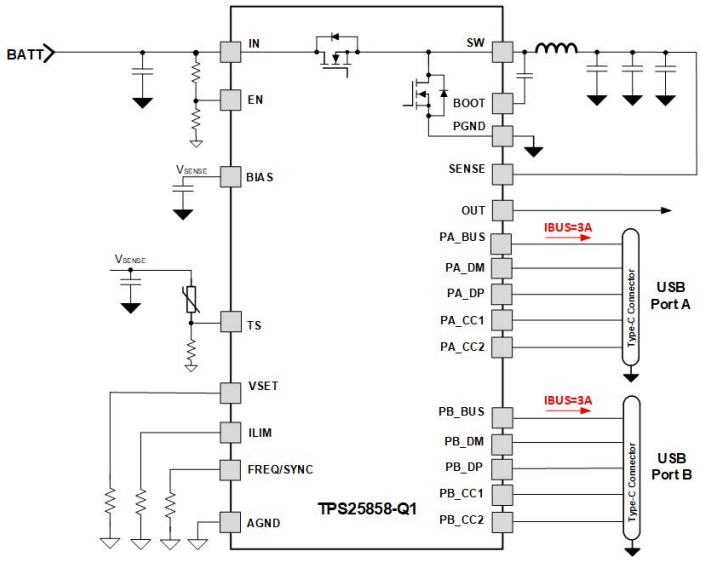
Test Report: PMP40731

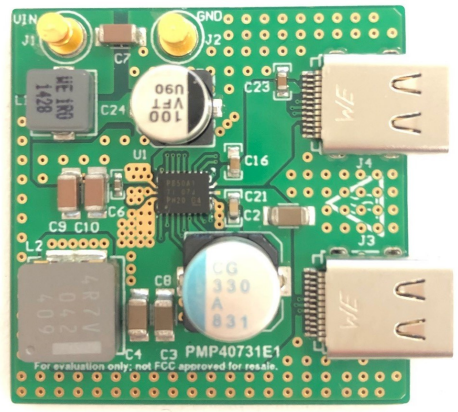
Small-Size and Thermal-Optimization Rated 30-W Automotive Dual USB Type-C® Charger Reference Design

Description

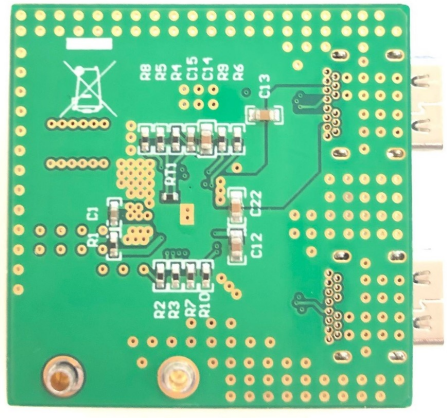
This reference design is a small size and thermal optimization design for automotive USB Type-C® charger with dual 15-W output. The TPS25858-Q1 device is a cost-competitive DC/DC regulator and dual USB Type-C® port controller. The efficiency is 92.83% at dual 15-W output. Programmable cable droop compensation helps portable devices charge at optimum current and voltage under heavy loads. A negative temperature coefficient (NTC) thermistor is implemented for intelligent thermal management to reprogram the output voltage in overtemperature condition.



Block Diagram



Top Photo



Bottom Photo

1 Test Prerequisites

1.1 Design Requirements

Table 1-1. Design Requirements

Parameter	Specifications
Input Voltage	13.5 V_{DC}
PA_BUS Output Voltage	5.17 V_{DC}
PA_BUS Maximum Output Current	3 A
PB_BUS Output Voltage	5.17 V_{DC}
PB_BUS Maximum Output Current	3 A
Switching Frequency	400 kHz

1.2 Required Equipment

- Multimeter (Voltage): Fluke 287C
- Multimeter (current): Fluke 287C
- DC Source: Chroma 62006P-100-25
- E-Load: Chroma 63105A module
- Oscilloscope: Tektronix DPO4104B
- Electrical Thermography: Fluke TiS55
- Thermal Data Acquisition: Agilent 34970A
- Temperature Chamber: ESPEC BTZ-175E

1.3 Dimensions

The dimension of this board is 35 mm (length) × 35 mm (width).

