TI Designs：TIDA-050021
适用于智能仪表的 GSM 模块备用电源参考设计

说明

此参考设计提供 GSM 模块的备用电源参考设计。通过增加一个简单的电荷泵电路，此解决方案即使在超级电容器电压降至 1V 时也能支持 3.8V/2A 输出功率。因此可以最大限度利用存储在超级电容器中的能量。

资源

TIDA-050021	设计文件夹
TPS61088	产品文件夹

TI E2E™ Community

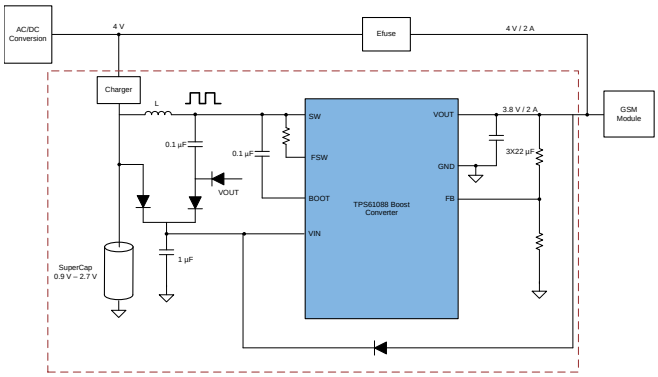
咨询我们的 E2E™ 专家

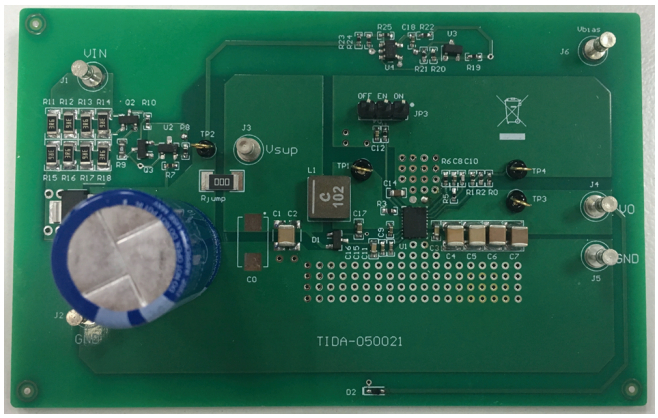
特性

- 超级电容器电压范围：0.9V 至 2.7V
- 最大输出功率：3.8V/2A
- 高效率
- 小型尺寸
- 大约 0.8A 的大电流线性充电器

应用

- 电表
- 燃气表
- 水表





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。

TIDUEL6 — http://www-s.ti.com/sc/techlit/TIDUEL6
版权 © 2018, Texas Instruments Incorporated

1 System Description

Nowadays, smart meters are more and more popular world-wide. Smart meters are replacing traditional meters because energy providers can remotely access the energy meters. They can monitor meter readings regularly without visiting each house. A GSM-based wireless communication module is integrated in the energy meter. This GSM module is powered by a 3.6-V to 4-V DC voltage generated from the AC mains. When the AC mains brown out, the GSM module must report the fault conditions as well as the latest usage of electricity to a GSM receiver at the other end. Thus, in smart meters backup power is needed to power the GSM module in the AC mains brownout condition. The size of the backup power must be as small as possible due to limited space, as long enough power is supplied to the GSM module.

TI reference design TIDA-050021 focuses on the above requirements. This reference design includes a high current linear charger, a Super-Capacitor, and a high-current high-efficiency boost converter.

1.1 Key System Specifications

表 1 gives the performance specification of the TI design TIDA-050021. The TPS61088 boost converter can output 3.8 V, 2 A even when the super-capacitor voltage drops to 0.9 V.

表 **1. TIDA050021 Performance Specification**

LINEAR CHARGER INPUT VOLTAGE RANGE	SUPER CAPACITOR VOLTAGE RANGE	BOOST CONVERTER OUTPUT VOLTAGE	BOOST CONVERTER LOAD CURRENT
3.4 V to 4 V	0.9 V to 2.7 V	3.8 V	2-A peak at 100 ms

TIDUEL6 — http://www-s.ti.com/sc/techlit/TIDUEL6
版权 © 2018, Texas Instruments Incorporated

2 System Overview

2.1 Block Diagram

图 1 shows the block diagram of TIDA-050021. It utilizes a super capacitor as the energy storage cell. When the AC mains present, the GSM module is powered by 4-VDC voltage generated from the AC/DC conversion. The super capacitor is charged by a linear charger. When the AC mains brown out, the GSM module is powered by 3.8-VDC voltage generated from the TPS61088 boost converter, which is supplied by the super capacitor.

