Power Management Unit (PMU) for Processor

1 Device Summary

1.1 Features

- Seven Step-Down Switched-Mode Power Supply (SMPS) Regulators:
  - One 0.7 to 1.65 V at 6 A (10-mV Steps)
    - Dual-Phase Configuration With Digital Voltage Scaling (DVS) Control
  - One 0.7 to 1.65 V at 4 A (10-mV Steps)
    - Dual-Phase Configuration With DVS Control
  - One 0.7 to 3.3 V at 3 A (10 or 20-mV Steps)
    - Single-Phase Configuration
    - This Regulator can be Combined With the 6 A Resulting in a 9 A Triple-Phase Regulator (DVS Controlled)
  - Two 0.7 to 3.3 V at 2 A (10 or 20-mV Steps)
    - Single-Phase Configuration
    - One Regulator With DVS Control, Which can also be Configured as a 3-A Regulator
  - Two 0.7 to 3.3 V at 1 A (10 or 20-mV Steps)
    - Single-Phase Configuration
    - One Regulator With DVS Control
  - Output Current Measurement in All Except 1-A SMPS Regulators
  - Differential Remote Sensing (Output and Ground) in Dual-Phase and Triple-Phase Regulators
  - Hardware and Software-Controlled ECO-mode™ up to 5 mA with 15-µA Quiescent Current
  - Short-Circuit Protection
  - Powergood Indication (Voltage and Overcurrent Indication)
  - Internal Soft-Start for In-Rush Current Limitation
  - Ability to synchronize SMPS to External Clock or Internal Fallback Clock With Phase Synchronization
- Eleven General-Purpose Low Dropout (LDO) Regulators (50-mV Steps):
  - Two 0.9 to 3.3 V at 300 mA With Preregulated Supply
  - Six 0.9 to 3.3 V at 200 mA With Preregulated Supply
  - One 0.9 to 3.3 V at 50 mA With Preregulated Supply
  - One 100-mA USB LDO
  - One Low-Noise LDO 0.9 to 3.3 V up to 100 mA (Low Noise Performance up to 50 mA)
  - Two Additional LDOs for PMU Internal Use
  - Short-Circuit Protection
- Clock Management 16-MHz Crystal Oscillator and 32-kHz RC Oscillator
  - One Buffered 32-kHz Output
- Real-Time Clock (RTC) With Alarm Wake-Up Mechanism
- 12-bit Sigma-Delta General-Purpose Analog-to-Digital-Converter (GPADC) With Three External Input Channels and Six Internal Channels for Self Monitoring
- Thermal Monitoring
  - High Temperature Warning
  - Thermal Shutdown
- Control
  - Configurable Power-Up and Power-Down Sequences (One-Time Programmable [OTP])
  - Configurable Sequences Between the SLEEP and ACTIVE States (OTP Programmable)
  - One Dedicated Digital Output Signal (REGEN) that can be Included in the Start-up Sequence
  - Three Digital Output Signals MUXed With GPIO that can be Included in the Start-up Sequence
  - Selectable Control Interface
    - One Serial Peripheral Interface (SPI) for Resource Configurations and DVS Control
    - Two I^2C Interfaces. One Dedicated for DVS Control, and a General Purpose I^2C Interface for Resource Configuration and DVS Control
- Undervoltage Lockout
- System Voltage Range from 3.135 to 5.25 V
- Package Options
  - 12-mm × 12-mm 169-pin nFBGA with 0,8-mm Ball Pitch

1.2 Applications

- Automotive Infotainment
- Automotive Digital Cluster
- Automotive Sensor Fusion
- Programmable Logic Controller

An IMPORTANT NOTICE at the end of this data sheet addresses availability, warranty, changes, use in safety-critical applications, intellectual property matters and other important disclaimers. PRODUCTION DATA.