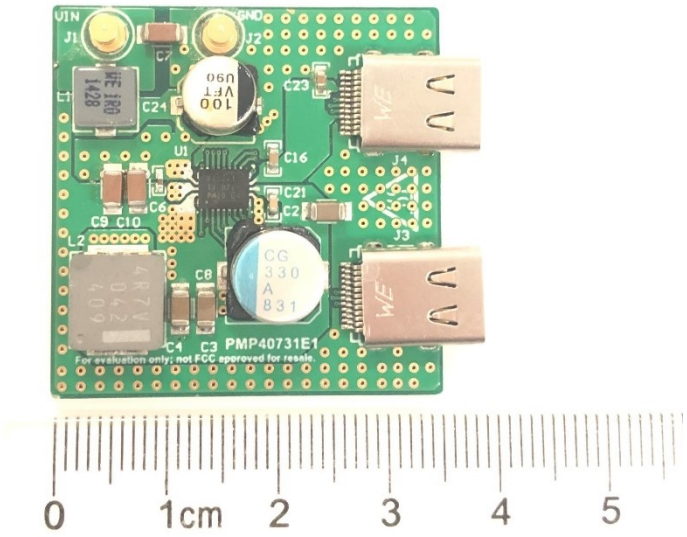


Figure 1-1. Dimension

2 Testing and Results

2.1 Efficiency Graphs

Efficiency is shown in the following figure.

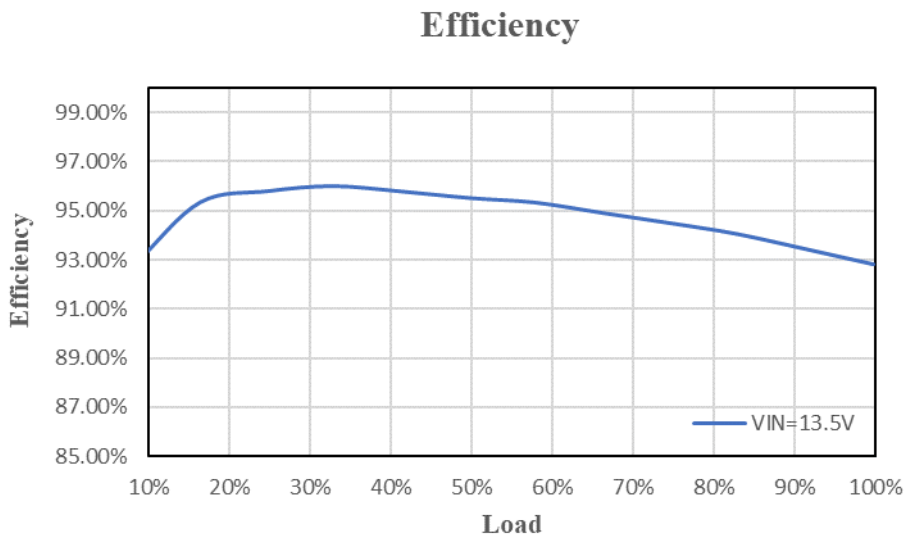


Figure 2-1. Efficiency Graph

2.2 Efficiency Data

Efficiency data is shown in the following table.

