

设计指南: TIDA-050015

针对解决方案尺寸和低噪声进行了优化的汽车类 ADAS 摄像头电源参考设计



说明

此宽输入电源参考设计专为空间受限的汽车 ADAS 摄像头印刷电路板 (PCB) 面积而设计。这款经过尺寸优化的设计将前端保护与宽输入电压直流/直流转换器相结合, 因此可实现脱离电池供电运行。对前端滤波器和组件选择进行了优化, 符合严格的 CISPR 25 5 类传导电磁干扰 (EMI) 标准。此参考设计已通过 CISPR 25 5 类标准测试, 可缩短客户设计时间。此电源系统为系统组件 (包括成像仪、图像处理器以及数据和视频接口) 提供了四个稳压电源轨。

资源

TIDA-050015	设计文件夹
LMR33630-Q1	产品文件夹
LMR34215-Q1	产品文件夹
TPS62420-Q1	产品文件夹
LM2775-Q1	产品文件夹
LP5907-Q1	产品文件夹
LMR36015-Q1	产品文件夹



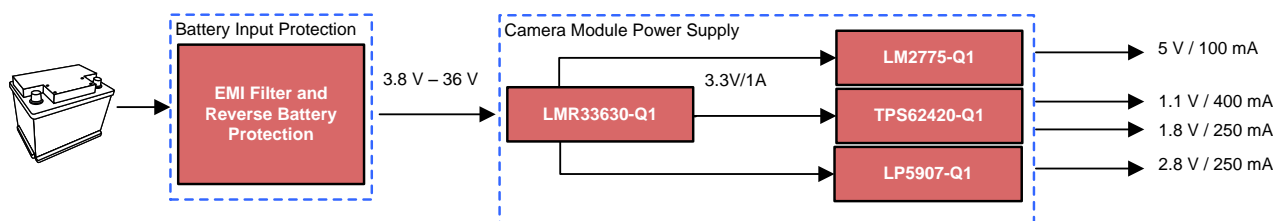
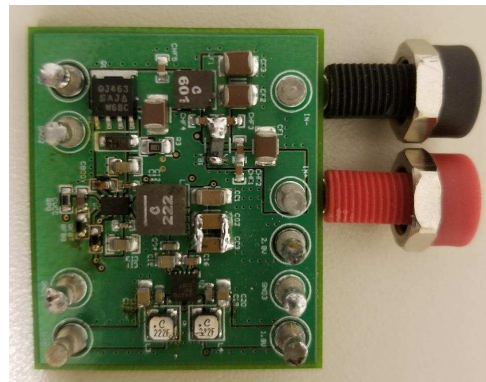
咨询我们的 E2E™ 专家

特性

- 无需采用额外组件即可直接连接电池
- 对于 ADAS 摄像头模块, 解决方案的总尺寸为 1272mm²
- 4V 至 36V 的宽输入电压范围支持启动/停止操作和负载突降运行
- 专为防范电池反向情况而设计
- 通过了 CISPR 25 5 类传导 EMI 标准的测试
- 提供四个稳压电源轨: 5V (最大电流 100mA)、2.8V (最大电流 200mA)、1.8V (最大电流 250mA)、1.1V (最大电流 400mA)
- 所有器件均符合 AEC-Q100 标准

应用

- 后置摄像头
- 不具有处理功能的摄像头模块
- 汽车热成像摄像头



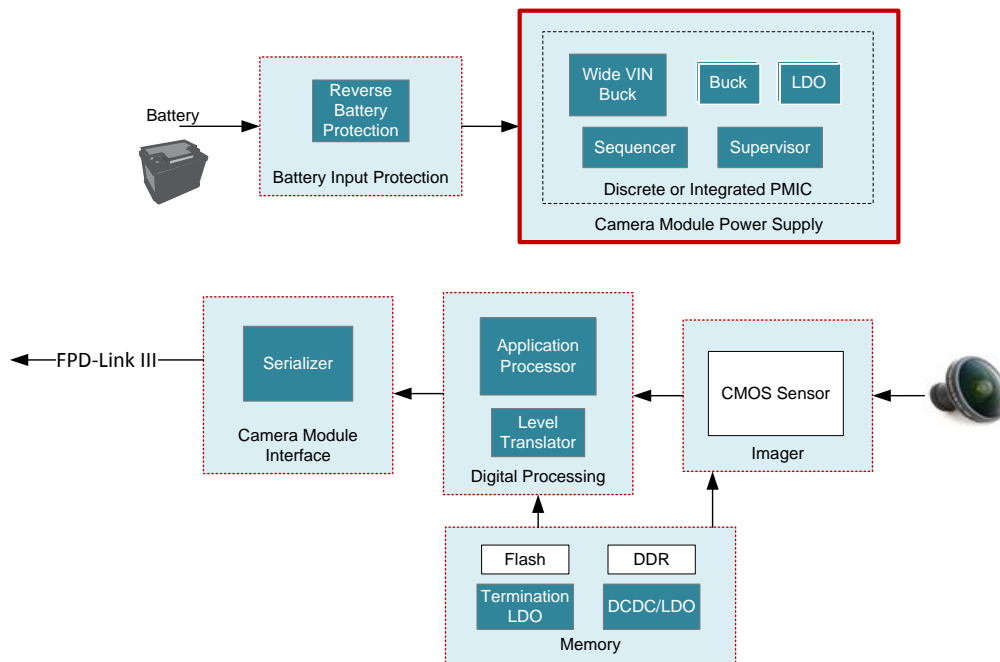


该 TI 参考设计末尾的重要声明表述了授权使用、知识产权问题和其他重要的免责声明和信息。

1 System Description

The TIDA-050015 power-supply design is optimized for size-sensitive automotive applications, specifically rear camera modules. The block diagram for a rear camera module is shown in 图 1, and the TIDA-050015 reference design highlights the camera module power supply highlighted below in red. This design has complete front-end protection and correspondingly accepts a wide input range from 3.8 V to 36 V. This design includes an electromagnetic interference (EMI) filter and is tested to CISPR 25 Class 5 conducted EMI standards without the use of additional shielding.