1.3 Description

The TPS659038-Q1 and TPS659039-Q1 devices are integrated power-management integrated circuits (PMICs) for automotive applications. The device provides seven configurable step-down converters with up to 6 A of output current for memory, processor core, input-output (I/O), or preregulation of LDOs. One of these configurable step-down converters can be combined with another 3-A regulator to allow up to 9 A of output current. All of the step-down converters can synchronize to an external clock source between 1.7 Mhz and 2.7 MHz, or an internal fall back clock at 2.2 MHz. The TPS659038-Q1 device contains 11 LDO regulators while the TPS659039-Q1 device contains six LDO regulators for external use. These LDO regulators can be supplied from either a system supply or a preregulated supply. The power-up and power-down controller is configurable and supports any power-up and power-down sequences (OTP based). The TPS659038-Q1 and TPS659039-Q1 devices include a 32-kHz RC oscillator to sequence all resources during power up and power down. In cases where a fast start up is needed, a 16-MHz crystal oscillator is also included to quickly generate a stable 32-kHz for the system. All LDOs and SMPS converters can be controlled by the SPI or I^2C interface, or by power request signals. In addition, voltage scaling registers allow transitioning the SMPS to different voltages by SPI, I^2C, or roof and floor control. One dedicated pin in each package can be configured as part of the power-up sequence to control external resources. General-purpose input-output (GPIO) functionality is available and two GPIOs can be configured as part of the power-up sequence to control external resources. Power request signals enable power mode control for power optimization. The device includes a general-purpose (GP) sigma-delta analog-to-digital converter (ADC) with three external input channels. The TPS659038-Q1 and TPS659039-Q1 device is available in a 13-ball × 13-ball nFBGA package with a 0,8-mm pitch.

Device Information(1)

PART NUMBER	PACKAGE	BODY SIZE (NOM)
TPS659038-Q1	ZWS (169)	12.00 mm × 12.00 mm
TPS659039-Q1		

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

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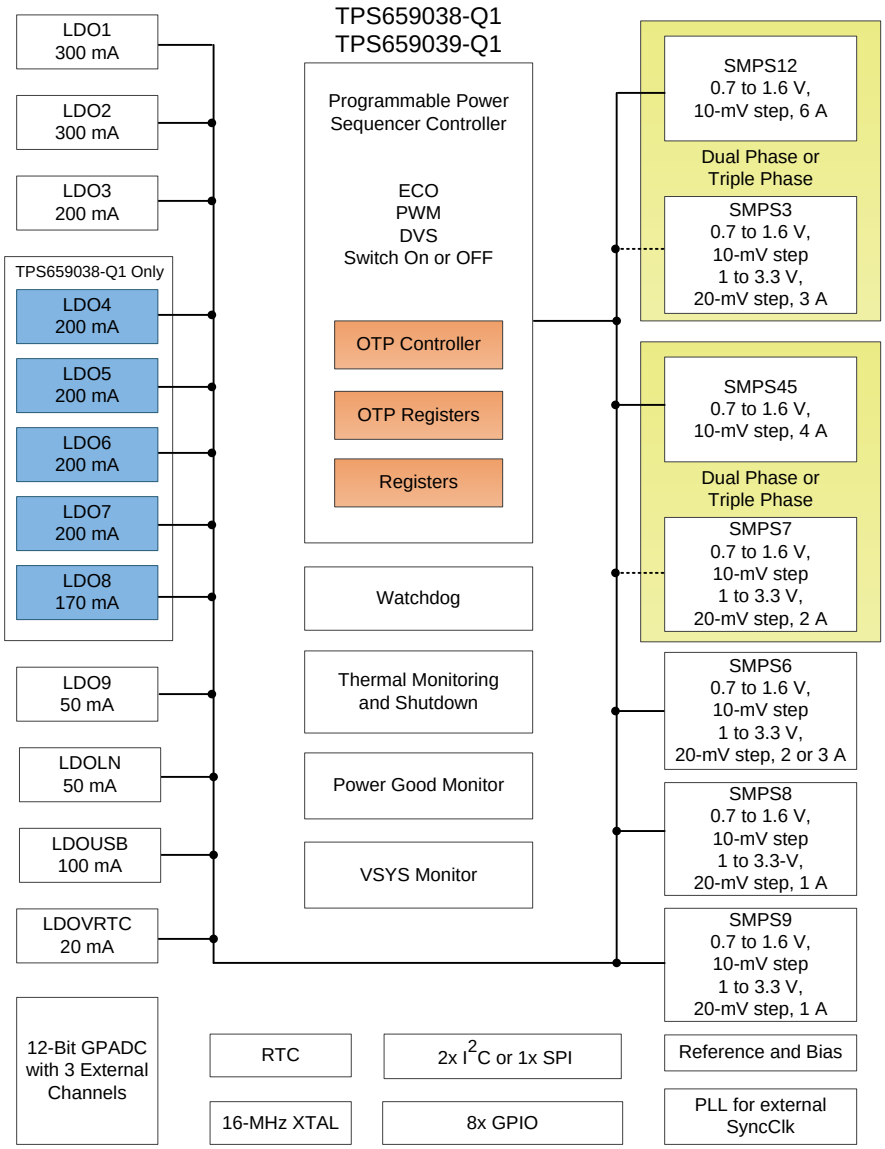
1.4 Simplified Block Diagram