VIN (V)	IIN (A)	VPA_BUS (V)	IPA_BUS (A)	VPB_BUS (V)	IPB_BUS (A)	Eff
13.499	0.0290	5.1586	0.0000	5.1586	0.0000	0.00%
13.502	0.2270	5.1616	0.2492	5.1616	0.2484	83.80%
13.502	0.4275	5.1678	0.4989	5.1678	0.4981	89.26%
13.507	0.6268	5.1726	0.7484	5.1727	0.7477	91.41%
13.500	0.8279	5.1771	0.9983	5.1772	0.9974	92.44%
13.503	1.0308	5.1818	1.2483	5.1819	1.2499	93.01%
13.505	1.2345	5.1868	1.4975	5.1870	1.4999	93.25%
13.499	1.4413	5.1922	1.7474	5.1923	1.7495	93.32%
13.500	1.6483	5.1976	1.9970	5.1980	1.9992	93.35%
13.500	1.8588	5.2028	2.2470	5.2035	2.2489	93.22%
13.503	2.0742	5.2063	2.4994	5.2070	2.5016	92.97%
13.496	2.2874	5.2023	2.7491	5.2030	2.7516	92.70%
13.498	2.5020	5.1980	2.9992	5.1987	3.0016	92.37%

2.3 Load Regulation

Load regulation is shown in the following figure.

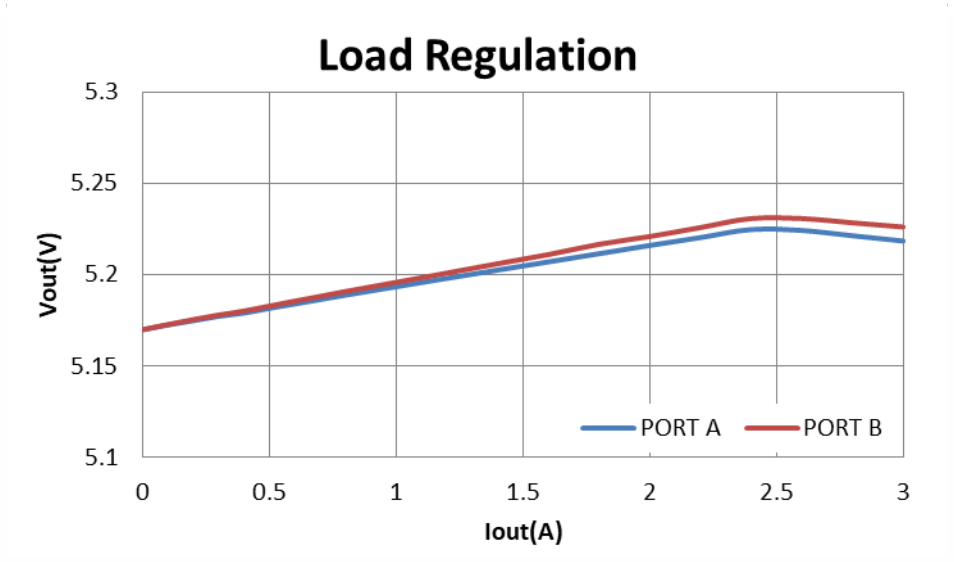


Figure 2-2. Load Regulation

2.4 Thermal Images

Thermal images are shown in the following figures. The ambient temperature is 25°C, and the thermal images were taken with all outputs at a full load of 3 A. The controller was operated for approximately 2 hours before thermal images were taken to ensure thermal steady state was reached.

