TI Designs: TIDA-01387
Power Supply for GPRS Modules From LISOCL2 Battery

Description

The TIDA-01387 demonstrates how to power GPRS modules in smart meters using LISOCL2 batteries. GPRS modules require peak current of up to 2 A during transmission. This TI Design reduces the peak load requirements on the battery by using the TPS61021A boost converter and a 20F super capacitor to provide the required transmit current. This reduces the overall cost of the system by allowing the use of low cost LISOCL2 batteries while maintaining a 10-year lifetime.

Resources

TIDA-001387	Design Folder
TPS61021A	Product Folder

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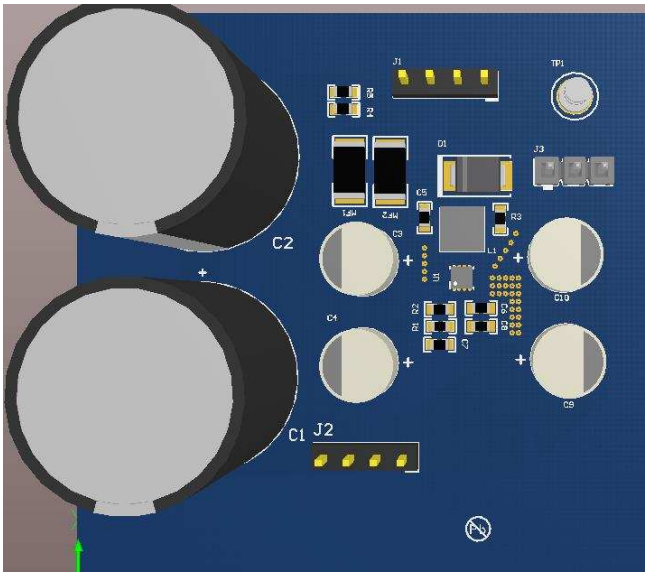
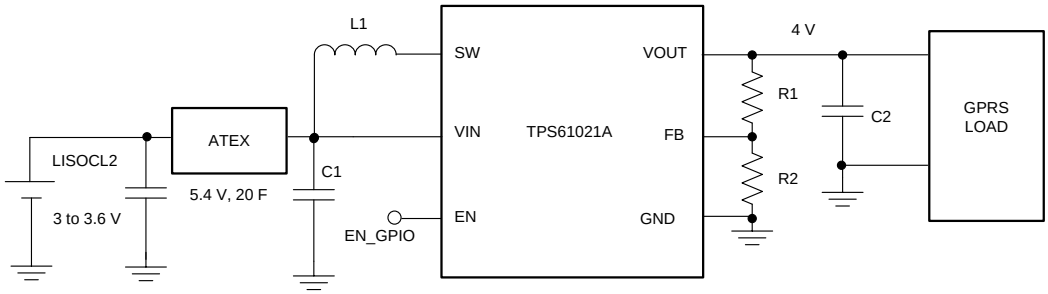
Features

- 0.7- to 4-V Input Voltage Range
- Small Boost Converter Solution
- Efficiency is Higher Than 85% With 3-V Input Voltage
- More Than 2-A Output Current Capability With 2.8-V Input
- Output Voltage Dip Less Than 200 mV

Applications

- Tracker
- GPRS Modules
- Electric and Water Meters





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1 System Description

The LISOCL2 battery currently has the highest energy density, the longest storage period, and the least self-discharge rate (less than 1% per year at room temperature). This battery is very useful for e-meters, water meters, and trackers, which are long-term products. The typical voltage of a LISOCL2 battery is approximately 3 to 3.6 V, and the maximum continuous output current is about 20 mA/1000 mAh. The GPRS modules need a 3.3- to 4.6-V power supply voltage and as high as 2-A pulse current while operating. A boost converter is needed between the LISOCL2 battery and the GPRS modules. The TPS61021A is very suitable for this application with an input voltage as low as 0.7 V and a 4.3-A typical current limit. A 5.4-V 20F supercapacitor is needed in parallel with the battery to support high current pulse because of the high impedance of the LISOCL2 battery. An ATEX circuit is used for limit inrush current when short circuit happens.