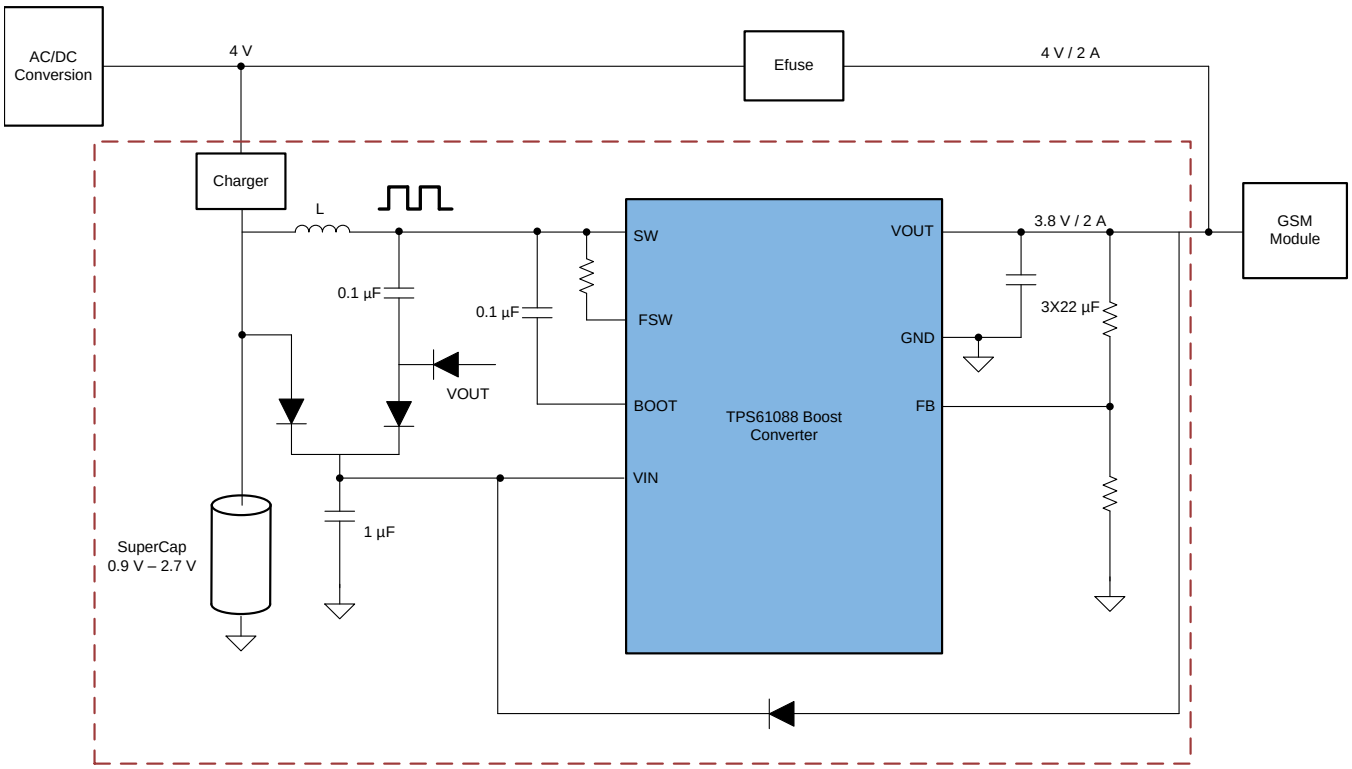


图 1. Block Diagram

2.2 Design Considerations

This reference design uses a charge-pump circuit to make the TPS61088 work properly even under a very low input voltage. By adding a simple charge-pump circuit, the VIN pin voltage of the TPS61088 boost converter is independent of the super-capacitor voltage. The VIN pin voltage is approximately twice the output voltage. Thus, the TPS61088 boost converter works with very high efficiency even when the super-capacitor voltage drops below 1.5 V.

