

LM686x5-Q1 65V, 2.5A/3.5A/4.5A, Automotive Synchronous Buck DC/DC Converters With Low-EMI ZEN 1 Switcher Technology Optimized for Safety-Relevant Applications

1 Features

- AEC-Q100 qualified for automotive applications:
 - Temperature grade 1: -40°C to $+125^{\circ}\text{C}$, T_A
- Functional Safety-Compliant**
 - Documentation available to aid ISO 26262 system 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 65V
 - Meets LV148 / ISO21780 requirements
- ZEN 1 switcher technology
 - Facilitates CISPR 25 class 5 compliance
 - $\pm 5\%$ dual-random spread spectrum
 - Enhanced HotRod™ QFN package
 - Switching frequency from 300kHz to 2.2MHz
 - Pin-configurable AUTO or FPWM operation
 - Internal compensation, current limit, and TSD
- Low minimum on time: 40ns (maximum)
 - Enables $36V_{\text{IN}}$ to $3.3V_{\text{OUT}}$ at 2.2MHz
- High-efficiency power conversion at all loads
 - $> 94\%$ peak efficiency at $24V_{\text{IN}}$, $5V_{\text{OUT}}$, 400kHz
 - $2.5\mu\text{A}$ switching input current at no load
- High power density
 - Compact $3.6\text{mm} \times 2.6\text{mm}$, 20-pin eQFN package with wettable flank
 - Pin compatible with 36V 4/6/8A LM654x0-Q1
 - $\Theta_{\text{JA}} = 24.0^{\circ}\text{C/W}$ (LM65645-Q1EVM)
- Create a custom design using the LM686x5-Q1 with the **WEBENCH® Power Designer**

2 Applications

- Advanced driver assistance systems (ADAS)
- Automotive infotainment and cluster
- Hybrid, electric, and powertrain systems

3 Description

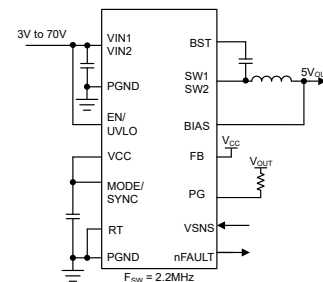
The LM686x5-Q1 are a family of automotive buck converters designed for high efficiency, high-power density, and ultra-low electromagnetic interference (EMI). The converters operate over a wide input voltage range of 3V to 65V (70V transient $< 100\text{ms}$), reducing the need for external input surge 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. AUTO mode enables frequency foldback during light load operation, allowing an unloaded current consumption as low as $1.36\mu\text{A}$ (typical) and high light load efficiency, which extends operating run-time in battery-powered systems.

Device Information

PART NUMBER ⁽³⁾	PACKAGE ⁽¹⁾	PACKAGE SIZE ⁽²⁾
LM68625-Q1, LM68635-Q1, LM68645-Q1	RZT (WQFN, 20)	$2.60\text{mm} \times 3.60\text{mm}$

- For more information, see [Section 7](#).
- The package size (length $\times$ width) is a nominal value and includes pins, where applicable.
- See the [Device Comparison Table](#).



Simplified Schematic



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).

The LM686x5-Q1 includes several features to simplify compliance with CISPR 25 emissions requirements. First, a symmetrical pinout provides excellent input capacitor placement and enables an ultra-low effective value for the power-loop parasitic inductance, which reduces switching losses and improves EMI performance at high input voltage and high switching frequency. A pin-selectable switch-node slew-rate control feature further reduces emissions at high frequencies. Resistor-adjustable switching frequency as high as 2.2MHz can be synchronized to an external clock source to eliminate beat frequencies in noise-sensitive applications.

Additional features of the LM686x5-Q1 include 150°C maximum junction temperature operation, open-drain power-good (PG) indicator for fault reporting and output voltage monitoring, precision enable input for input UVLO protection, monotonic start-up into prebiased loads, dual-input VCC bias subregulator powered from VIN or BIAS, hiccup-mode overload protection, and thermal shutdown protection with automatic recovery.