1.1 Key System Specifications

Table 1. Key System Specifications

PARAMETER	TEST CONDITION	VALUE
Input voltage range	–40°C to 85°C	0.7 to 4 V
Output voltage	–40°C to 85°C, I_{OUT} = 0 to 2 A, V_{IN} = 2.8 to 4 V	4 V
Load capacity	–40°C to 85°C, V_{IN} = 2.8 to 4 V	2 A
Load capacity	–40°C to 85°C, V_{IN} = 2.5 to 4 V	1.6 A
Load capacity	–40°C to 85°C, V_{IN} = 0.7 to 4 V	0.5 A
Output voltage drop	25°C, V_{IN} = 2.8 to 4 V, Iout = 0- to 2-A transient	200 mV max
Output voltage drop	25°C, V_{IN} = 2.5 to 4 V, I_{OUT} = 0- to 1.6-A transient	200 mV max

2 System Overview

2.1 Block Diagram

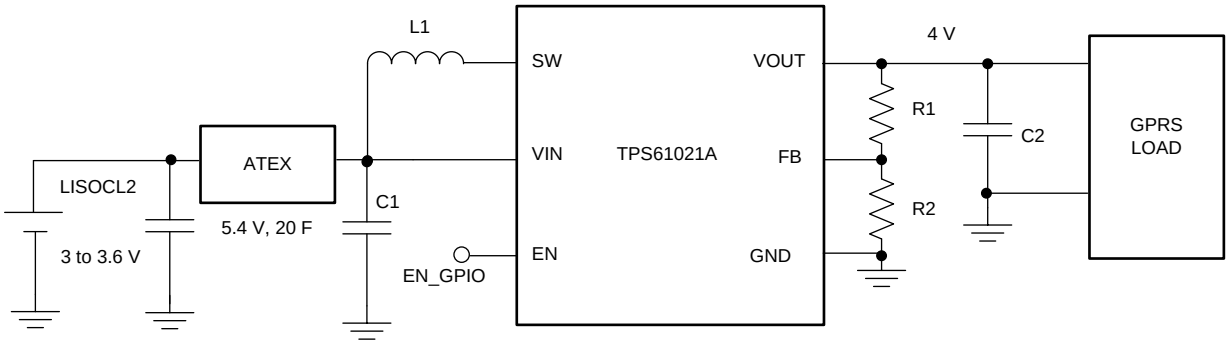

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Figure 1. Block Diagram

2.2 Highlighted Products

2.2.1 TPS61021A

The TPS61021A is a low-voltage and high-current limit boost converter. The TPS61021A is capable of outputting 4 V and 2 A from a 2.5-V input voltage with a 87% efficiency. The device operates at a 2-MHz switching frequency and can be shut down through the EN pin with a 0.5-µA shutdown current. The TPS61021A provides a 4.35-V output overvoltage protection, output short-circuit protection, and shutdown protection. The TPS61021A is available in a 2-mm×2-mm WSON package.

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3 System Design Theory

3.1 Operating Principle

The GPRS modules operate in a range from 3.3 to 4.6 V. The power supply for the GPRS modules should never drop below 3.3 V, even in sharp current pulse loads. When transmitting signals, the pulse current can be as high as 2 A and last as long as 577 µs within a 4.615-ms period. To guarantee the GPRS modules have good performance, the power supply is designed to output 4 V and the voltage dip is under 200 mV with a 2-A/2-µs slope rate.

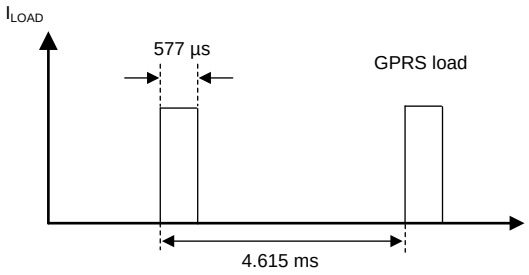

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Figure 2. GPRS Load Waveform

3.2 Inductor Selection

The TPS61021A operates with a 2-MHz switching frequency. The inductor is selected to make sure the current ripple is less than 30% of the DC current to have better efficiency and EMI performance. According to Equation 5 to Equation 6 from the TPS61021A datasheet[1]:

$$I_{L(DC)} = \frac{V_{OUT} \times I_{OUT}}{V_{IN} \times \eta} = \frac{4\,V \times 2\,A}{3\,V \times 0.87} = 3.07\ A \quad (1)$$

$$L = \frac{\left(V_{OUT} - V_{IN}\right) \times V_{IN}}{V_{OUT} \times f_{SW} \times \Delta I_{L(P-P)}} = \frac{1\,V \times 3\ V}{4\,V \times 2M \times 0.3 \times 3.07\ A} = 0.41\,\mu H \quad (2)$$

The larger the inductance, the smaller the inductor current ripple is. This TI Design uses an 0.47-µH inductor. From Table 2 of the TPS61021A datasheet[1], XFL4015-471ME (DCR = 8.36 mΩ, I_{SAT} = 6.6 A, 4.0-mm×4.0-mm×1.5-mm, Coilcraft®) is an option for this TI Design.