2.3 Highlighted Products

This TI design adopts TPS61088 as the boost converter. TPS61088 is a high-power-density boost converter that can provide more than 10-A peak switching current. Minimum input voltage at the VIN pin is 2.7 V. The VIN pin is an independent IC power supply pin for the internal control circuit. The voltage range of the super capacitor is 0.9 V to 2.7 V. It is too low to make the TPS61088 work properly. Thus, in TIDA-050021 a charge-pump circuit is used to make the VIN pin voltage twice the output voltage, which is much higher than the minimum requirement.

TIDUEL6 — http://www-s.ti.com/sc/techlit/TIDUEL6
版权 © 2018, Texas Instruments Incorporated

2.4 System Design Theory

图 2 shows the charger circuit of TIDA-050021. A linear charger is adopted in this reference design. The benefits of the linear charger are simplicity and low cost. Transistors Q2 and Q3 are added to limit the initial charge current below a certain level, which is about 0.9 A in TIDA-050021. The exist of Q2 and Q3 can also avoid Q1 being damaged in a short-circuit condition.

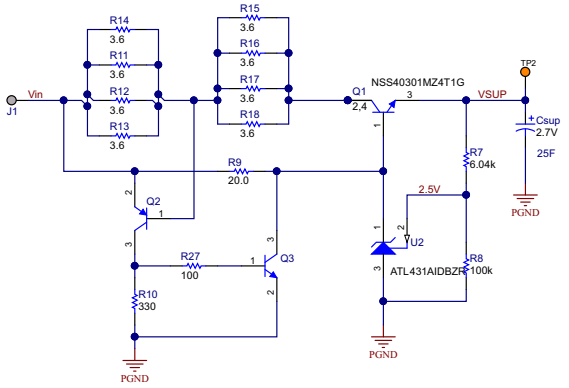


图 2. Super-Capacitor Charge Circuit

图 3 shows the TPS61088 boost converter, which is the main circuit of TIDA-050021. In order to make TPS61088 work in 0.9-V to 2.7-V low input-voltage range, a charge-pump circuit made up of D1, D2 and C17 is added to the VIN pin. Thus, the VIN pin voltage increases to approximately two times the output voltage after start-up. The TPS61088 boost converter works normally regardless of the low input voltage.