图 1. ADAS Rear Camera Module Block Diagram



The design is divided into four major blocks:

1. Front-end protection: Front-end protection has been implemented against positive and negative pulses (ISO7630 Pulse 1, 2a, 3a/b) through transient voltage suppression (TVS). A PMOSFET is responsible for implementing reverse battery protection.
2. EMI filter: The design uses a differential EMI filter for conducted EMI suppression. The design is tested to CISPR25 Class 5 conducted EMI standards without using any shielding or common-mode filters.
3. Low EMI front-end DC/DC converter: The design uses the LMR33630-Q1 as the front-end DC/DC converter, which is an automotive-qualified, low EMI, 2.1-MHz switching frequency, 3-A synchronous buck regulator. The device comes in an automotive-qualified HotRod™ QFN package with wettable flanks, which reduces parasitic inductance and resistance while increasing efficiency, minimizing switch node ringing, and dramatically lowering EMI. For lower power applications, the LMR34215-Q1 (1.5A) and LMR34206-Q1 (0.6A) offers a pin-to-pin capability that features fixed output voltages, spread spectrum, and forced PWM.
4. Point-of-load converters: The design uses LM2775-Q1, TPS62420-Q1, and LP5907-Q1 to provide regulated voltage for system components like the CMOS imager, CAN, high-speed serial interface, micro controllers or image signal processors. All three components enable a size-optimized, low-noise solution, which is designed to pass CISPR 25 class 5 limits.

1.1 Key System Specifications

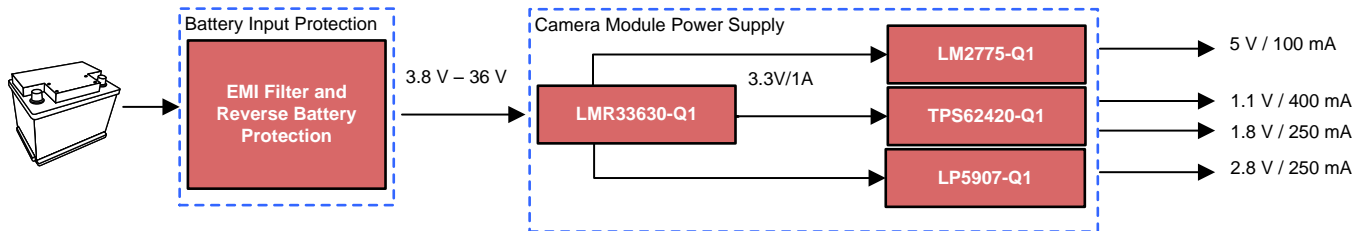
表 1. Key System Specifications

PARAMETER	SPECIFICATIONS
V_{IN} minimum	3.8 V
V_{IN} maximum	36 V
V_{OUT1}	3.3 V
I_{OUT1}	1 A
V_{OUT2}	5 V
I_{OUT2}	100 mA
V_{OUT3}	1.1 V
I_{OUT3}	400 mA
V_{OUT4}	1.8 V
I_{OUT4}	250 mA
V_{OUT5}	2.8 V
I_{OUT5}	250 mA
f_{SW}	2.1 MHz
ISO pulse test	TVS diode used for protection
EMI	Passes CISPR 25 Class 5 limits

2 System Overview

2.1 Block Diagram

图 2. TIDA-050015 Block Diagram



2.2 Design Considerations

The TIDA-050015 reference design is the power management subsystem designed specifically for ADAS camera module applications. This reference design uses a wide V_{IN} converter (LMR33630-Q1) and three point-of-load converters (LM2775-Q1, TPS62420-Q1, LP5907-Q1) with optimized switching frequencies, thermal performance, and form factor.

This camera module power supply has multiple protections at the front-end of the design.

- The TVS functions to clamp both positive and negative transient voltage pulses. These pulses included clamped load dump (up to 38 V) and other transients outlined in ISO 7637-2:2004.
- The PFET is used in the front end so that the system properly responds to a reverse battery polarity event and shuts down appropriately.

A front-end EMI filter enables compliance with the CISPR 25 class 5 automotive EMI standards, with respect to conducted emissions.

