TI Designs: TIDA-050021
GSM Module Back-Up Power Reference Design for Smart Meters

TEXAS INSTRUMENTS

Description

This reference design delivers a back-up power reference design for the GSM module. By adding a simple charge-pump circuit, this solution supports 3.8-V, 2-A output power even when the super-capacitor voltage drops to 1 V. This allows the energy stored in the super capacitor to be used to the maximum.

Resources

TIDA-050021	Design Folder
TPS61088	Product Folder

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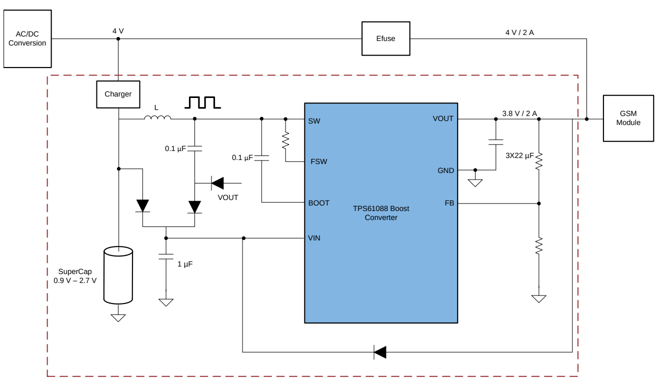
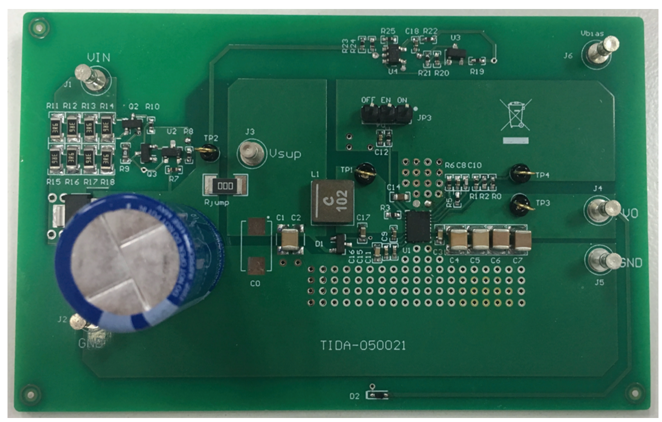
Features

- Super-Capacitor Voltage Range: 0.9 V to 2.7 V
- Maximum Output Power: 3.8 V, 2 A
- High Efficiency
- Small Size
- Approximately 0.8-A High-Current Linear Charger

Applications

- Electricity Meter
- Gas Meter
- Water Meter





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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

Table 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.

Table 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

2 System Overview

2.1 Block Diagram

Figure 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.