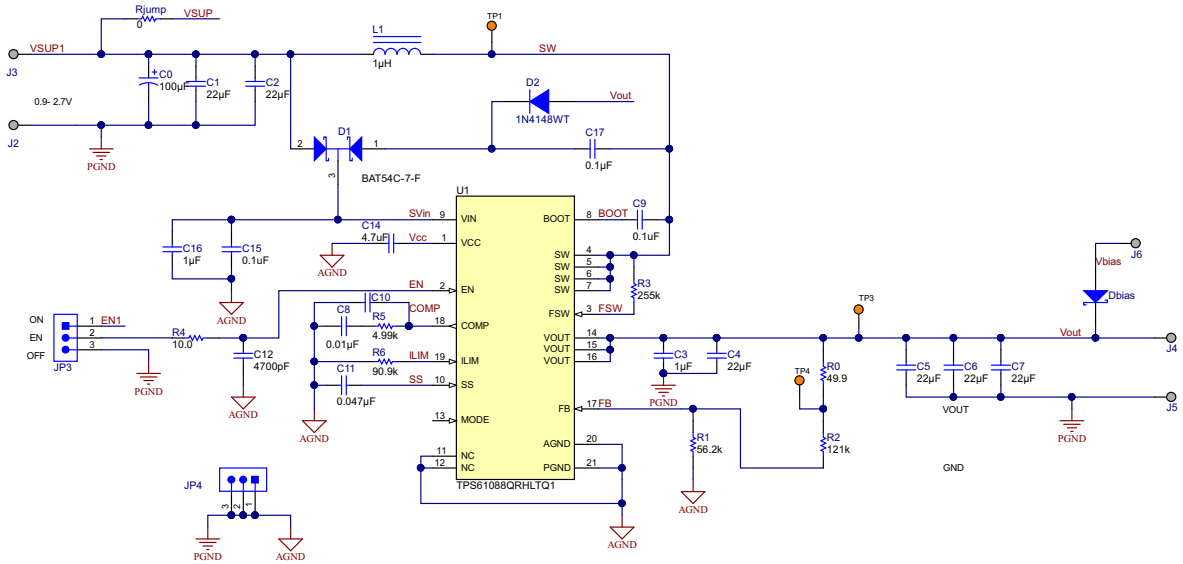


图 3. TPS61088 Boost Converter

图 4 shows the operation sequence of TIDA-050021. At time t0, AC mains ready, the super capacitor is charged by a 4-VDC voltage generated from the AC mains. The GSM module is also powered by this 4-VDC voltage. At time t1, the super capacitor voltage is charged to a level higher than 2.2 V, TPS61088 boost converter is enabled, and the GSM module is still powered by the 4-VDC voltage. At time t2, AC mains brown out, and the GSM module is powered by the output of the TPS61088 boost converter. At time t3, the super capacitor voltage drops to a very low level approximately 0.5 V, and TPS61088 boost converter is disabled.

TIDUEL6 — http://www-s.ti.com/sc/techlit/TIDUEL6
版权 © 2018, Texas Instruments Incorporated

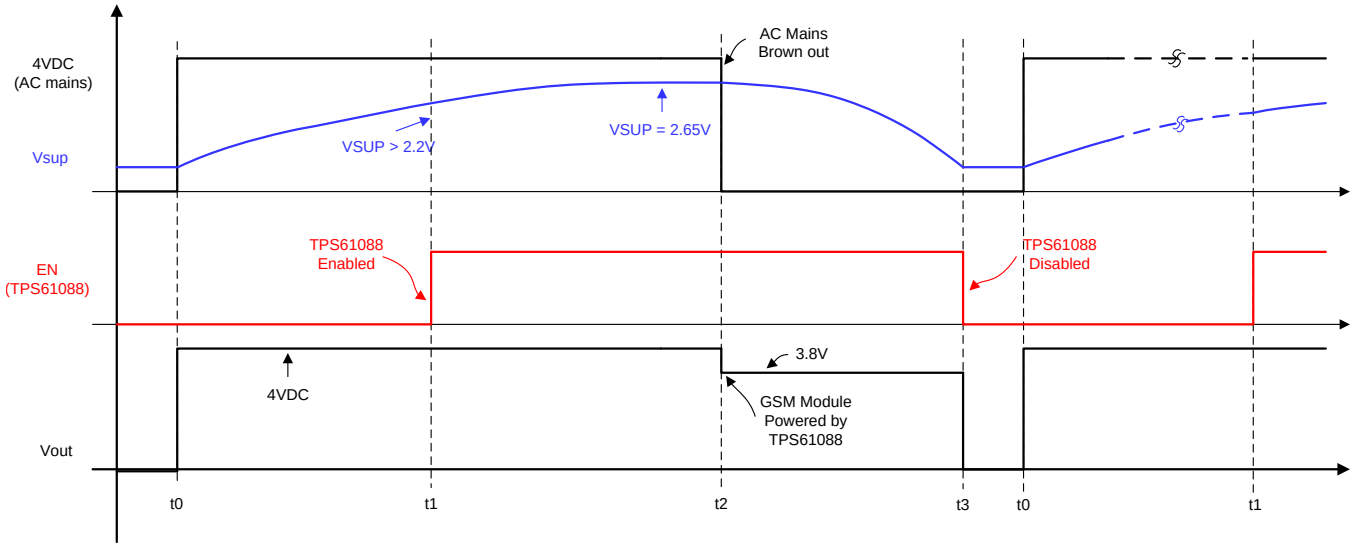


图 4. Operation Sequence

TIDUEL6 — http://www-s.ti.com/sc/techlit/TIDUEL6
版权 © 2018, Texas Instruments Incorporated

3 Hardware, Software, Testing Requirements, and Test Results

3.1 Required Hardware

3.1.1 Hardware

This reference design uses following hardware to do the measurement.

- Two DC Power Supply
- One E-Load
- One Digital Oscilloscope

3.2 Testing and Results

3.2.1 Test Setup

This section describes how to properly connect and set up the TIDA-050021.