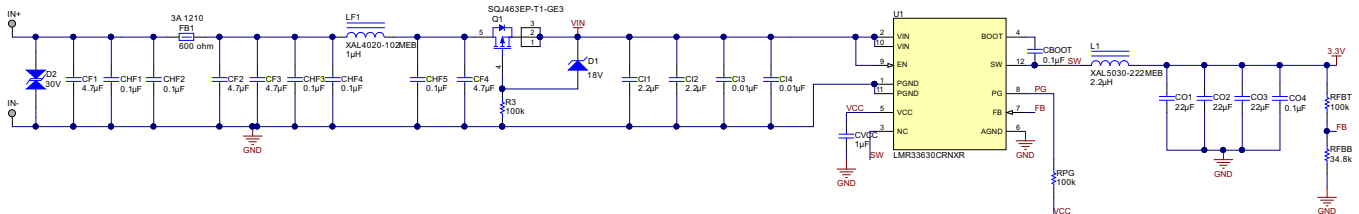
The LMR33630-Q1 synchronous buck converter is a wide-input-voltage, low-quiescent-current, high-performance regulator with internal compensation. The LMR33630-Q1 was chosen as the front-end, wide VIN converter for the TIDA-050015 because of small package size (3 mm × 2 mm), the switching frequency, the 3-A current capability, and the input voltage range of the regulator. The operating frequency for the LMR33630-Q1 regulator is 2.1 MHz, and the device implements a precise current limit. Consequently, the output filter size and component values are minimized. The device is designed with a flip-chip or HotRod technology, which greatly reduces the parasitic inductance of the pins. In addition, the layout of the device can help reduce the radiated noise generated by switching action through the partial cancellation of the current-generated magnetic field.

The 3.3-V output option for the LMR33630-Q1 was chosen to support cold crank conditions. When the engine cranks at low ambient temperature, a car battery voltage can drop to 4 V. This behavior is referred to as cold crank. With a 3.3-V output, the power supply must output a constant voltage rail as the battery voltage drops and ramps to a nominal voltage of 12 V to 13.5 V.

The LMR336xx family of devices offer flexibility to use this size-optimized layout for various power demands of additional automotive applications. For TIDA-050015, the LMR33630-Q1 output voltage is set to 3.3 V with a resistor divider from FB to V_{OUT} . Depending on the power requirement of the downstream components, the output voltage can be adjusted. In addition, the output current can be scaled down to 2 A with the use of the LMR33620-Q1. The LMR33620-Q1 uses a lower current limit and consequently enables the capability to shrink the inductor size.

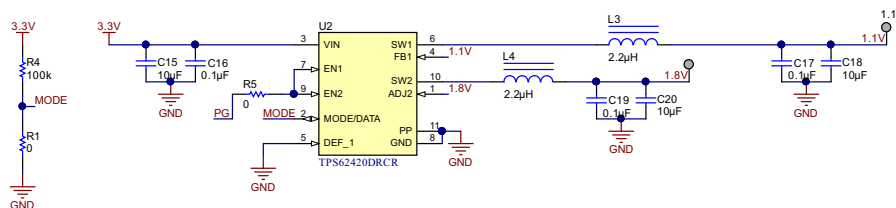
For lower current applications, the output current can be scaled down to 1.5 A or 600mA with the use of pin compatible devices, LMR34215-Q1 (42 V, 1.5 A) and LMR34206-Q1 (42 V, 600 mA). The LMR342xx-Q1 device family offers key features such as fixed output voltages, spread spectrum, and forced PWM. Fixed output voltages removes the need for external resistor devices that can cause inaccuracies. Spread spectrum eliminates peak emissions by spreading the emissions across a wider range of frequencies which will help pass stringent automotive EMI standards. For higher voltage variants, the LMR36006-Q1 (60 V, 600 mA) and LMR36015-Q1 (60 V, 1.5 A) are pin compatible devices with the same features .

图 3. Schematic of LMR33630-Q1



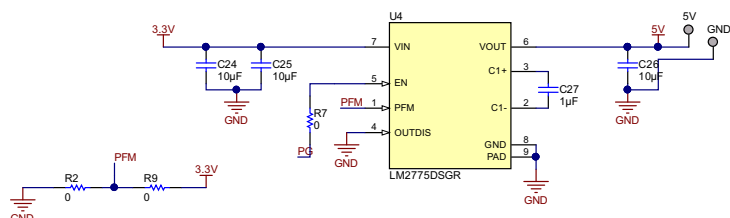
The TPS62420-Q1 is a dual-channel, step-down converter that can operate from a standard 3.3-V input rail and regulate dual output rails at 1.8-V and 1.1-V. The 1.8-V output rail powers both the FPD-Link III serializer and the imager IO rails while the 1.1-V rail powers the imager core voltage rail. The TPS62420-Q1 was chosen as one point-of-load converter for the TIDA-050015 because of the small package (3 mm × 3 mm), the switching frequency, the 600-mA current capability, and the input voltage range of the regulator. The operating frequency of the TPS6240-Q1 is a fixed 2.25-MHz switching frequency. At low output currents, the TPS62420-Q1 reduces its quiescent current by operating in pulse frequency modulation (PFM).

图 4. Schematic of TPS62520-Q1



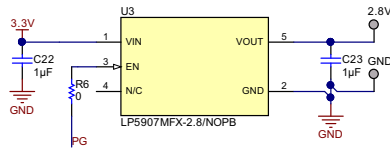
The LM2775-Q1 is a 5-V boost converter capable of powering the CAN communication. The LM2775-Q1 is a switch-capacitor boost converter that enables a small and cost optimized solution by eliminating the need for an inductor. In addition the LM2775-Q1 is selected as one of the point-of-load converters for the TIDA-050015 because of its switch-capacitor topology small package (2 mm × 2 mm), the switching frequency, and the 200-mA current capability. The operating frequency of the LM2775-Q1 is 2-MHz switching frequency. At low output currents, the LM2775-Q1 reduces its quiescent current by operating in PFM.

图 5. Schematic of LM2775-Q1



The LP5907-Q1 is a ultra-low-noise, low- I_Q device that powers the analog rail or pixel rail of the imager. The LP5907-Q1 is selected as one of the point-of-load converters for the TIDA-050015 because of the small package (0.675 mm × 0.675 mm) and low component count solution, which requires two external components. Ultimately, the LP5907-Q1 enables an ultra-small solution with good noise performance.