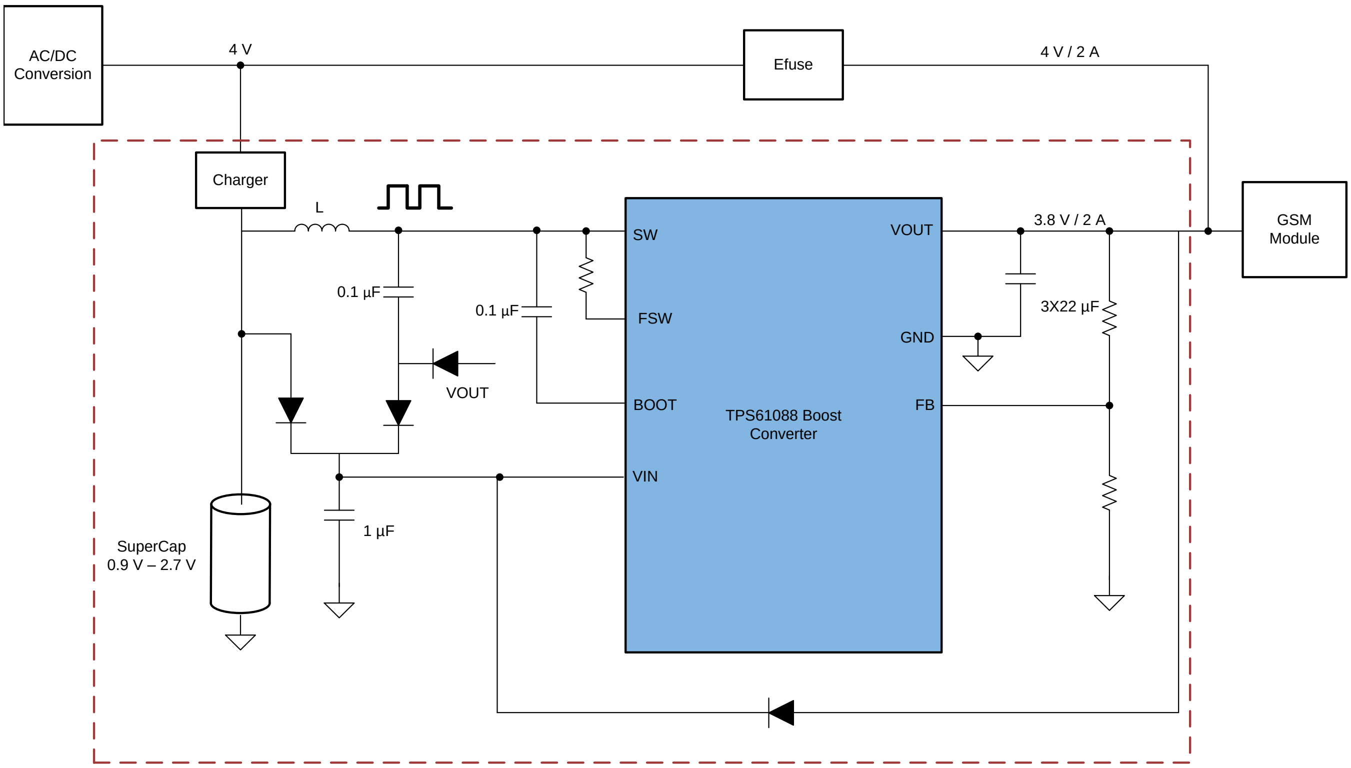

Figure 1. Block Diagram

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.

2.4 System Design Theory

Figure 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.

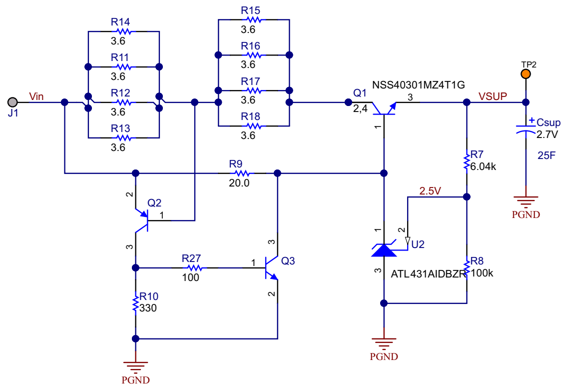

Figure 2. Super-Capacitor Charge Circuit

Figure 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.

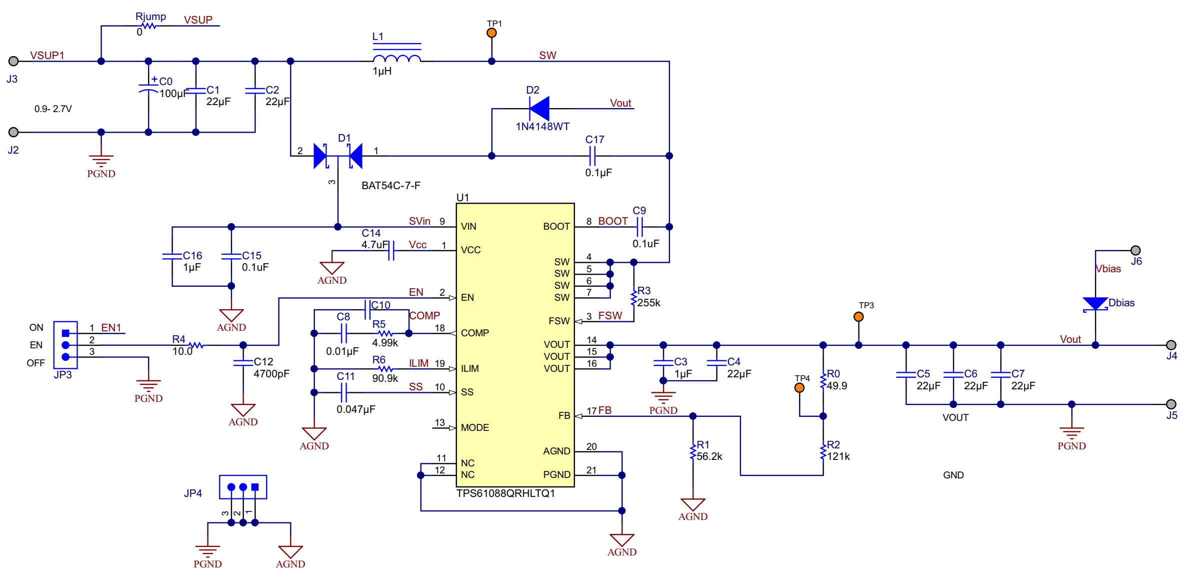

Figure 3. TPS61088 Boost Converter

Figure 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.