3.3 Input Capacitor and Output Capacitor Selection

Input capacitors are very critical to stabilize the input voltage, especially when the input battery is distant from the TPS61021A. Even a 50-mΩ ESR can introduce a 200-mV input voltage dip if I_{IN} = 4 A. This TI Design uses two 470-µF aluminum capacitors and a 10-µF X5R ceramic capacitor. The ceramic capacitor has an ESR of less than 1 mΩ and is placed as close as possible to the TPS61021A. The output capacitors determine the output ripple and output voltage dip when suffering from a high pulse load current. 0.1-µF, 22-µF X5R ceramic capacitors and two 470-µF aluminum capacitors are used to make sure the output voltage under short is not higher than 200 mV at V_{IN} =3V and a 2-A pulse current condition. According to Equation 8 and Equation 9 in the TPS61021A datasheet[1], the output voltage ripple can be calculated as follows:

$$V_{OUT(ripple)} = \frac{D_{MAX} \times I_{OUT}}{C_{OUT} \times f_{SW}} + I_{OUT} \times ESR = \frac{0.25 \times 2\,A}{1022\,\mu F \times 2M} + 2\,A \times 0.01\,\Omega = 20.25\ mV \quad (3)$$

where D_{MAX} is the maximum switching duty cycle (V_{IN} = 3 V, V_{OUT} = 4 V, D_{MAX} = 0.25).

4 Getting Started Hardware

See Section 6.1 and Section 6.2 for the test schematic and BOM, respectively.

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5 Testing and Results

Unless otherwise noted, typical values are at T_A = 25°C. ATEX is replaced by two 40-mΩ resistors in series. The output voltage dip can be less than 200 mV under the load transient condition. The hold time is defined as when doing discharge test, the minimum output voltage value can be higher than 3.8 V.

5.1 Startup Waveforms

This section shows the startup progress with resistor load(the resistor is removed during OFF state by a load switch) and GPRS load.

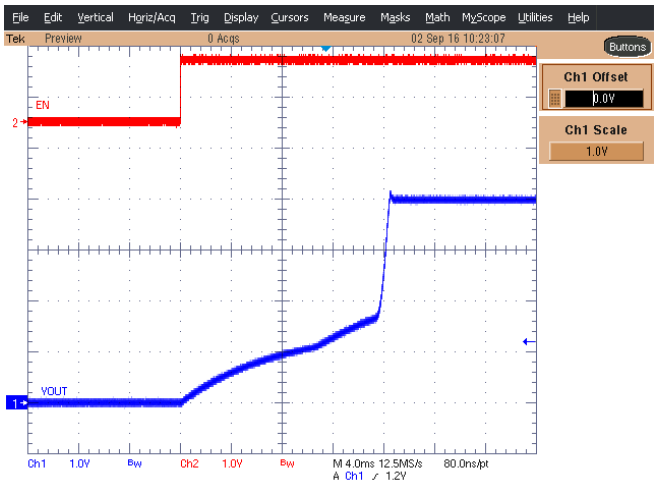

Figure 3. Startup With Resistor Load

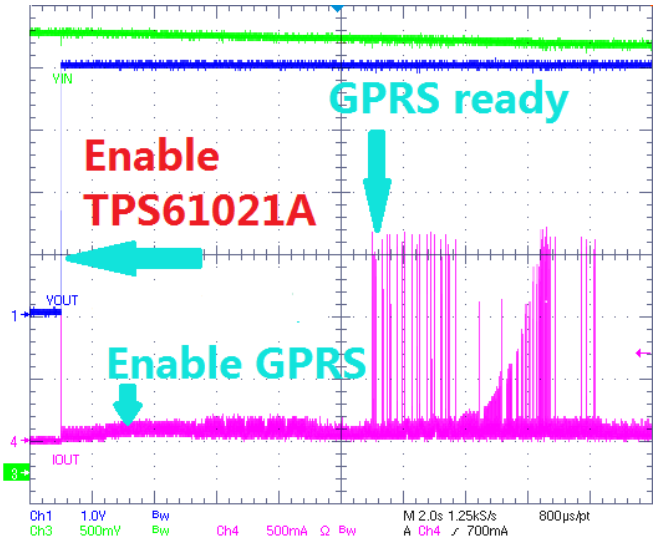

Figure 4. Startup With GPRS Load (GPRS Module: L206)

5.2 Switching Wavefroms

This section shows the switching waveforms with continuous output current.