图 6. Schematic of LP5907-Q1



For design calculations and layout examples, see the data sheets for the relevant devices:

- LMR33630-Q1: [LMR33630-Q1 3.8-V to 36-V, 3-A Synchronous Step-Down Voltage Converter](#)
- TPS62420-Q1: [2.25-MHz 600-mA/1000-mA Dual Step-Down Converter](#)
- LM2775-Q1: [LM2775-Q1 Switched Capacitor 5-V Boost Converter](#)
- LP5907-Q1: [LP5907-Q1 Automotive 250-mA, Ultra-Low-Noise, Low- \$I_Q\$ LDO](#)

2.3 Highlighted Products

2.3.1 LMR33630-Q1

Features:

- Synchronous buck converter
- Wide operation input voltage: 3.8 V to 36 V (with transient protection up to 38 V)
- 2.1-MHz switching frequency
- Low quiescent current: 25 μ A
- Maximum load current: 2 A for LMR33620-Q1 and 3 A for LMR33630-Q1
- QFN package: 3 mm × 2 mm
- Pin-to-pin capability with LMR34215-Q1 (42 V, 1.5 A) and LMR34206-Q1 (42 V, 600 mA)

2.3.2 LM2775-Q1

Features:

- Synchronous boost converter
- Fixed 5-V output
- Inductorless solution: Only requires 3 small ceramic capacitors
- 2.7-V to 5.5-V input range
- 2-MHz switching frequency
- Maximum load current: 200 mA
- QFN package: 2 mm × 2 mm

2.3.3 TPS62420-Q1

Features:

- Synchronous buck converter

- Adjustable output voltage from 0.6 V to V_{IN}
- 2.5-V to 6-V input range
- 2.25-MHz switching frequency
- Maximum load current: 1000 mA
- QFN package: 3 mm × 3 mm

2.3.4 LP5907-Q1

Features:

- Solution requires 1- μ F ceramic input and output capacitors
- Adjustable output voltage from 1.2 V to 4.5 V
- 2.2-V to 5.5-V input range
- Low quiescent current: 12 μ A
- QFN package: 2.96 mm × 1.60 mm

3 Hardware, Software, Testing Requirements, and Test Results

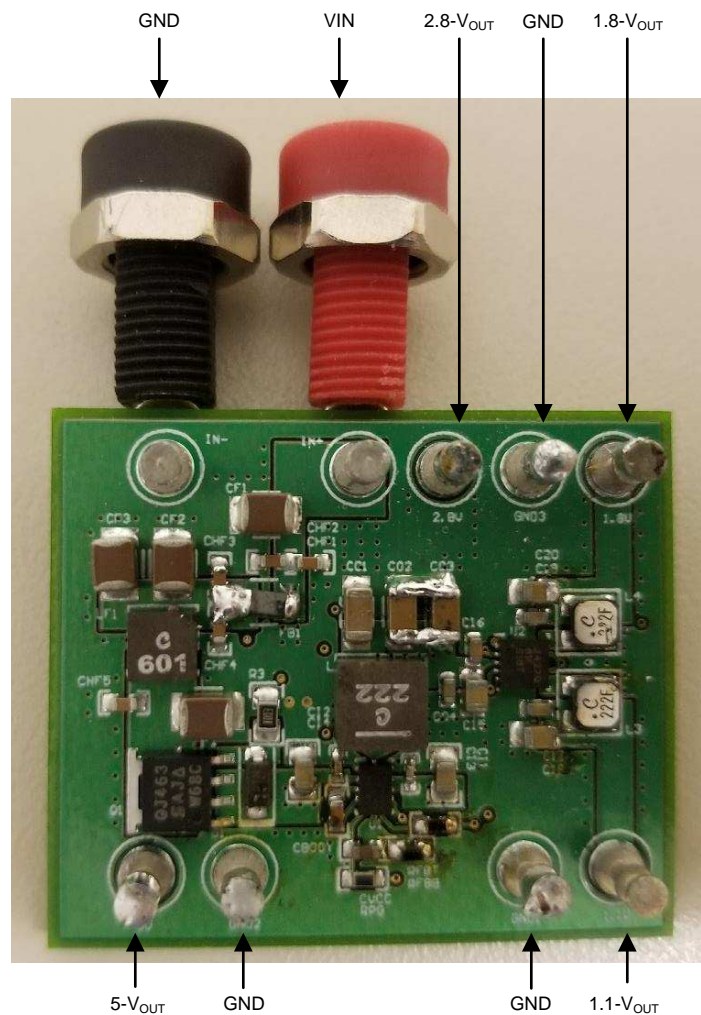
3.1 Required Hardware

3.1.1 Hardware

The following steps outline the hardware setup.

1. Connect a DC power supply to VIN and GND, as labeled in 图 7.
2. Connect electronic or resistive load to the four output posts (2.8-V_{OUT}, 1.8-V_{OUT}, 5-V_{OUT}, 1.1-V_{OUT}), as labeled in 图 7.

图 7. Hardware Setup



3.2 Testing and Results

3.2.1 Test Set Up

For the following test results the TIDA-050015 was set up as detailed in 节 3.1.1.