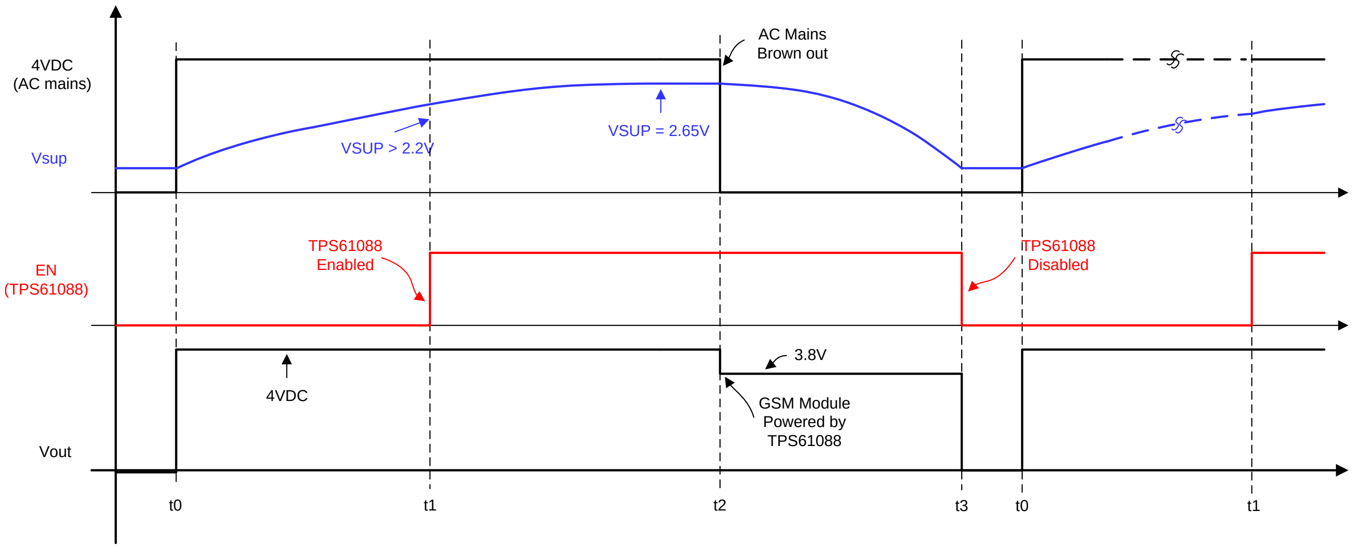

Figure 4. Operation Sequence

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.

3.2.2 Test Results

The following shows the test results of this reference design.

3.2.2.1 Linear Charger Operating Waveform

Figure 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.

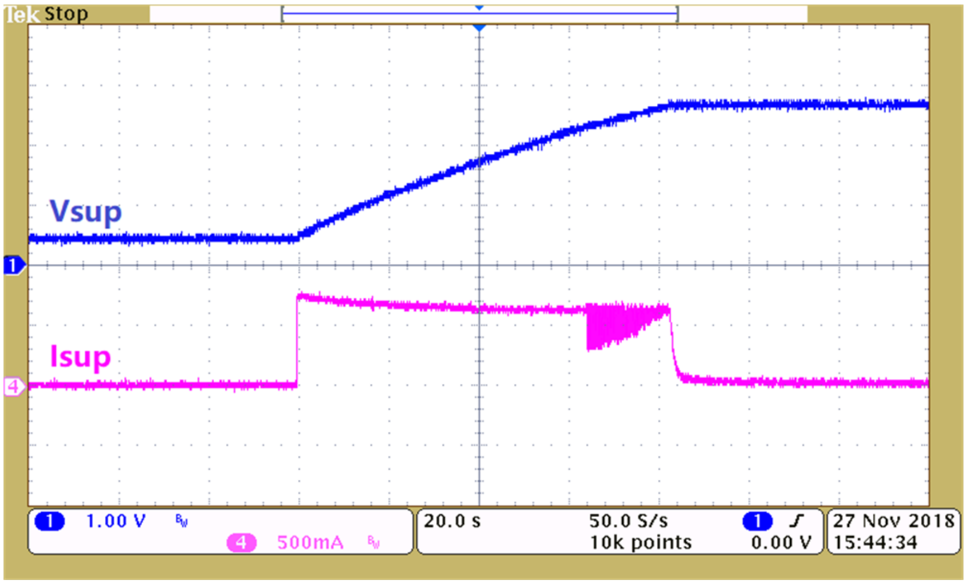

Figure 5. Charge Voltage and Charge Current Across the 25-F Super Capacitor

3.2.2.2 Working Sequence

Figure 6 and Figure 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.