The LM686x5-Q1 comes in a 3.6mm × 2.6mm, thermally enhanced, 20-pin eQFN package with additional pin clearance for increased reliability. Also included are wettable-flank pins to facilitate optical inspection during manufacturing. Leveraging a flip-chip routable leadframe (FCRLF) packaging technique, the LM686x5-Q1 with useable current, lifetime reliability, and cost advantages targets applications requiring high power density. The wide input voltage range, low quiescent current consumption, high-temperature operation, cycle-by-cycle current limit, low EMI signature, and small design size provide an excellent point-of-load regulator design for applications requiring enhanced robustness and durability.

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4 Device Comparison Table

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

(1) For more information about sampling requests, please contact Texas Instruments.

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 note](#)
- Texas Instruments, [A Guide to Board Layout for Best Thermal Resistance for Exposed Pad Packages application note](#)
- Texas Instruments, [How to Properly Evaluate Junction Temperature with Thermal Metrics application note](#)
- Texas Instruments, [Layout Guidelines for Switching Power Supplies application note](#)
- Texas Instruments, [Simple Switcher PCB Layout Guidelines application note](#)
- Texas Instruments, [Construction Your Power Supply- Layout Considerations seminar](#)
- Texas Instruments, [Low Radiated EMI Layout Made Simple with LM4360x and LM4600x application note](#)
- 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.

Changes from Revision * (October 2024) to Revision A (November 2025)	Page
• Changed document status from Advance Information to Production Data.....	1
• Updated text to include better description of device functionality	1

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.

PACKAGING INFORMATION

Orderable part number	Status (1)	Material type (2)	Package Pins	Package qty Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
LM68625SFRZTRQ1	Active	Production	WQFN-FCRLF (RZT) 20	2500 LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 150	625SFQ
LM68635SFRZTRQ1	Active	Production	WQFN-FCRLF (RZT) 20	2500 LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 150	635SFQ
LM68645SFRZTRQ1	Active	Production	WQFN-FCRLF (RZT) 20	2500 LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 150	645SFQ
PLM68645SFRZTRQ1	Active	Preproduction	WQFN-FCRLF (RZT) 20	2500 LARGE T&R	-	Call TI	Call TI	-40 to 150	
PLM68645SFRZTRQ1.A	Active	Preproduction	WQFN-FCRLF (RZT) 20	2500 LARGE T&R	-	Call TI	Call TI	-40 to 150	

⁽¹⁾ **Status:** For more details on status, see our [product life cycle](#).

⁽²⁾ **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

⁽³⁾ **RoHS values:** Yes, No, RoHS Exempt. See the [TI RoHS Statement](#) for additional information and value definition.

⁽⁴⁾ **Lead finish/Ball material:** Parts 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.

⁽⁵⁾ **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

⁽⁶⁾ **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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TAPE AND REEL INFORMATION



*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
LM68625SFRZTRQ1	WQFN-FCRLF	RZT	20	2500	330.0	12.4	3.4	4.27	0.7	8.0	12.0	Q1
LM68635SFRZTRQ1	WQFN-FCRLF	RZT	20	2500	330.0	12.4	3.4	4.27	0.7	8.0	12.0	Q1
LM68645SFRZTRQ1	WQFN-FCRLF	RZT	20	2500	330.0	12.4	3.4	4.27	0.7	8.0	12.0	Q1