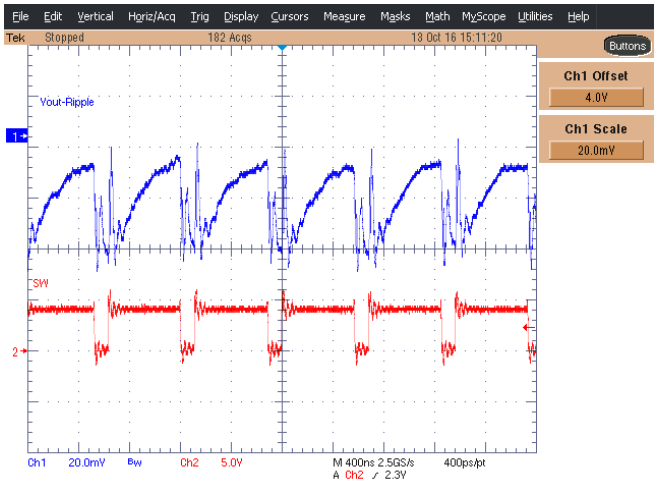

Figure 5. V_{IN} = 3.6 V, I_{OUT} = 2 A

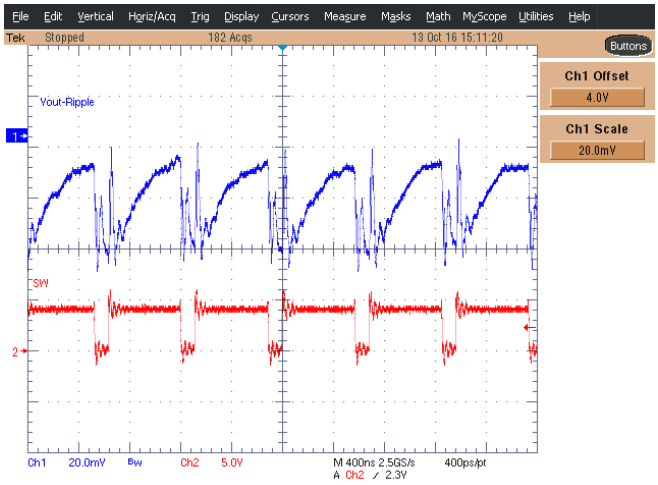

Figure 6. V_{IN} = 3.6 V, I_{OUT} = 1 A

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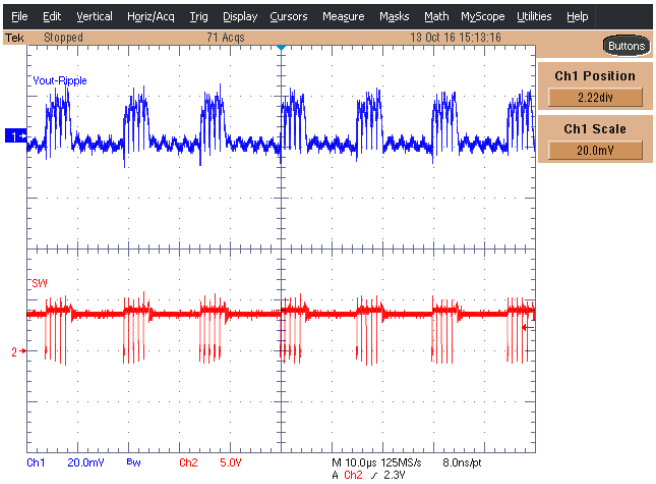