1.5 Device Comparison

POWER BREAKDOWN	TPS659038-Q1	TPS659039-Q1
Total DC-DC converters	9	9
Total DC-DC converter rails	7	7
LDOs	11	6
Package	0,8-mm pitch 169ZWS (12 × 12 mm) nFBGA	0,8-mm 169ZWS (12 × 12 mm) nFBGA

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2 Revision History

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

Changes from Revision A (August 2014) to Revision B	Page
• Added the *Community Resources* section	2

3 Device and Documentation Support

3.1 Documentation Support

3.1.1 Related Documentation

For related documentation see the following:

Guide to Using the GPADC in TPS65903x and TPS6591x Devices SLIA087

3.2 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 3-1. Related Links

PARTS	PRODUCT FOLDER	SAMPLE & BUY	TECHNICAL DOCUMENTS	TOOLS & SOFTWARE	SUPPORT & COMMUNITY
TPS659038-Q1	Click here	Click here	Click here	Click here	Click here
TPS659039-Q1	Click here	Click here	Click here	Click here	Click here

3.3 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.

3.4 Trademarks

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3.5 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.

3.6 Glossary

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

4 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.

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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
O9038A342IZWSRQ1	ACTIVE	NFBGA	ZWS	169	1000	RoHS & Green	SNAGCU	Level-3-260C-168 HR	-40 to 85	TPS659038 OTP 42 1.3	Samples
O9038A352IZWSRQ1	ACTIVE	NFBGA	ZWS	169	1000	RoHS & Green	SNAGCU	Level-3-260C-168 HR	-40 to 85	TPS659038 OTP 52 1.3	Samples
O9039A385IZWSRQ1	ACTIVE	NFBGA	ZWS	169	1000	RoHS & Green	SNAGCU	Level-3-260C-168 HR	-40 to 85	TPS659039 OTP 85 1.3	Samples
O9039A385IZWSTQ1	ACTIVE	NFBGA	ZWS	169	250	RoHS & Green	SNAGCU	Level-3-260C-168 HR	-40 to 85	TPS659039 OTP 85 1.3	Samples
O9039A387IZWSRQ1	ACTIVE	NFBGA	ZWS	169	1000	RoHS & Green	SNAGCU	Level-3-260C-168 HR	-40 to 85	TPS659039 OTP 87 1.3	Samples
O9039A387IZWSTQ1	ACTIVE	NFBGA	ZWS	169	250	RoHS & Green	SNAGCU	Level-3-260C-168 HR	-40 to 85	TPS659039 OTP 87 1.3	Samples
O9039A389IZWSRQ1	ACTIVE	NFBGA	ZWS	169	1000	RoHS & Green	SNAGCU	Level-3-260C-168 HR	-40 to 85	TPS659039 OTP 89 1.3	Samples
O9039A389IZWSTQ1	ACTIVE	NFBGA	ZWS	169	250	RoHS & Green	SNAGCU	Level-3-260C-168 HR	-40 to 85	TPS659039 OTP 89 1.3	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.