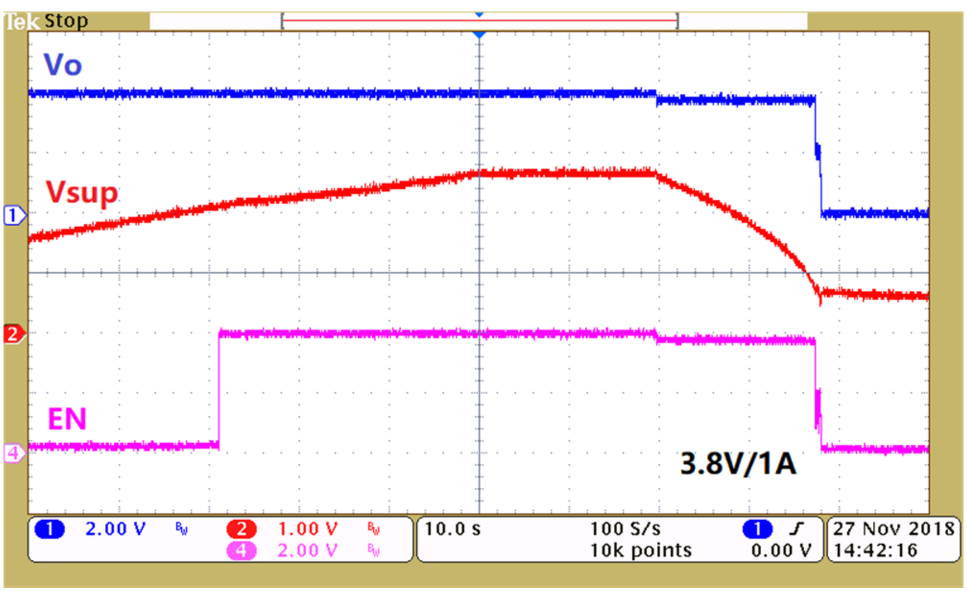

Figure 6. Working Sequence at V_O = 3.8 V, I_O=1A

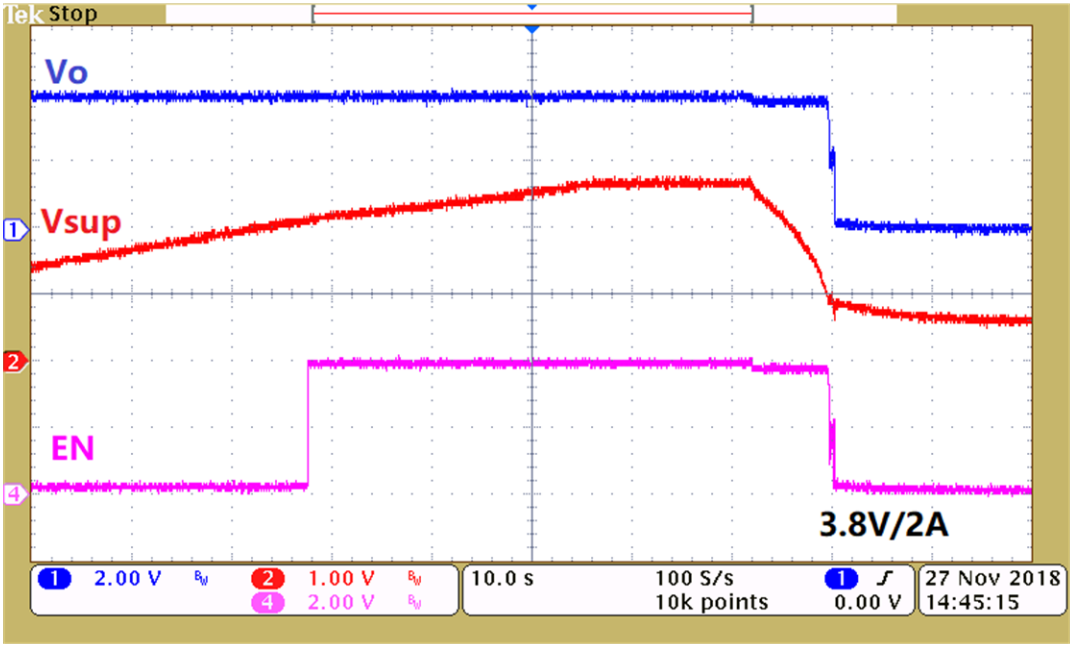

Figure 7. Working Sequence at V_O = 3.8 V, I_O = 2 A

3.2.2.3 *Boost Converter Operaing Waveform*

Figure 8 and Figure 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.