Figure 7. V_{IN} = 3.6 V, I_{OUT} = 0.1 A

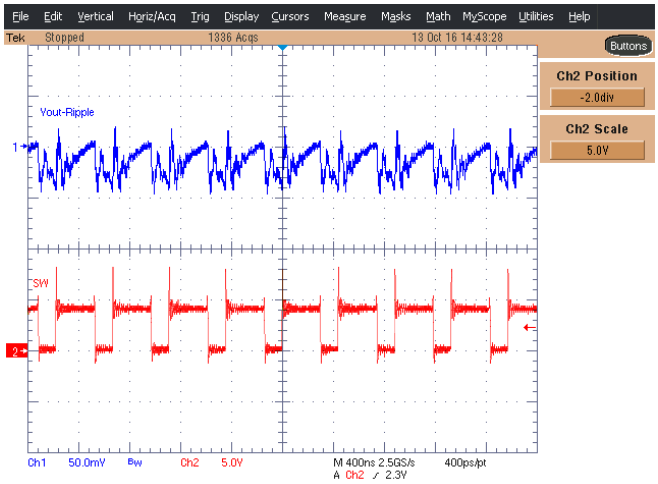

Figure 8. V_{IN} = 3 V, I_{OUT} = 2 A

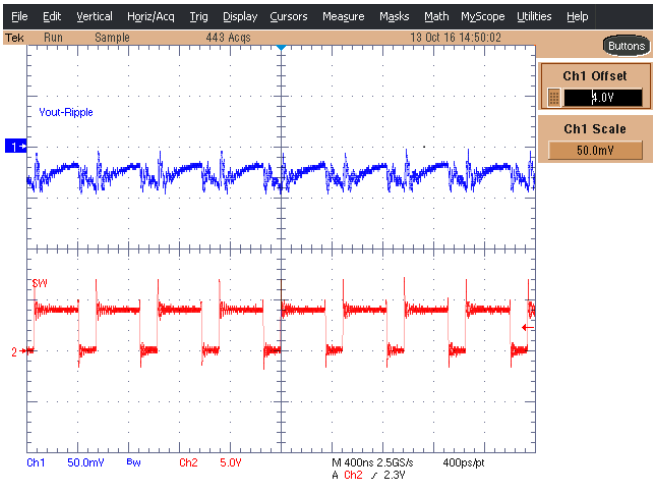

Figure 9. V_{IN} = 3 V, I_{OUT} = 1 A

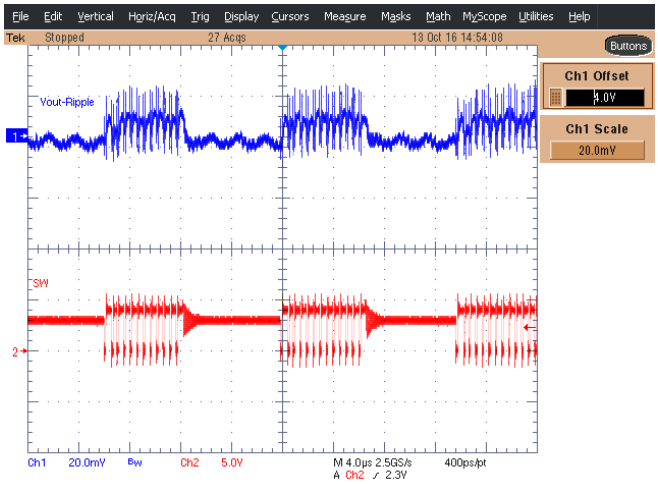

Figure 10. V_{IN} = 3 V, I_{OUT} = 0.1 A

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5.3 Hold Time Measurement

Hold time is defined as the time from when the supercapacitor (fully charged to 3.6 V) begins to discharge until the minimum output voltage triggers 3.5 V with continuous or pulses current.

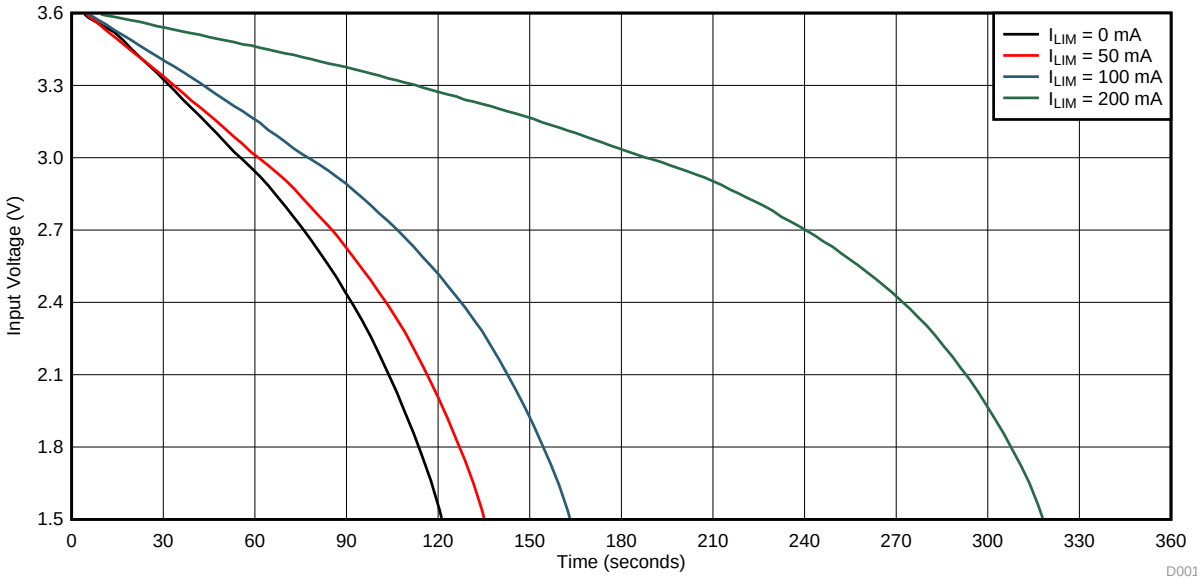

Figure 11. Hold Time With Continuous Load (250 mA)