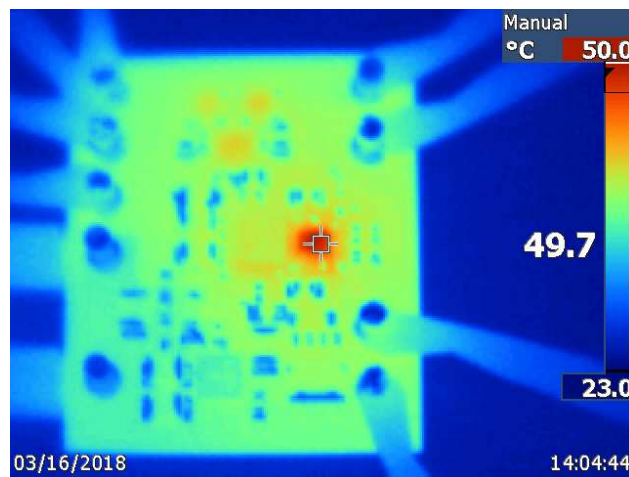
3.2.2 Test Results

The following diagrams show the design performance.

3.2.2.1 Thermal Data

The infrared (IR) thermal image in 图 8 was taken at steady-state with $V_{IN} = 12V$ and the TPS62821 output at a full load (no airflow). The ambient temperature is approximately 22°C. The maximum IC temperature is 47°C.

图 8. TIDA-050015 Thermal Image: $V_{IN} = 12 V$, $I_{OUT1} = 1 A$, $V_{OUT1} = 3.3 V$, $V_{OUT2} = 5 V$, $I_{OUT2} = 100 mA$, $V_{OUT3} = 1.1 V$, $I_{OUT3} = 400 mA$, $V_{OUT4} = 1.8 V$, $I_{OUT4} = 250 mA$, $V_{OUT5} = 2.8 V$, $I_{OUT5} = 250 mA$



3.2.2.2 Efficiency Data

图 9 shows the efficiency of the LMR33630-Q1 device versus the load current. 图 10 shows the total system efficiency versus the input voltage at full load.

图 9. LMR33630-Q1 Efficiency Versus Load Current: $I_{OUT1} = 0 \text{ A}$ to 3 A (Includes Front End Protection and EMI Filter)

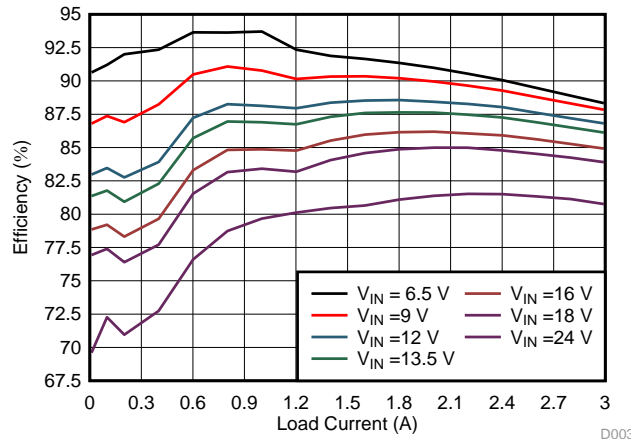
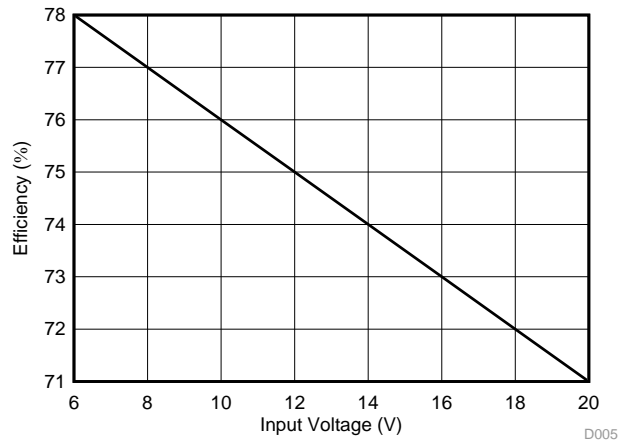


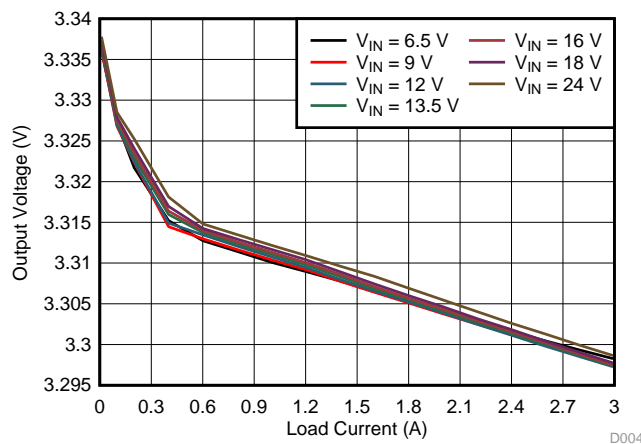
图 10. System Efficiency vs Input Voltage: $I_{OUT1} = 1 \text{ A}$, $I_{OUT2} = 100 \text{ mA}$, $I_{OUT3} = 400 \text{ mA}$, $I_{OUT4} = 250 \text{ mA}$, $I_{OUT5} = 250 \text{ mA}$



3.2.2.3 Output Load Regulation

图 11 shows the output load regulation of the wide input converter (LMR33630-Q1).

图 11. LMR33630-Q1 Load Regulation: V_{OUT1} vs I_{OUT1}



3.2.2.4 Reverse Battery Protection

This design has implemented protection against a reverse battery connection. 图 12 and 图 13 show this performance.