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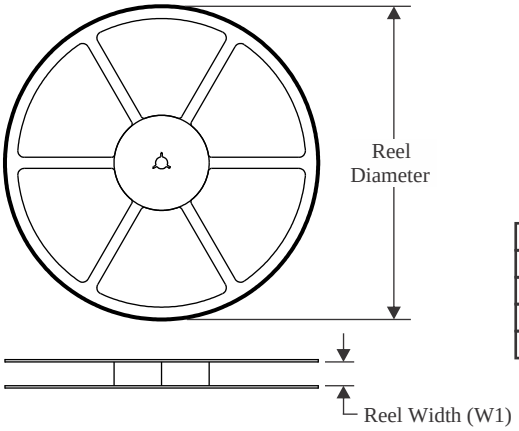
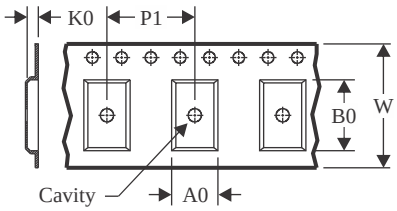
TAPE AND REEL INFORMATION

REEL DIMENSIONS

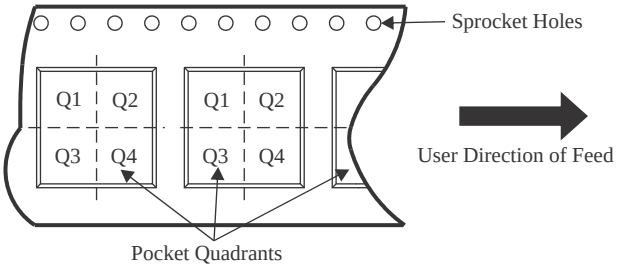


TAPE DIMENSIONS



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

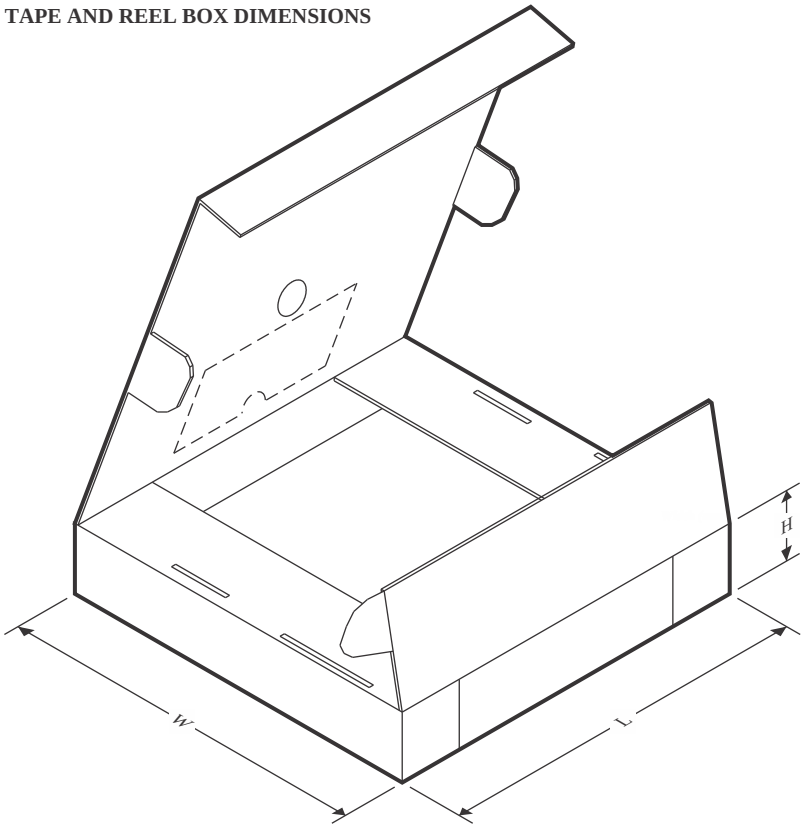
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All dimensions are nominal