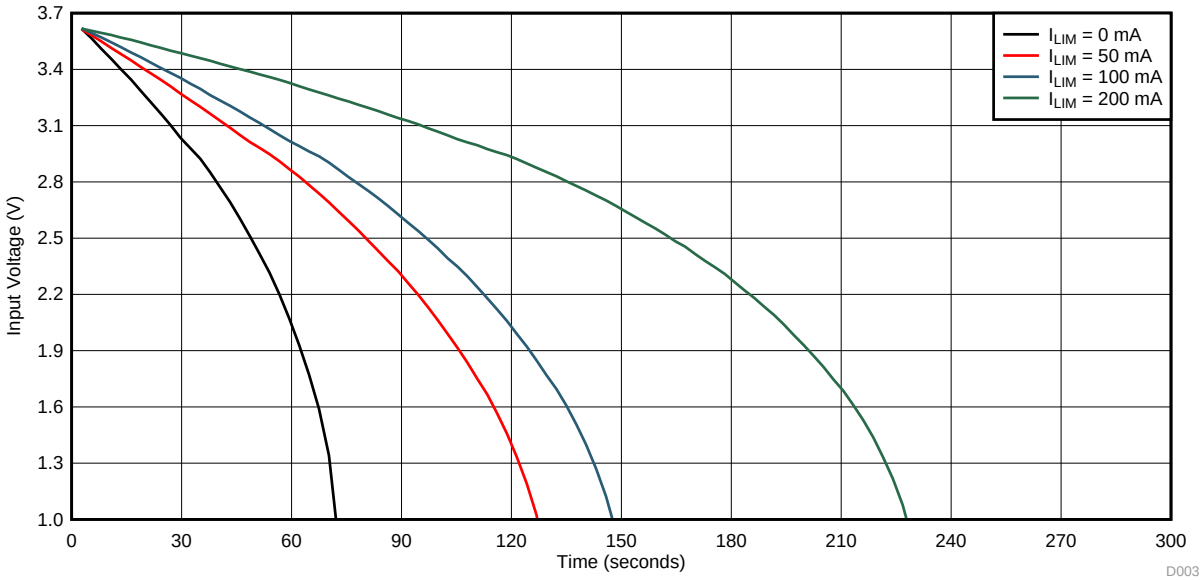

Figure 12. Hold Time With Pulse Load (2-A Peak D = 1/8)

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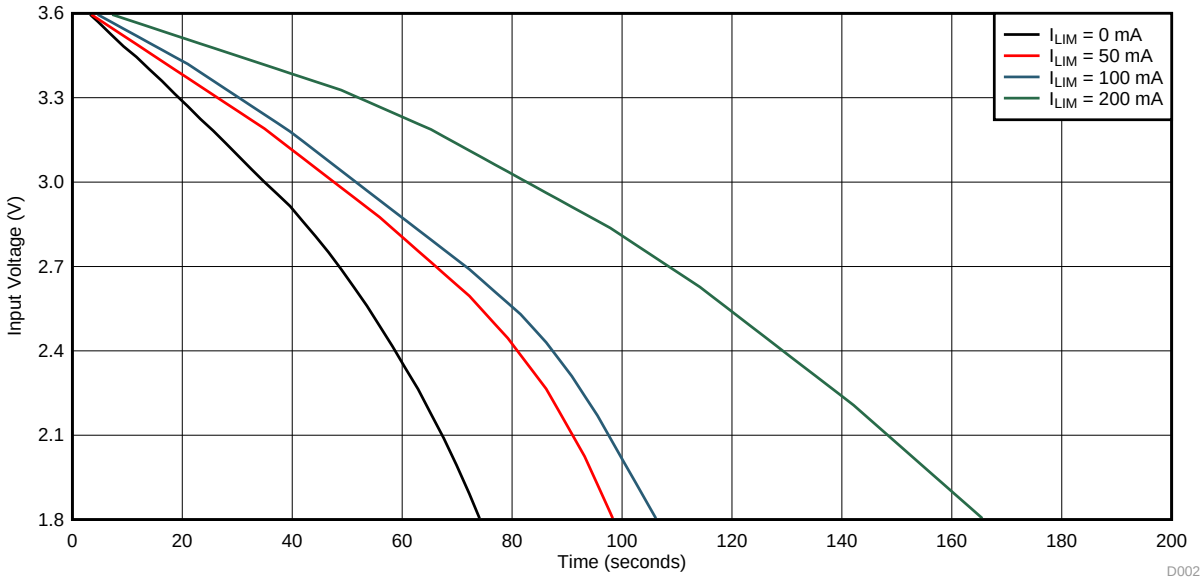

Figure 13. Hold Time With Pulse Load (1.6-A Peak D = 1/8)