- Connect the positive terminal of DC power supply one to J6 (Vbias), and its GND terminal to J5 (GND).
- Connect the positive terminal of DC power supply two to J1 (VIN), and its GND terminal to J2 (GND).
- Connect the positive input of the E-load to J4(VOUT), and its GND input to J5 (GND).
- Keep the DC power supplies and E-load off. Set the DC power supply one to 4.5 V, set the DC power supply two to 4 V, and set the E-load to 2 A.
- Turn on DC power supply two, then turn on DC power supply one and the E-load.

版权 © 2018, Texas Instruments Incorporated

3.2.2 Test Results

The following shows the test results of this reference design.

3.2.2.1 Linear Charger Operating Waveform

图 5 shows the voltage and the current across the 25-F super capacitor during charge-up. The initial charge current is well limited. The super-capacitor voltage rises from 0.4 V to 2.65 V within approximately 80 seconds.

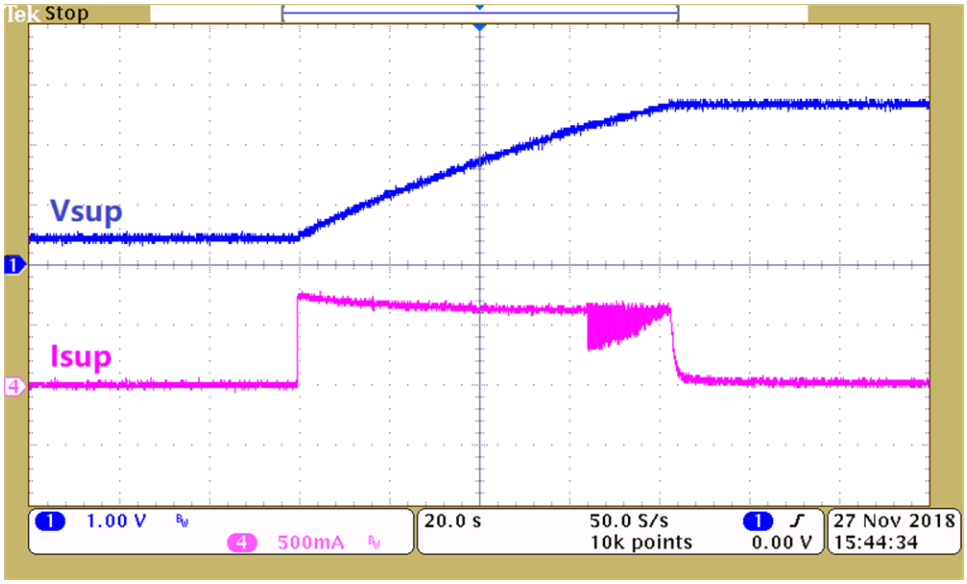


图 5. Charge Voltage and Charge Current Across the 25-F Super Capacitor

3.2.2.2 Working Sequence

图 6 and 图 7 show the working sequence of the TI design TIDA-050021. The test result matches the paper analysis. The super capacitor voltage can last a total of approximately 16 seconds when the GSM module consumes 3.8 V, 1 A and around approximately 8 seconds when the GSM module consumes 3.8 V, 2 A.

