# LM25137F 4V to 42V, 100% Duty Cycle Capable, Dual-Channel, Synchronous Buck DC/DC Controller Family for Functional Safety Applications

## 1 Features

- Functional Safety-Compliant
  - Developed for functional safety applications
    - Three orderable part numbers for Capable, SIL 2, and SIL 3 options
  - Documentation available to aid IEC 61508 systems design up to SIL 3 per IEC TR 62380
  - Systematic capability up to SIL 3
  - Random fault integrity up to SIL 3
- Versatile dual synchronous buck DC/DC controller
  - Wide input voltage range of 4V to 42V
  - 1% accurate, fixed 3.3V, 5V, 12V, or adjustable outputs from 0.8V to 36V
  - Current monitor output for each channel
  - Charge-pump gate drivers for 100% duty cycle
  - Sleep quiescent current of 1.8µA (typical)
  - Internal hiccup-mode overcurrent protection
- Two interleaved synchronous buck channels
  - Dual channel or single-output multiphase
  - Stackable up to four phases
  - SYNC in and SYNC out capability
  - Selectable light-load PFM or FPWM
  - 22ns $t_{ON(min)}$ for high $V_{IN}/V_{OUT}$ ratio
- Designed for ultra-low EMI requirements
  - Dual Random Spread Spectrum (DRSS)
  - Switching frequency from 100kHz to 2.64MHz
- VQFN-36 package with wettable flanks
- Create a custom design using the LM25137F with the WEBENCH® Power Designer

## 2 Applications

- Personal electronics: computer peripherals
- Industrial: 24V bus systems, power delivery
- Enterprise systems: high-performance computing

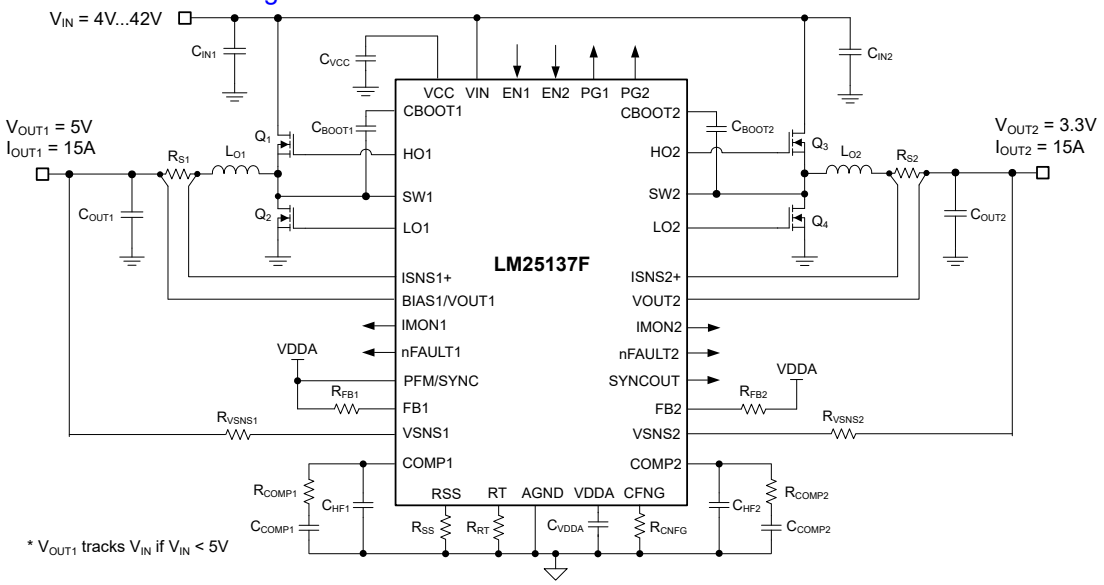
## 3 Description

The LM25137F is a 42V, dual-channel, buck controller offered from a family with three options for functional safety: Capable, SIL 2, or SIL 3. The device uses an interleaved, stackable, peak current-mode architecture for easy loop compensation, fast transient response, excellent load and line regulation, and accurate current sharing with paralleled phases for high output current. A high-side switch minimum on-time of 22ns facilitates large step-down ratios, enabling the direct conversion from 12V and 24V inputs to low-voltage rails for reduced system design cost and complexity. The LM25137F continues to operate during input voltage dips as low as 4V, at 100% duty cycle if needed.

**Package Information**

| PART NUMBER | PACKAGE(1) | PACKAGE SIZE(2) |
|---|---|---|
| LM25137F | RHA (VQFN, 36) | 6.0mm × 6.0mm |

(1) For more information, see Section 7.
(2) The package size (length × width) is a nominal value and includes pins, where applicable.