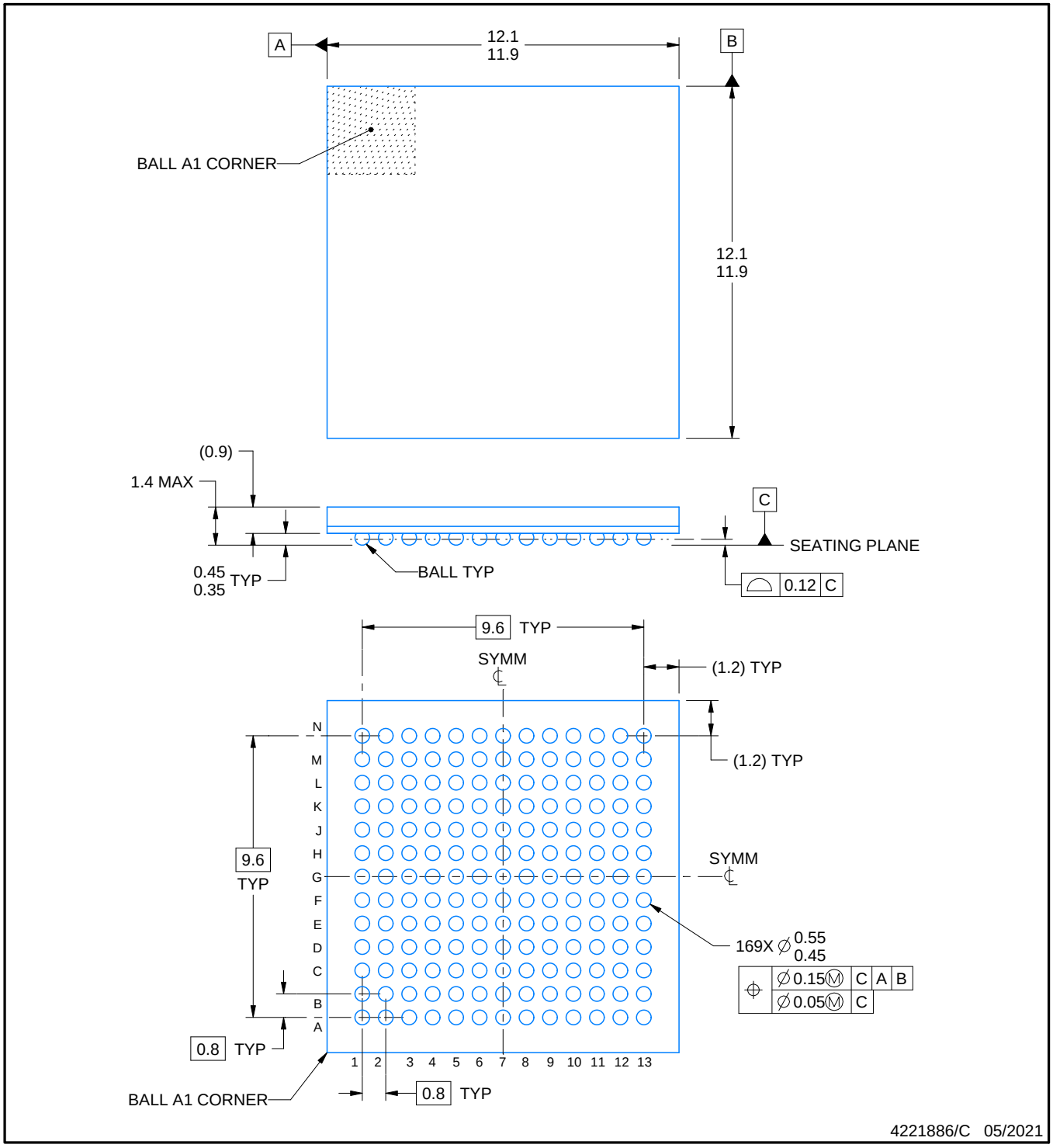
Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
O9039A385IZWSRQ1	NFBGA	ZWS	169	1000	330.0	24.4	12.35	12.35	2.3	16.0	24.0	Q1
O9039A385IZWSTQ1	NFBGA	ZWS	169	250	330.0	24.4	12.35	12.35	2.3	16.0	24.0	Q1
O9039A387IZWSRQ1	NFBGA	ZWS	169	1000	330.0	24.4	12.35	12.35	2.3	16.0	24.0	Q1
O9039A387IZWSTQ1	NFBGA	ZWS	169	250	330.0	24.4	12.35	12.35	2.3	16.0	24.0	Q1
O9039A389IZWSRQ1	NFBGA	ZWS	169	1000	330.0	24.4	12.35	12.35	2.3	16.0	24.0	Q1
O9039A389IZWSTQ1	NFBGA	ZWS	169	250	330.0	24.4	12.35	12.35	2.3	16.0	24.0	Q1