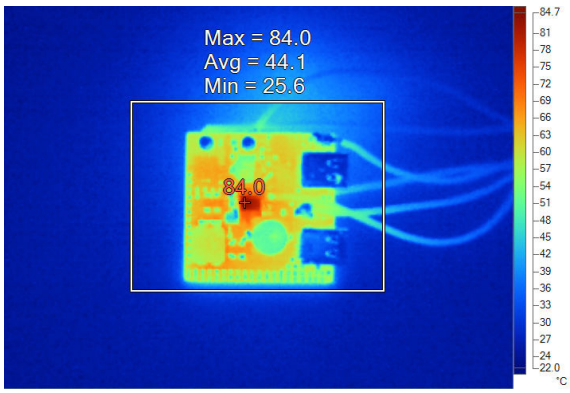


Figure 2-3. Top Side

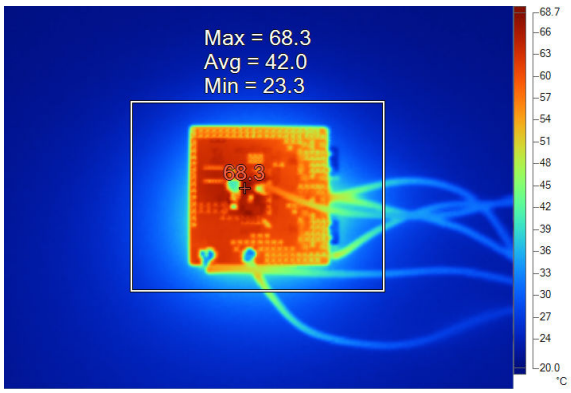
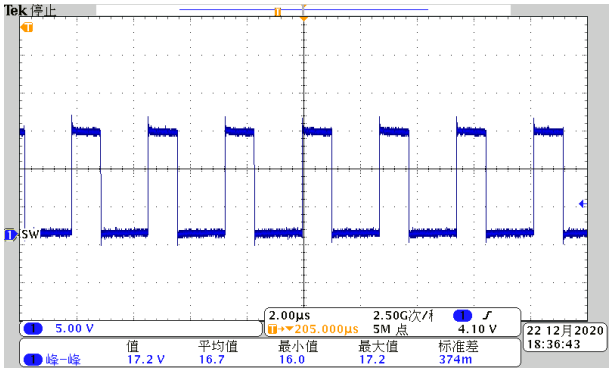


Figure 2-4. Bottom Side

3 Waveforms

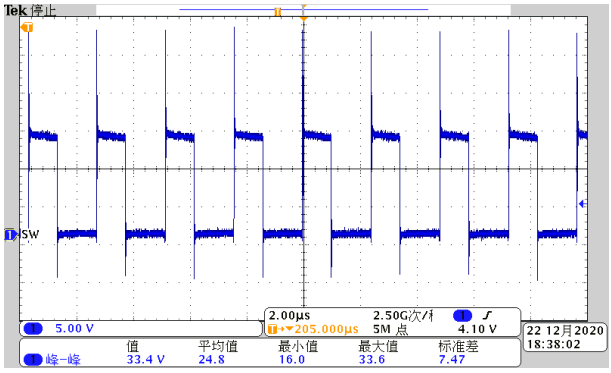
3.1 Switching

Switching behavior is shown in the following figures.



CH1: V_{SW}

Figure 3-1. 13.5-V Input, 5.17-V No-Load

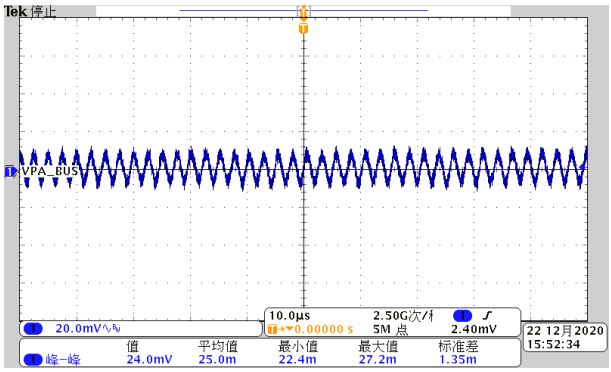


CH1: V_{SW}

Figure 3-2. 13.5-V Input, 5.17-V Full Load

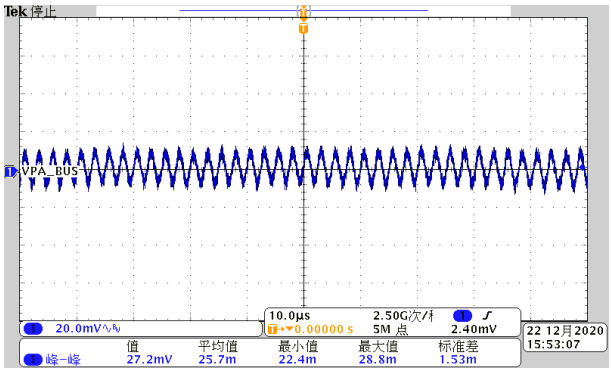
3.2 Output Voltage Ripple

Output voltage ripple is shown in the following figures.