TAPE AND REEL BOX DIMENSIONS



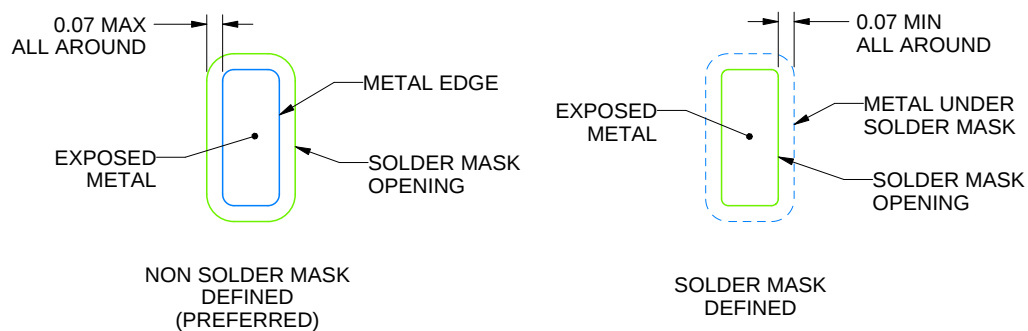
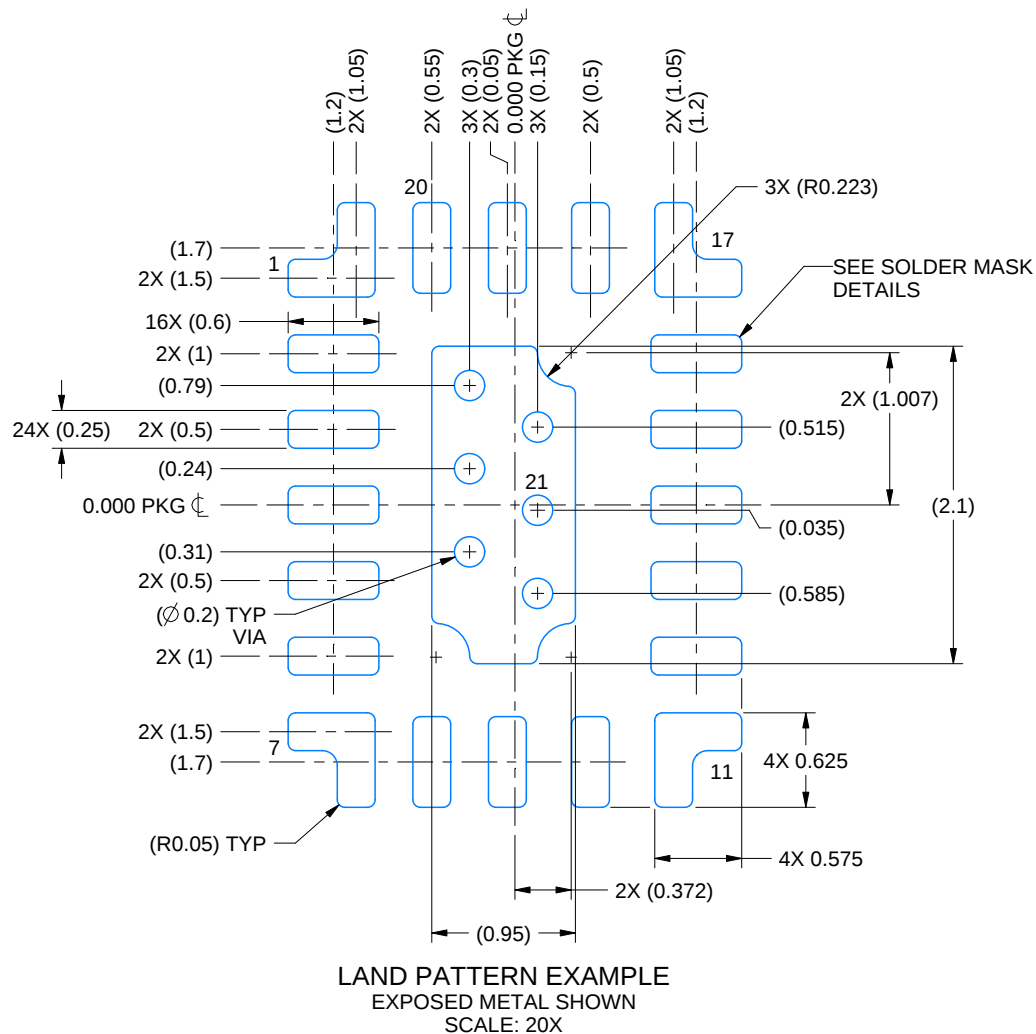
*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
LM68625SFRZTRQ1	WQFN-FCRLF	RZT	20	2500	346.0	346.0	33.0
LM68635SFRZTRQ1	WQFN-FCRLF	RZT	20	2500	346.0	346.0	33.0
LM68645SFRZTRQ1	WQFN-FCRLF	RZT	20	2500	346.0	346.0	33.0