TAPE AND REEL BOX DIMENSIONS



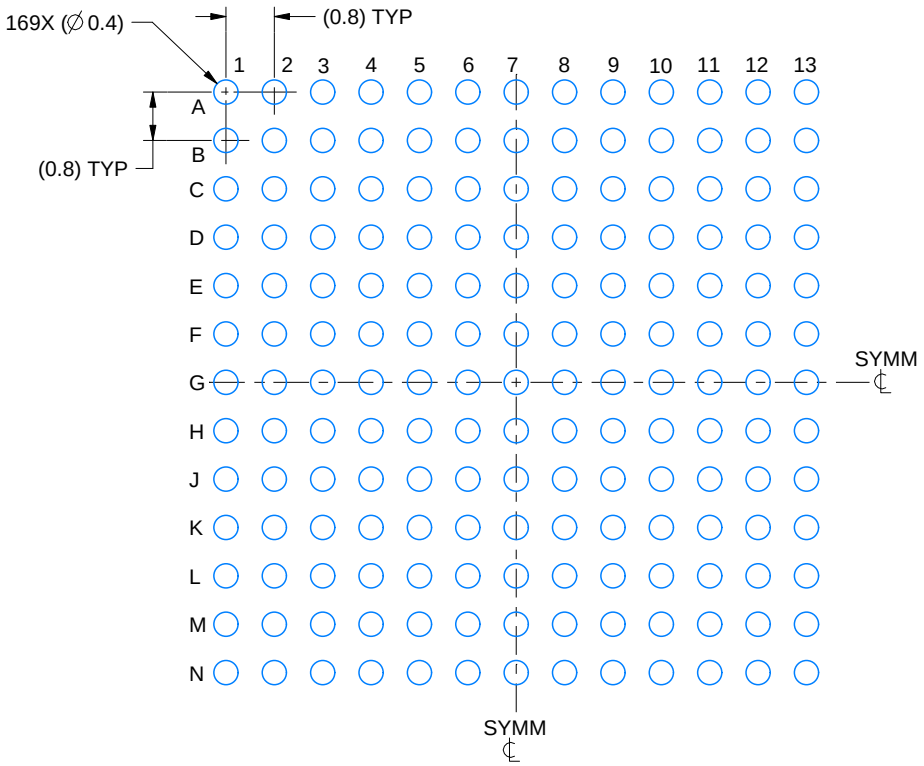
*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
O9039A385IZWSRQ1	NFBGA	ZWS	169	1000	336.6	336.6	41.3
O9039A385IZWSTQ1	NFBGA	ZWS	169	250	336.6	336.6	41.3
O9039A387IZWSRQ1	NFBGA	ZWS	169	1000	336.6	336.6	41.3
O9039A387IZWSTQ1	NFBGA	ZWS	169	250	336.6	336.6	41.3
O9039A389IZWSRQ1	NFBGA	ZWS	169	1000	336.6	336.6	41.3
O9039A389IZWSTQ1	NFBGA	ZWS	169	250	336.6	336.6	41.3