图 12. Continuous Reverse Voltage at Input - C1: V_{IN} (Input for DC/DC Converter), C3: Input (Input Terminal for Battery)

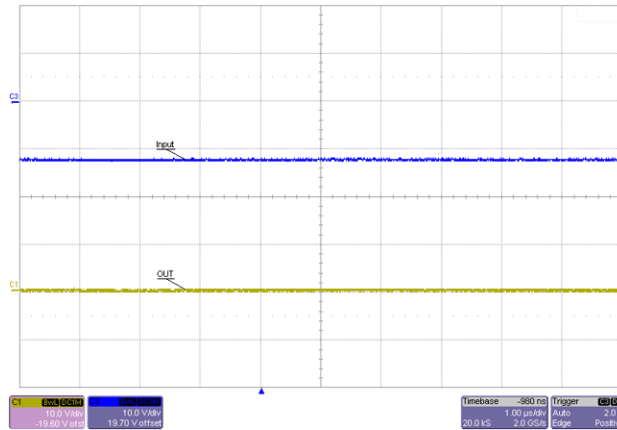
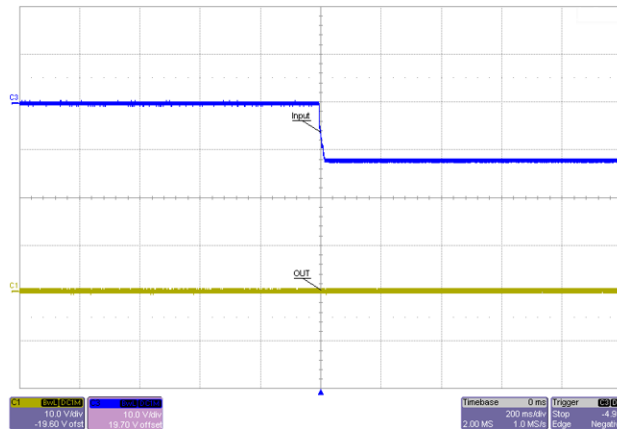


图 13. Transition to Reverse Voltage at Input - C1: V_{IN} (Input for DC/DC Converter), C3: Input (Input Terminal for Battery)



3.2.2.5 Switch Node and Output Voltage Ripple

图 14 显示了 LMR33630-Q1 在 12 V_{IN} 和满载时的稳态性能，展示了开关节点和输出电压纹波。图 15 显示了 TPS62420-Q1 在 12 V_{IN}、1.8 V_{OUT} 和满载时的稳态性能，展示了开关节点和输出电压纹波。图 16 显示了 TPS62420-Q1 在 12 V_{IN}、1.1 V_{OUT} 和满载时的稳态性能，展示了开关节点和输出电压纹波。

图 14. LMR33630-Q1 稳态波形在 12 V_{IN} 和满载 - C1: 3.3-V_{OUT} (AC 耦合), Ch3: 开关节点

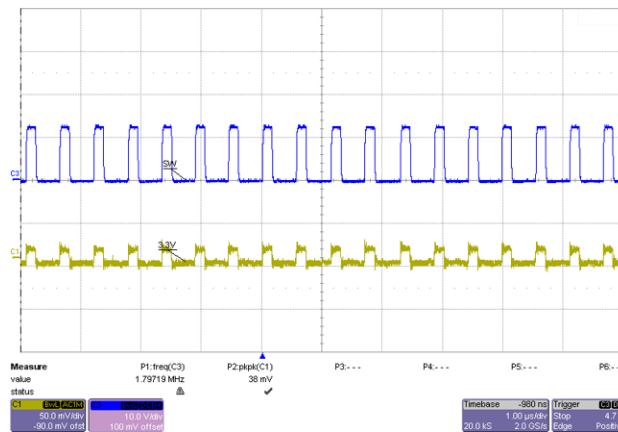


图 15. TPS62420-Q1 稳态波形在 12 V_{IN} 和满载 - C1: 1.8 V_{OUT} (AC 耦合), Ch3: 开关节点

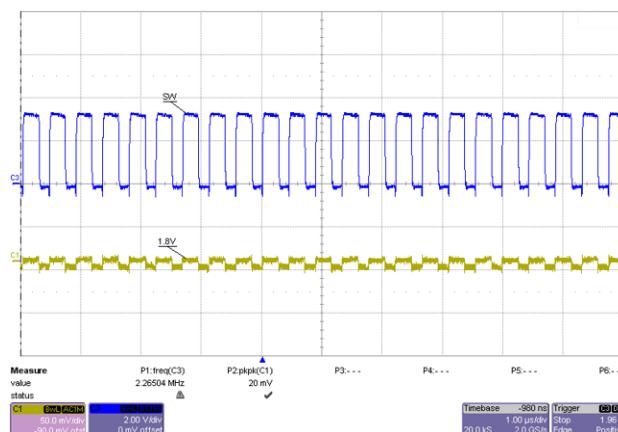
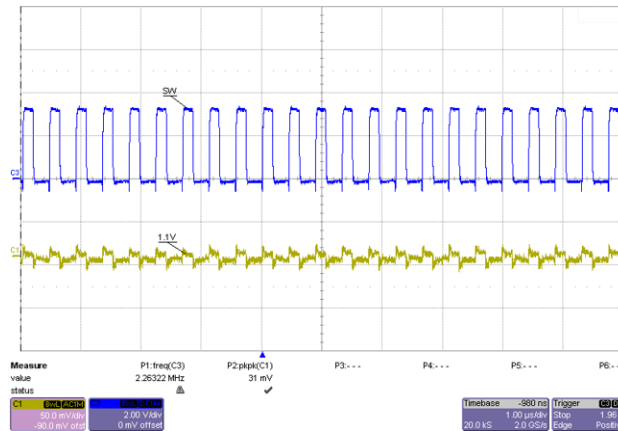


图 16. TPS62420-Q1 Steady-State Waveform at 12 V_{IN} and Full Load - C1: 1.1 V_{OUT} (AC Coupled), Ch3: Switch Node



3.2.2.6 Load Transient

The load transient waveform monitor the output voltage and the load current. Channel 1 (yellow) represents the output current of the LMR33630-Q1 or TPS62420-Q1. Channel 3 (blue) represents the output current. 图 17 到 图 20 show the load transient results.