版权 © 2018, Texas Instruments Incorporated

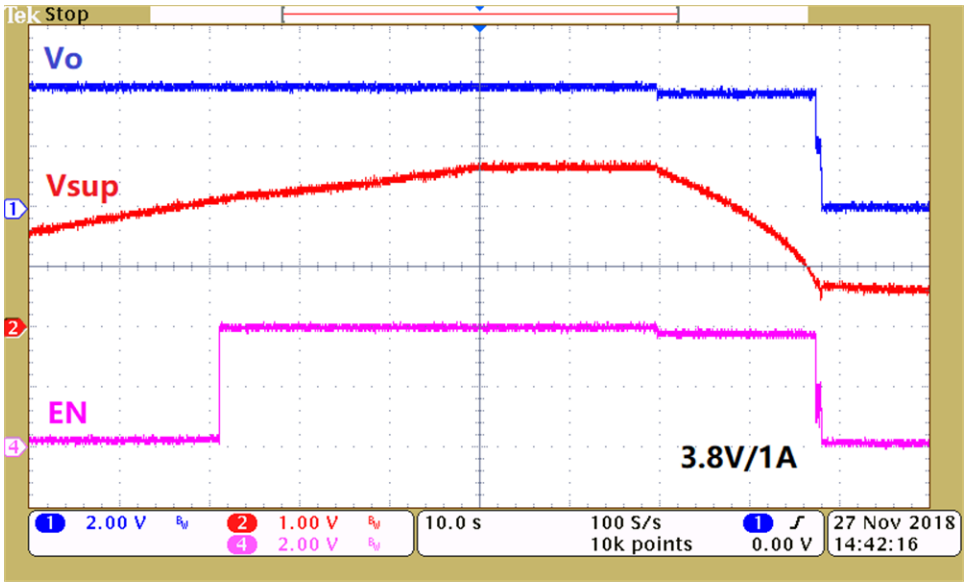


图 6. Working Sequence at V_O = 3.8 V, I_O=1A

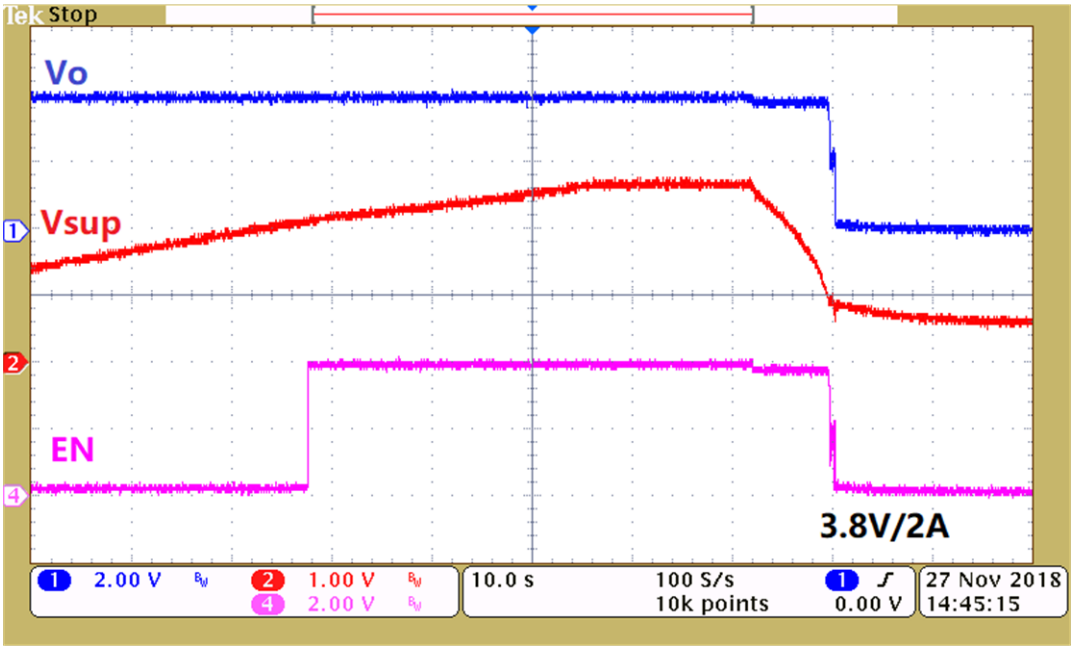


图 7. Working Sequence at V_O = 3.8 V, I_O = 2 A

3.2.2.3 Boost Converter Operaing Waveform

图 8 and 图 9 show the SW and VIN pins waveform under different super capacitor voltage. The voltage of the VIN pin stays at 6.4 V regardless of the super capacitor voltage. Thus, the TPS61088 boost converter is stable under a very low input voltage.