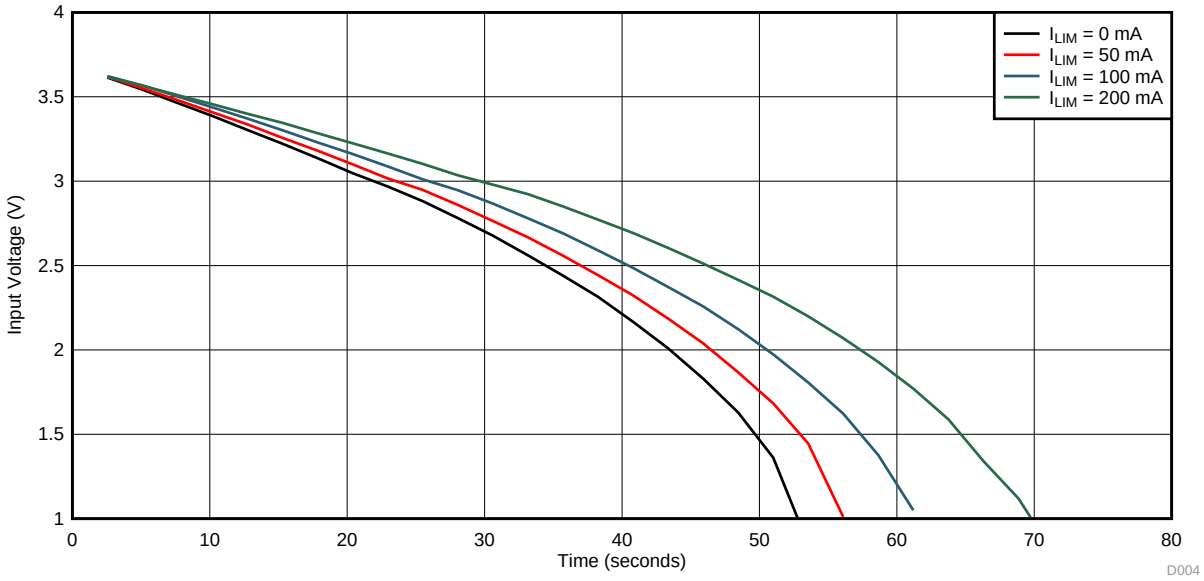

Figure 14. Hold Time With Continuous Load (500 mA)

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5.4 Load Transient

The load slew rate is 1 A/µs. Channel1: Vout Ripple(4.0V Offset); Channel 4: IOUT.