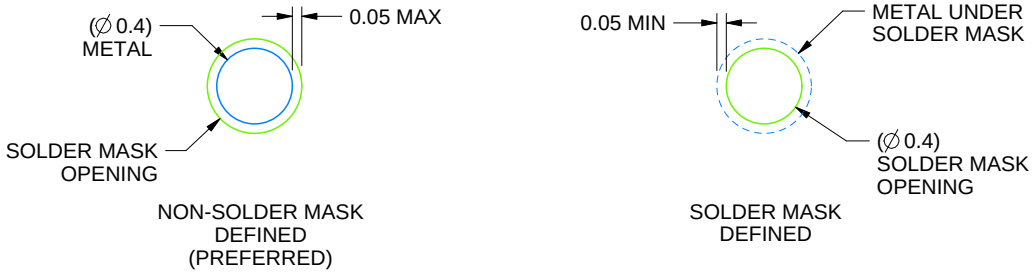


NOTES:

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:8X



SOLDER MASK DETAILS
NOT TO SCALE

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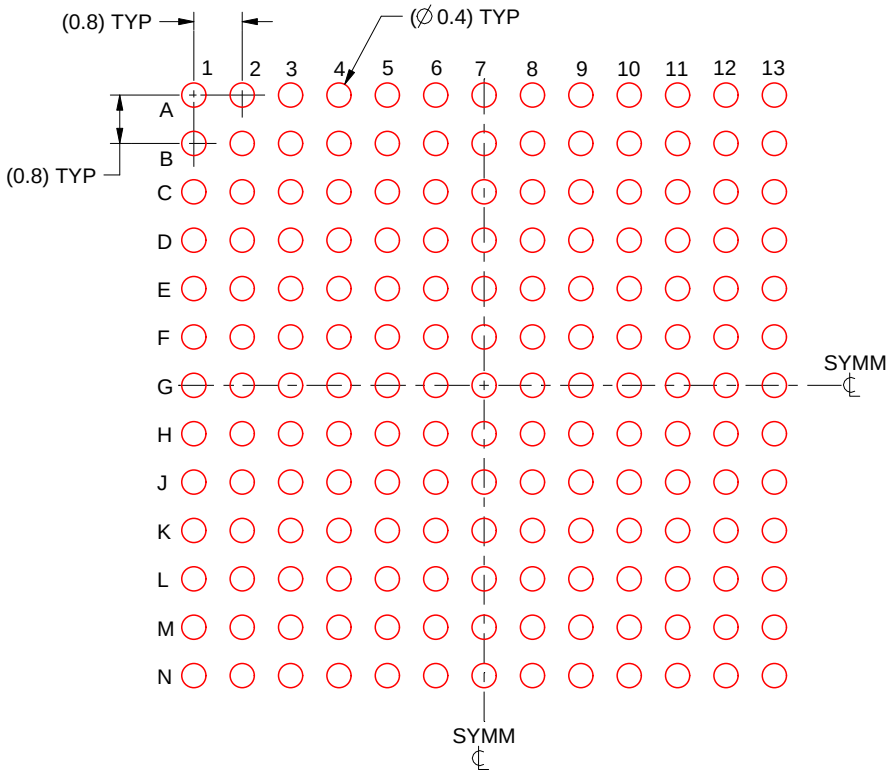
NOTES: (continued)

3. Final dimensions may vary due to manufacturing tolerance considerations and also routing constraints.
   For information, see Texas Instruments literature number SSZA002 (www.ti.com/lit/ssza002).



SOLDER PASTE EXAMPLE
BASED ON 0.15 mm THICK STENCIL
SCALE:8X

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NOTES: (continued)

4. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release.

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