图 17. LMR33630-Q1 Load Transient: 12 V_{IN}, I_{OUT1} = 0.4 A to 3 A, t_r = t_f = 5 μs - C1: 3.3 V_{OUT} (AC Coupled), Ch3: I_{OUT1}

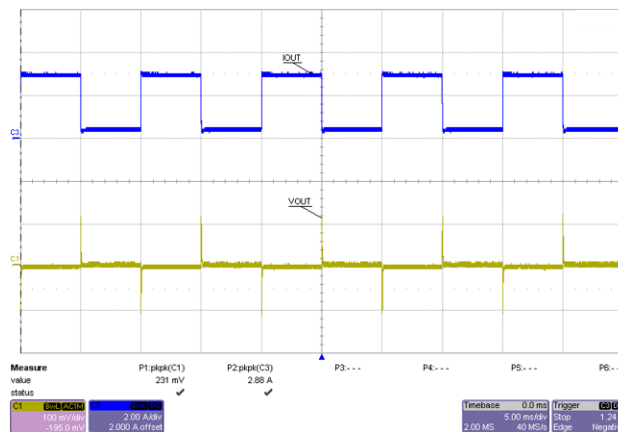


图 18. PS62420-Q1 Load Transient: 12 V_{IN}, I_{OUT2} = 0.1 A to 0.4 A, t_r = t_f = 3 μs - C1: 1.8 V_{OUT} (AC Coupled), Ch3: I_{OUT2}

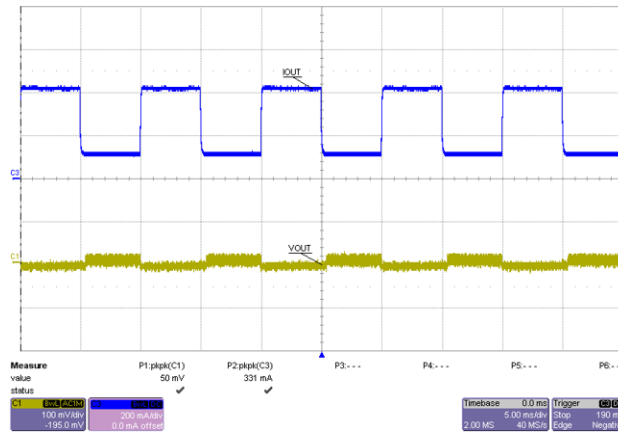


图 19. TPS62420-Q1 Load Transient: 12 V_{IN}, I_{OUT3} = 0.2 A to 0.8 A, t_r = t_f = 6 μs - C1: 1.1 V_{OUT} (AC Coupled), Ch3: I_{OUT3}

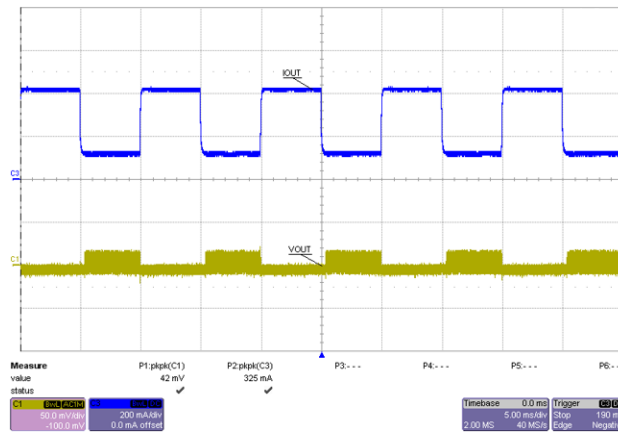
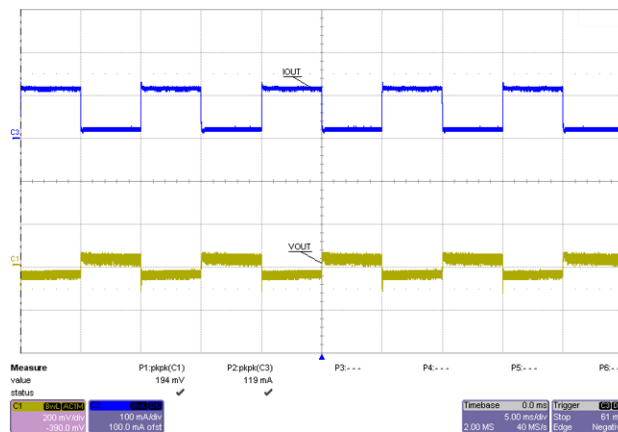


图 20. LM2775-Q1 Load Transient: 12 V_{IN}, I_{OUT4} = 0.01 A to 0.1 A, t_r = t_f = 1 μs - C1: 5 V_{OUT} (AC Coupled), Ch3: I_{OUT2}