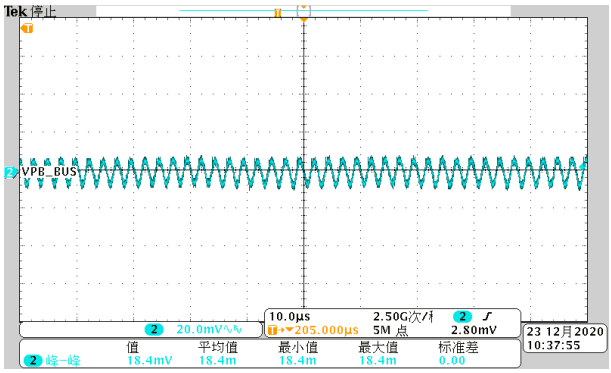
CH1: V_{PA_BUS}

Figure 3-3. Port A: 13.5-V Input, 5.17-V No-Load



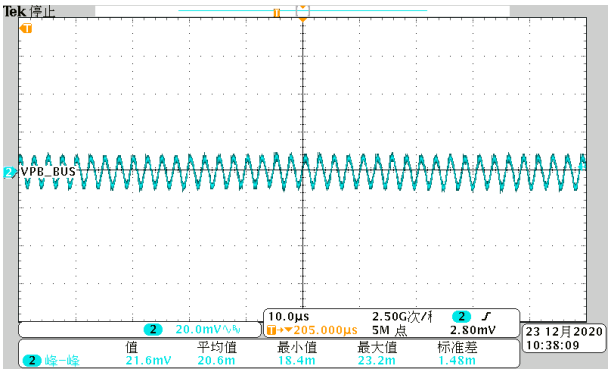
CH1: V_{PA_BUS}

Figure 3-4. 13.5-V Input, 5.17-V 3-A Load



CH2: V_{PB_BUS}

Figure 3-5. 13.5-V Input, 5.17-V No Load

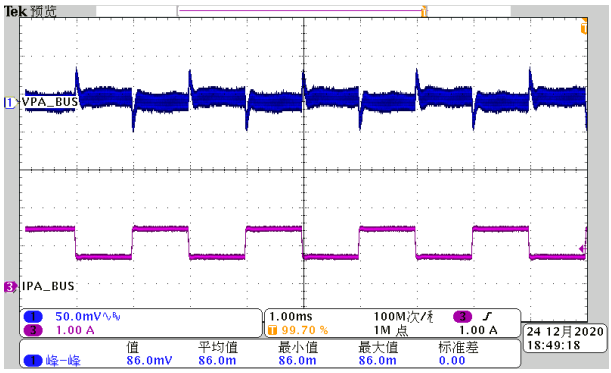


CH2: V_{PB_BUS}

Figure 3-6. 13.5-V Input, 5.17-V 3-A Load

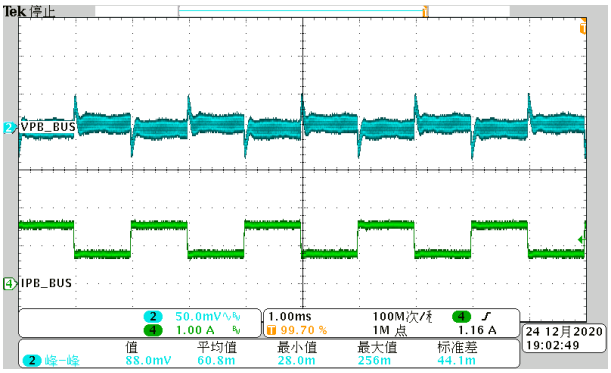
3.3 Load Transients

The load transient response is shown in the following figures. The slew rate is set to 2.5 A/µs for the test.