RZT0020A

WQFN-FCRLF - 0.7 mm max height

PLASTIC QUAD FLATPACK - NO LEAD



SOLDER MASK DETAILS

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NOTES: (continued)

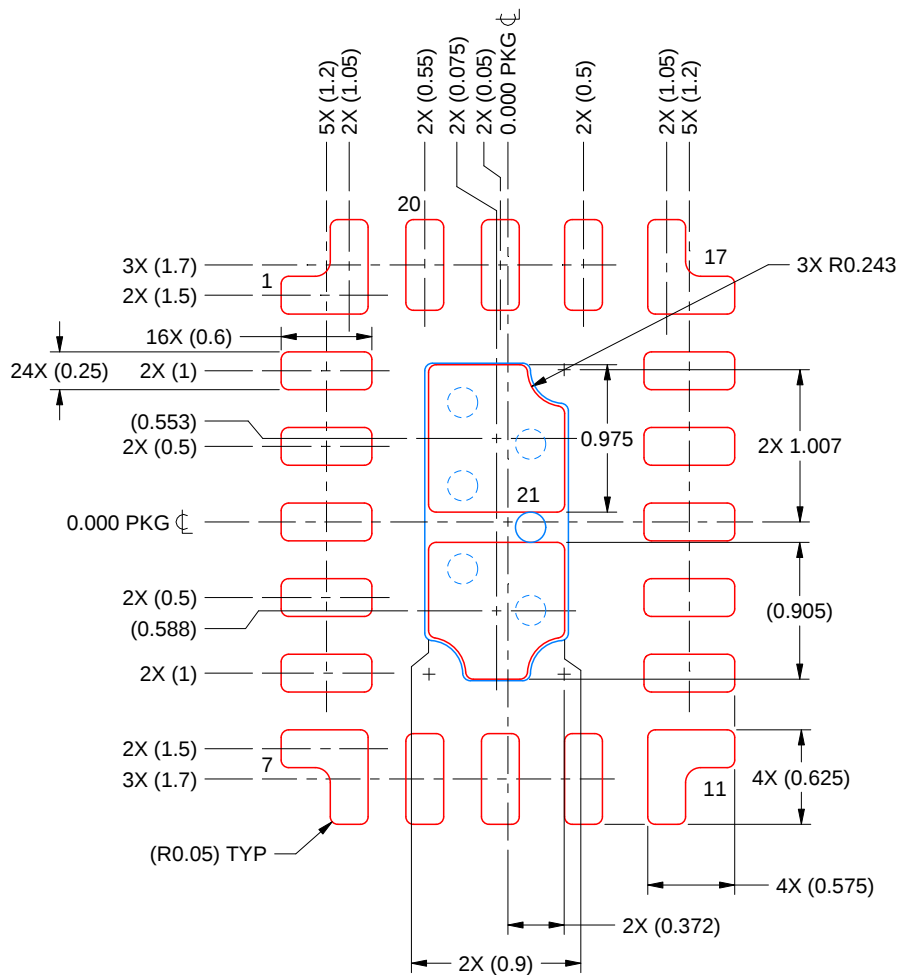
4. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 (www.ti.com/lit/sl原因271).
5. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown 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



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

EXPOSED PAD 21:
 85% 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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