3.2.2.7 Conducted Emissions

图 21 和 图 22 显示基于 CISPR 25 类 5 标准的传导发射图。输入电压为 12 V，所有输出均为满载。

图 21. EMI Performance From 150 kHz to 30 MHz: $V_{IN} = 12\text{ V}$
(Yellow: Peak Detection Result; Blue: Average Detection Result; Red: CISPR 25 Class 5 Limits)

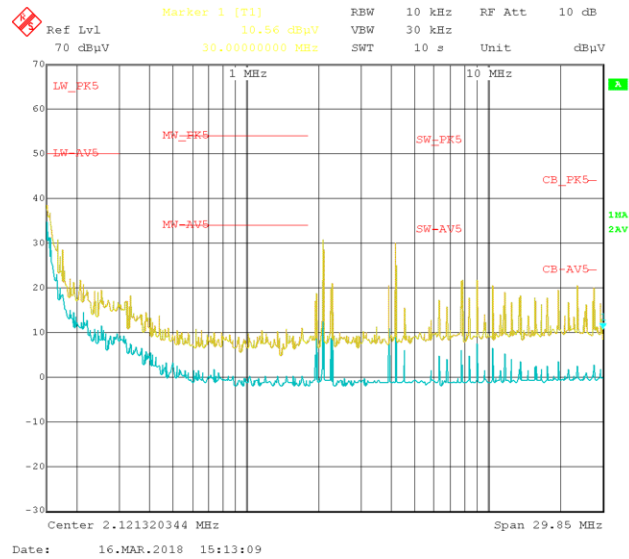
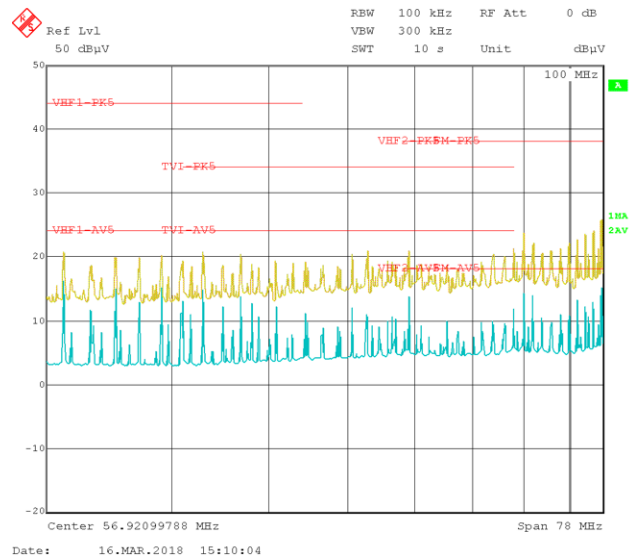


图 22. EMI Performance From 30 MHz to 108 MHz: $V_{IN} = 12\text{ V}$
(Yellow: Peak Detection Result; Blue: Average Detection Result; Red: CISPR 25 Class 5 Limits)



4 Design Files

4.1 Schematics

To download the schematics, see the design files at [TIDA-050015](#).

4.2 Bill of Materials

To download the bill of materials (BOM), see the design files at [TIDA-050015](#).

4.3 PCB Layout Recommendations

4.3.1 Layout Prints

To download the layer plots, see the design files at [TIDA-050015](#).

4.4 Altium Project

To download the Altium Designer® project files, see the design files at [TIDA-050015](#).

4.5 Gerber Files

To download the Gerber files, see the design files at [TIDA-050015](#).

4.6 Assembly Drawings

To download the assembly drawings, see the design files at [TIDA-050015](#).

5 Software Files

To download the software files, see the design files at [TIDA-050015](#).

5.1 商标

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6 Related Documentation

1. Texas Instruments, [LMR33630-Q1 3.8-V to 36-V, 3-A Synchronous step-down voltage converter](#)
2. Texas Instruments: [2.25-MHz 600-mA/1000-mA Dual step-down converter \(TPS62420-Q1\)](#)
3. Texas Instruments, [LM2775-Q1 Switched capacitor 5-V boost converter](#)
4. Texas Instruments, [LP5907-Q1 Automotive 250-mA, ultra-low-noise, low- \$I_Q\$ LDO](#)

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修订历史记录

注：之前版本的页码可能与当前版本有所不同。

Changes from Original (February 2019) to A Revision	Page
• 已添加 LMR34215-Q1 产品文件夹	1
• 已添加 "For lower power applications, the LMR34215-Q1 (1.5A) and LMR34206-Q1 (0.6A) offers a pin-to-pin capability that features fixed output voltages, spread spectrum, and forced PWM."	2
• 已添加 "For lower current applications, the output current can be scaled down to 1.5 A or 600mA with the use of pin compatible devices, LMR34215-Q1 (42 V, 1.5 A) and LMR34206-Q1 (42 V, 600 mA). The LMR342xx-Q1 device family offers key features such as fixed output voltages, spread spectrum, and forced PWM. Fixed output voltages removes the need for external resistor devices that can cause inaccuracies. Spread spectrum eliminates peak emissions by spreading the emissions across a wider range of frequencies which will help pass stringent automotive EMI standards. For higher voltage variants, the LMR36006-Q1 (60 V, 600 mA) and LMR36015-Q1 (60 V, 1.5 A) are pin compatible devices with the same features ."	5
• 已添加 "Pin-to-pin capability with LMR34215-Q1 (42 V, 1.5 A) and LMR34206-Q1 (42 V, 600 mA)"	6

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