**LM25137F Dual-Output Buck Switching Regulator – Simplified Schematic**

Several features are included to simplify compliance with CISPR 11 and CISPR 32 EMI requirements. Adaptively timed, high-current MOSFET gate drivers minimize body diode conduction during switching transitions, reducing switching losses and improving thermal and EMI performance at high input voltage and high switching frequency. To reduce input capacitor ripple current and EMI filter size, 180° interleaved operation is provided for two outputs. A 90° out-of-phase clock output works well for cascaded, multi-channel or multiphase power stages. Resistor-adjustable switching frequency as high as 2.2MHz can be synchronized to an external clock source up to 2.64MHz to eliminate beat frequencies in noise-sensitive applications.

The 1.8µA sleep quiescent current with the output voltage in regulation extends operating run-time in battery-powered systems. Additional features of the LM25137F include 150°C maximum junction temperature operation, user-selectable PFM mode for lower current consumption at light-load conditions, configurable soft-start functions, open-drain FAULT and PG flags for fault reporting and output monitoring, independent enable inputs, monotonic start-up into prebiased loads, integrated VCC bias supply regulator powered from VIN or VOUT1, hiccup-mode overload protection, and thermal shutdown protection with automatic recovery. Current is sensed using an optional shunt resistor for high accuracy. Specific features for functional safety applications, including ABIST at start-up, VOUT1/2 and VCC ripple detection, redundant bandgap with error monitoring, redundant and fast VOUT1/2 monitoring, feedback path failure detection, and redundant thermal shutdown significantly reduces FIT rate.

The LM25137F controller comes in a 6mm × 6mm thermally-enhanced, 36-pin VQFN package with additional pin clearance for increased reliability. Also included are wettable flank pins to facilitate optical inspection during manufacturing. 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 functional safety (FuSa) applications requiring enhanced robustness and durability.

# Table of Contents

# 4 Related Products

**Table 4-1. Orderable Part Numbers**

| GENERIC PART NUMBER | ORDERABLE PART NUMBER | TI FUNCTIONAL SAFETY CLASSIFICATION(1) | PRODUCT DATA SHEET |
|---|---|---|---|
| LM25137 | LM25137RHAR | Functional safety-capable | Available here |
| LM25137F | LM25137F2RHAR | SIL 2 functional safety-compliant | Request the full data sheet here |
| | LM25137F3RHAR | SIL 3 functional safety-compliant | |

(1) Refer to the functional safety homepage to understand the TI functional safety classifications (in terms of the development process, analysis report, and diagnostics description).

# 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

With an input operating voltage as low as 3.5V and up to 100V as specified in Table 5-1, the family of synchronous buck controllers from TI provides flexibility, scalability, and optimized design size for a variety of applications.

With the LM5137F and LM25137F available to aid in functional safety system design up to SIL 3, the controller family enables DC/DC designs with high density, low EMI, and increased system reliability.

**Table 5-1. Synchronous Buck DC/DC Controller Family**

| DC/DC CONTROLLER | SINGLE or DUAL | $V_{IN}$ RANGE | CONTROL METHOD | GATE DRIVE VOLTAGE | SYNC OUTPUT | KEY FEATURE |
|---|---|---|---|---|---|---|
| LM5137 | Dual | 4V to 80V | Peak current mode | 5V | 90° phase shift | 100% duty cycle |
| LM5137F | Dual | 4V to 80V | Peak current mode | 5V | 90° phase shift | SIL 2 or 3 |
| LM25137 | Dual | 4V to 42V | Peak current mode | 5V | 90° phase shift | 100% duty cycle |
| LM25137F | Dual | 4V to 42V | Peak current mode | 5V | 90° phase shift | SIL 2 or 3 |
| LM25139 | Single | 4V to 42V | Peak current mode | 5V | N/A | DRSS |
| LM5141 | Single | 3.8V to 65V | Peak current mode | 5V | N/A | Split gate drive |
| LM25141 | Single | 3.8V to 42V | Peak current mode | 5V | N/A | Split gate drive |
| LM5143 | Dual | 3.5V to 65V | Peak current mode | 5V | 90° phase shift | Split gate drive |
| LM25143 | Dual | 3.5V to 42V | Peak current mode | 5V | 90° phase shift | Split gate drive |
| LM5145 | Single | 5.5V to 75V | Voltage mode | 7.5V | 180° phase shift | No shunt |
| LM5146 | Single | 5.5V to 100V | Voltage mode | 7.5V | 180° phase shift | 100V input capability |
| LM5148 | Single | 3.5V to 80V | Peak current mode | 5V | 180° phase shift | DRSS |
| LM25148 | Single | 3.5V to 42V | Peak current mode | 5V | 180° phase shift | DRSS |
| LM5149 | Single | 3.5V to 80V | Peak current mode | 5V | 180° phase shift | AEF |
| LM25149 | Single | 3.5V to 42V | Peak current mode | 5V | 180° phase shift | AEF |
| LM5190 | Single | 5V to 80V | Peak current mode | 7.5V | N/A | CC/CV |
| LM25190 | Single | 5V to 42V | Peak current mode | 7.5V | N/A | CC/CV |