TIDUEL6 — http://www-s.ti.com/sc/techlit/TIDUEL6
版权 © 2018, Texas Instruments Incorporated

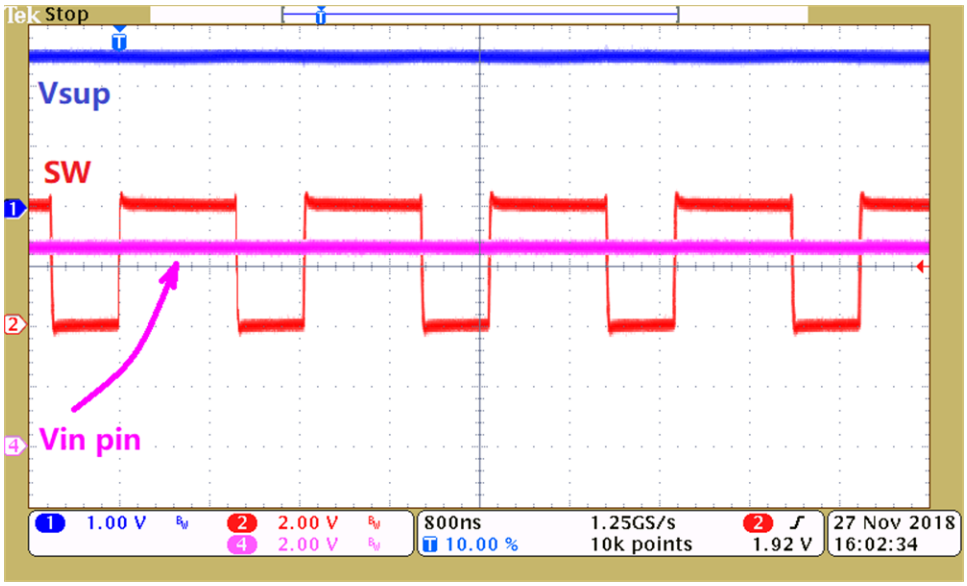


图 8. SW and VIN Pin Waveform When Vsup = 2.5 V

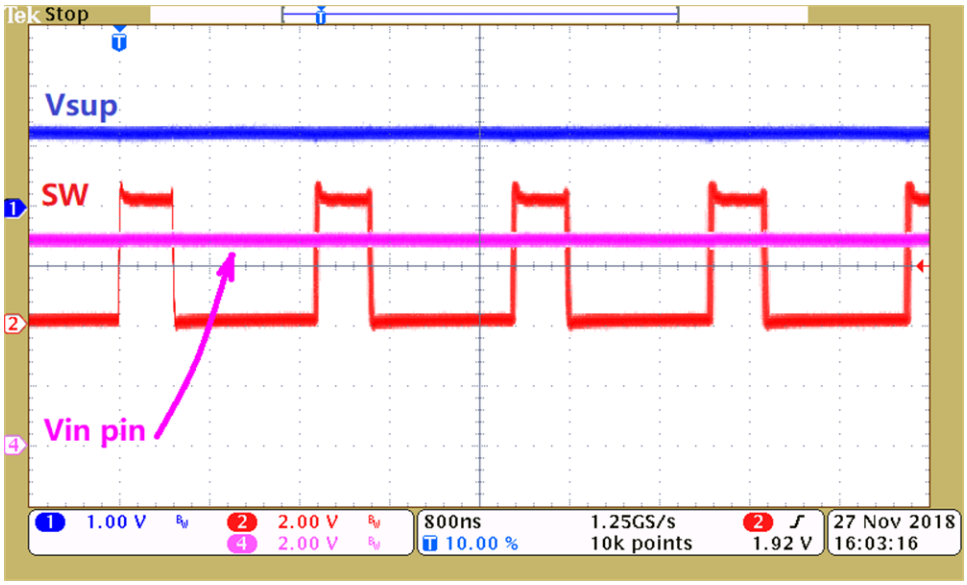


图 9. SW and VIN Pin Waveform When Vsup = 1.2 V

TIDUEL6 — http://www-s.ti.com/sc/techlit/TIDUEL6
版权 © 2018, Texas Instruments Incorporated

4 Design Files

4.1 Schematics

To download the schematics, see the design files at TIDA-050021.

4.2 Bill of Materials

To download the bill of materials (BOM), see the design files at TIDA-050021.

4.3 PCB Layout Recommendations

4.3.1 Layout Prints

To download the layer plots, see the design files at TIDA-050021.

4.4 Altium Project

To download the Altium Designer® project files, see the design files at TIDA-050021.

4.5 Gerber Files

To download the Gerber files, see the design files at TIDA-050021.

4.6 Assembly Drawings

To download the assembly drawings, see the design files at TIDA-050021.