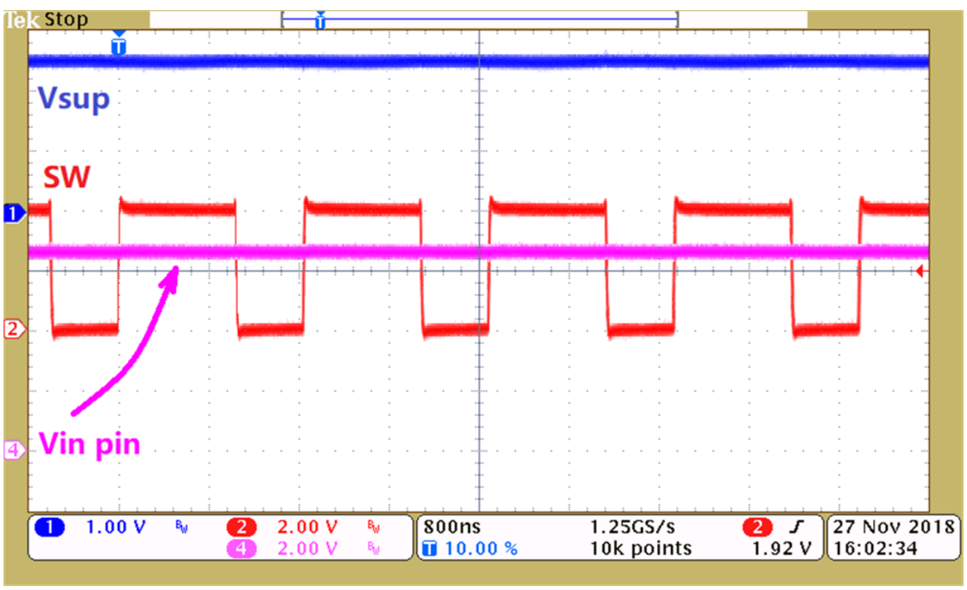

Figure 8. SW and VIN Pin Waveform When Vsup = 2.5 V

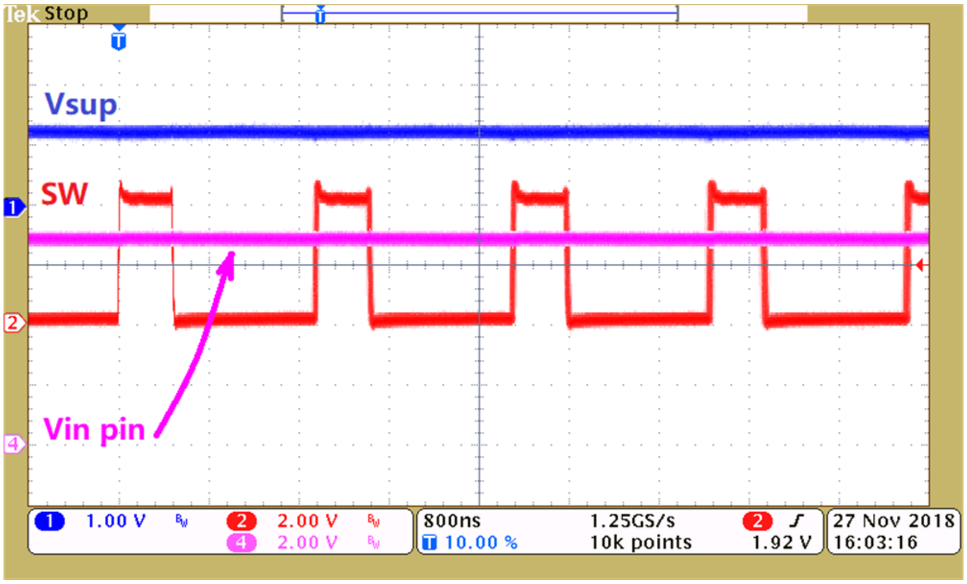

Figure 9. SW and VIN Pin Waveform When Vsup = 1.2 V

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*

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