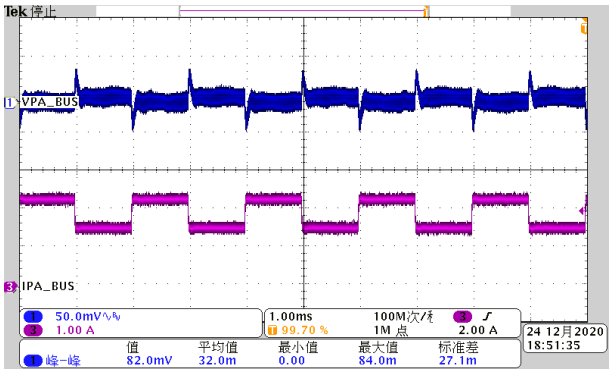
CH1: V_{PA_BUS} CH3: I_{PA_BUS}

Figure 3-7. Port A: 13.5-V Input, 0.75 A→1.5 A



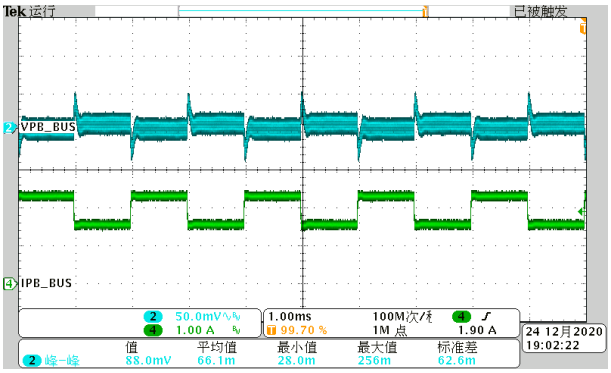
CH2: V_{PB_BUS} CH4: I_{PB_BUS}

Figure 3-8. Port B: 13.5-V Input, 0.75 A→1.5 A



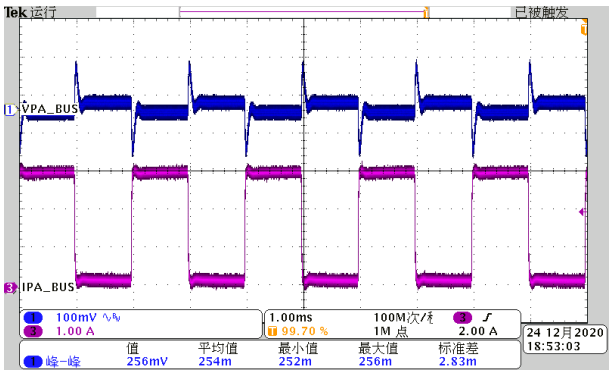
CH1: V_{PA_BUS} CH3: I_{PA_BUS}

Figure 3-9. Port A: 13.5-V Input, 1.5 A→2.25 A