5 Related Documentation

1. *TPS61088 10-A Fully-Integrated Synchronous Boost Converter*
2. *Power Supply Reference Design for GPRS Modems using LiSoCL2 Batteries*

5.1 商标

E2E is a trademark of Texas Instruments.
Altium Designer is a registered trademark of Altium LLC or its affiliated companies.
All other trademarks are the property of their respective owners.

5.2 Third-Party Products Disclaimer

TI'S PUBLICATION OF INFORMATION REGARDING THIRD-PARTY PRODUCTS OR SERVICES DOES NOT CONSTITUTE AN ENDORSEMENT REGARDING THE SUITABILITY OF SUCH PRODUCTS OR SERVICES OR A WARRANTY, REPRESENTATION OR ENDORSEMENT OF SUCH PRODUCTS OR SERVICES, EITHER ALONE OR IN COMBINATION WITH ANY TI PRODUCT OR SERVICE.

TIDUEL6 — http://www-s.ti.com/sc/techlit/TIDUEL6
版权 © 2018, Texas Instruments Incorporated

重要声明和免责声明

TI 均以“原样”提供技术性及可靠性数据（包括数据表）、设计资源（包括参考设计）、应用或其他设计建议、网络工具、安全信息和其他资源，不保证其中不含任何瑕疵，且不做任何明示或暗示的担保，包括但不限于对适销性、适合某特定用途或不侵犯任何第三方知识产权的暗示担保。

所述资源可供专业开发人员应用TI 产品进行设计使用。您将对以下行为独自承担全部责任：(1) 针对您的应用选择合适的TI 产品；(2) 设计、验证并测试您的应用；(3) 确保您的应用满足相应标准以及任何其他安全、安保或其他要求。所述资源如有变更，恕不另行通知。TI 对您使用所述资源的授权仅限于开发资源所涉及TI 产品的相关应用。除此之外不得复制或展示所述资源，也不提供其它TI或任何第三方的知识产权授权许可。如因使用所述资源而产生任何索赔、赔偿、成本、损失及债务等，TI对此概不负责，并且您须赔偿由此对TI 及其代表造成的损害。

TI 所提供产品均受TI 的销售条款 (http://www.ti.com.cn/zh-cn/legal/termsofsale.html) 以及ti.com.cn上或随附TI产品提供的其他可适用条款的约束。TI提供所述资源并不扩展或以其他方式更改TI 针对TI 产品所发布的可适用的担保范围或担保免责声明。

邮寄地址：上海市浦东新区世纪大道 1568 号中建大厦 32 楼，邮政编码：200122
Copyright © 2019 德州仪器半导体技术（上海）有限公司

重要声明和免责声明

TI 均以“原样”提供技术性及可靠性数据（包括数据表）、设计资源（包括参考设计）、应用或其他设计建议、网络工具、安全信息和其他资源，不保证其中不含任何瑕疵，且不做任何明示或暗示的担保，包括但不限于对适销性、适合某特定用途或不侵犯任何第三方知识产权的暗示担保。

所述资源可供专业开发人员应用TI 产品进行设计使用。您将对以下行为独自承担全部责任：(1) 针对您的应用选择合适的TI 产品；(2) 设计、验证并测试您的应用；(3) 确保您的应用满足相应标准以及任何其他安全、安保或其他要求。所述资源如有变更，恕不另行通知。TI 对您使用所述资源的授权仅限于开发资源所涉及TI 产品的相关应用。除此之外不得复制或展示所述资源，也不提供其它TI或任何第三方的知识产权授权许可。如因使用所述资源而产生任何索赔、赔偿、成本、损失及债务等，TI对此概不负责，并且您须赔偿由此对TI 及其代表造成的损害。

TI 所提供产品均受TI 的销售条款 (http://www.ti.com.cn/zh-cn/legal/termsofsale.html) 以及ti.com.cn上或随附TI产品提供的其他可适用条款的约束。TI提供所述资源并不扩展或以其他方式更改TI 针对TI 产品所发布的可适用的担保范围或担保免责声明。

邮寄地址：上海市浦东新区世纪大道 1568 号中建大厦 32 楼，邮政编码：200122
Copyright © 2019 德州仪器半导体技术（上海）有限公司