For development support, see the following:

- LM25137F DC/DC controller *Quickstart Calculator* and PSPICE simulation models
- LM5137F-Q1-EVM12V and LM25137F-Q1-EVM5D3 Altium layout source files
- For TI's WEBENCH design environments, visit the WEBENCH® Design Center
- For TI's reference design library, visit TI Designs
- TI reference designs:
  - *450W four-phase interleaved buck converter reference design*
  - *20$V_{IN}$ to 60$V_{IN}$, 600W, automotive two-phase buck regulator with GaN power switches reference design*

#### 5.1.2.1 Custom Design With WEBENCH® Tools

Click here to create a custom design using the LM25137F 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 gives 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:

- User's guides:
  - Texas Instruments, *LM5137F-Q1 12V, 20A Single-Output Evaluation Module*
  - Texas Instruments, *LM25137-Q1 Evaluation Module*
  - Texas Instruments, *LM5143-Q1 EVM User's Guide*
  - Texas Instruments, *LM5141-Q1 EVM User's Guide*
  - Texas Instruments, *LM5146-Q1 EVM User's Guide*
  - Texas Instruments, *LM5145EVM-HD-20A High Density Evaluation Module*
  - Texas Instruments, *LM5149-Q1 Buck Converter Evaluation Module User's Guide*
  - Texas Instruments, *LM5190-Q1 CC-CV Buck Controller Evaluation Module*
- Application notes:
  - Texas Instruments, *How to Implement a Four-Phase Interleaving Buck With the LM5137F-Q1*
  - Texas Instruments, *LM5143-Q1 4-phase Buck Regulator Design for Automotive ADAS Applications*
- Technical articles:
  - Texas Instruments, *Achieving functional safety compliance in automotive off-battery buck preregulator designs*
  - Texas Instruments, *Powering next-generation ADAS processors with TI Functional Safety-Compliant buck regulators*

#### 5.2.1.1 Low-EMI Design Resources

- Texas Instruments, *Low EMI* landing page
- Texas Instruments, *Tackling the EMI challenge* company blog
- Texas Instruments, *An Engineer's Guide to Low EMI in DC/DC Regulators* e-book
- Texas Instruments, *Designing a low-EMI power supply* video series
- White papers:
  - Texas Instruments, *An Overview of Conducted EMI Specifications for Power Supplies*
  - Texas Instruments, *An Overview of Radiated EMI Specifications for Power Supplies*
  - Texas Instruments, *Time-Saving and Cost-Effective Innovations for EMI Reduction in Power Supplies*
  - Texas Instruments, *Valuing Wide $V_{IN}$, Low EMI Synchronous Buck Circuits for Cost-driven, Demanding Applications*
- Texas Instruments, *Improve High-Current DC/DC Regulator EMI for Free With Optimized Power Stage Layout* application brief
- Texas Instruments, *Reduce Buck Converter EMI and Voltage Stress by Minimizing Inductive Parasitics* analog design journal

#### 5.2.1.2 Thermal Design Resources

- Texas Instruments, *Improving Thermal Performance in High Ambient Temperature Environments With Thermally Enhanced Packaging* white paper
- Applications notes:
  - Texas Instruments, *Thermal Design by Insight, Not Hindsight*
  - Texas Instruments, *A Guide to Board Layout for Best Thermal Resistance for Exposed Pad Packages*
  - Texas Instruments, *Semiconductor and IC Package Thermal Metrics*
  - Texas Instruments, *PowerPAD™ Thermally Enhanced Package*
  - Texas Instruments, *Using New Thermal Metrics*
- Texas Instruments, *PowerPAD™ Made Easy* application brief

#### 5.2.1.3 PCB Layout Resources

- LM5137F-Q1-EVM12V and LM25137F-Q1-EVM5D3 *Altium layout* source files
- Texas Instruments, *AN-1149 Layout Guidelines for Switching Power Supplies* application note
- Texas Instruments, *Improve High-Current DC/DC Regulator EMI Performance for Free With Optimized Power Stage Layout* application brief
- Texas Instruments, *Constructing Your Power Supply – Layout Considerations* seminar

### 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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### 5.6 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

| DATE | REVISION | NOTES |
|---|---|---|
| December 2025 | * | Initial Release |

## 7 Mechanical, Packaging, and Orderable Information

The following pages show 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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