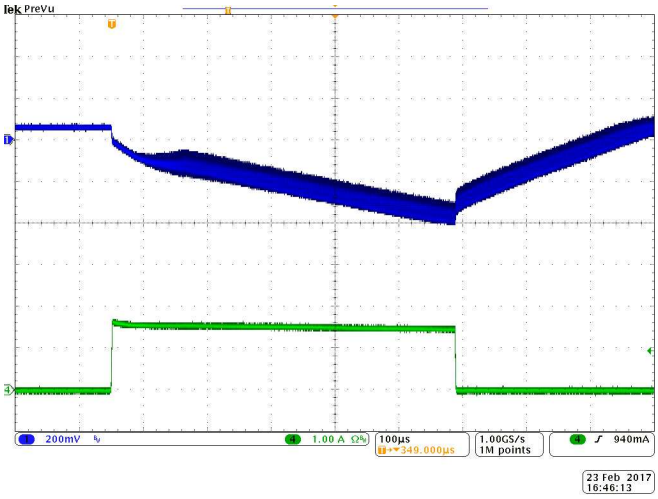

Figure 15. V_{IN} = 1.6 V, I_{OUT} = 0-1.6-0 A

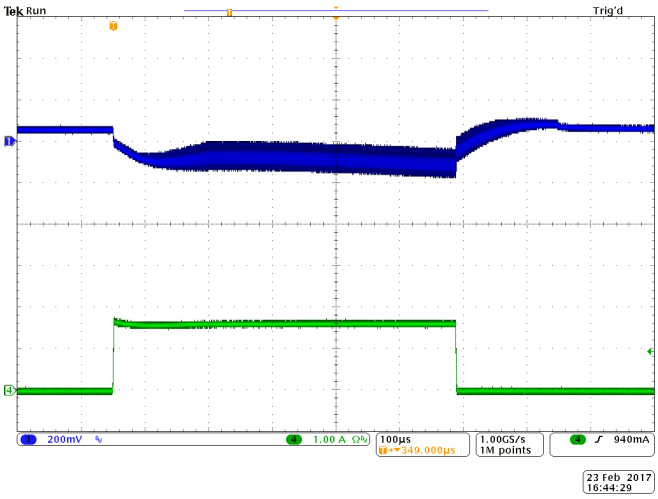

Figure 16. V_{IN} = 2 V, I_{OUT} = 0-1.6-0 A

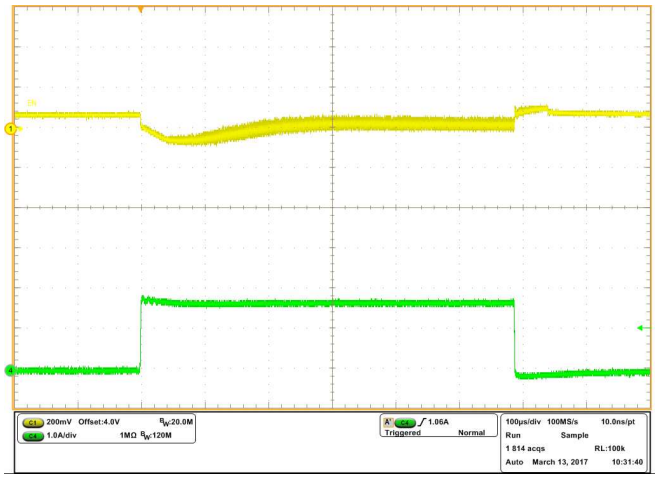

Figure 17. V_{IN} = 3 V, I_{OUT} = 0-1.6-0 A

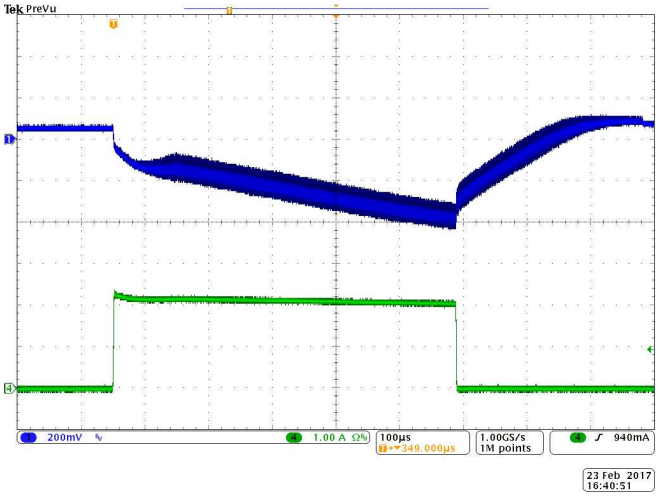

Figure 18. V_{IN} = 2.0 V, I_{OUT} = 0-2-0 A

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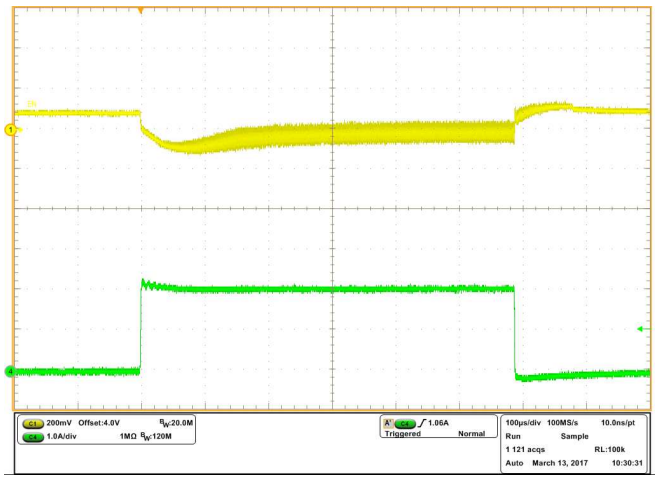

Figure 19. V_{IN} = 2.5 V, I_{OUT} = 0-2-0 A

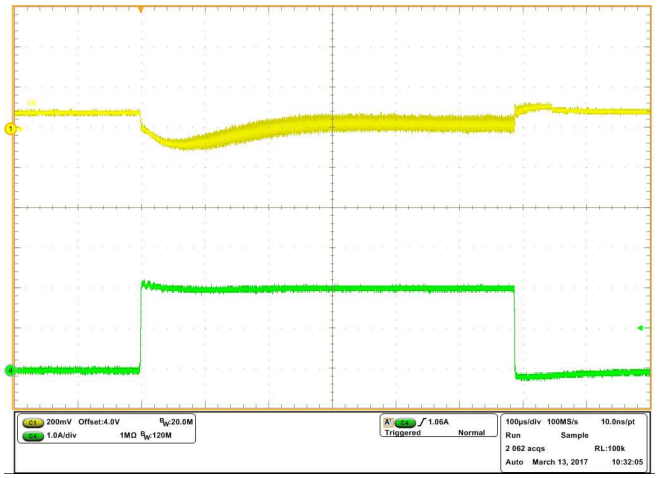

Figure 20. V_{IN} = 3.0 V, I_{OUT} = 0-2-0 A

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6 Design Files

6.1 Schematics

To download the schematics, see the design files at TIDA-01387.

6.2 Bill of Materials

To download the bill of materials (BOM), see the design files at TIDA-01387.

6.3 PCB Layout Recommendations

6.3.1 Layout Prints

To download the layer plots, see the design files at TIDA-01387.

6.4 Altium Project

To download the Altium project files, see the design files at TIDA-01387.

6.5 Gerber Files

To download the Gerber files, see the design files at TIDA-01387.

6.6 Assembly Drawings

To download the assembly drawings, see the design files at TIDA-01387.

7 References

1. Texas Instruments, *TPS61021A 3-A Boost Converter with 0.5-V Ultra Low input Voltage*, TPS61021A Datasheet (SLVSDM0)

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