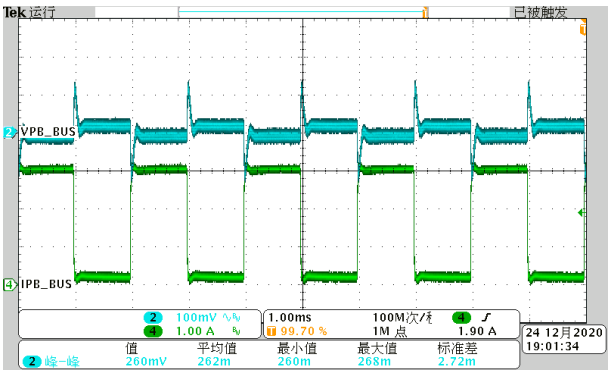
CH2: V_{PB_BUS} CH4: I_{PB_BUS}

Figure 3-10. Port B: 13.5-V Input, 1.5 A→2.25 A



CH1: V_{PA_BUS} CH3: I_{PA_BUS}

Figure 3-11. Port A: 13.5-V Input, 0.15 A→3 A

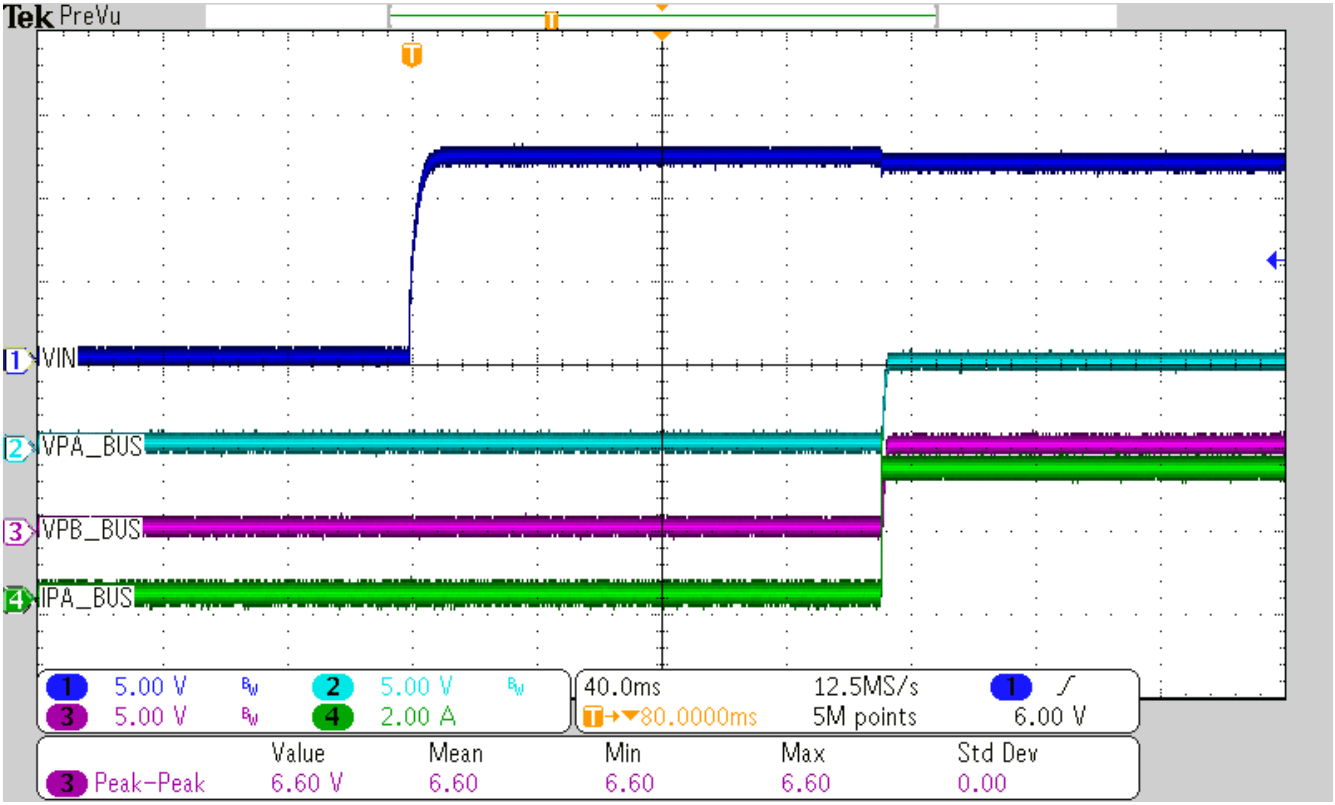


CH2: V_{PB_BUS} CH4: I_{PB_BUS}

Figure 3-12. Port B: 13.5-V Input, 0.15 A→3 A

3.4 Start-up Sequence

Start-up behavior is shown in the following figure.

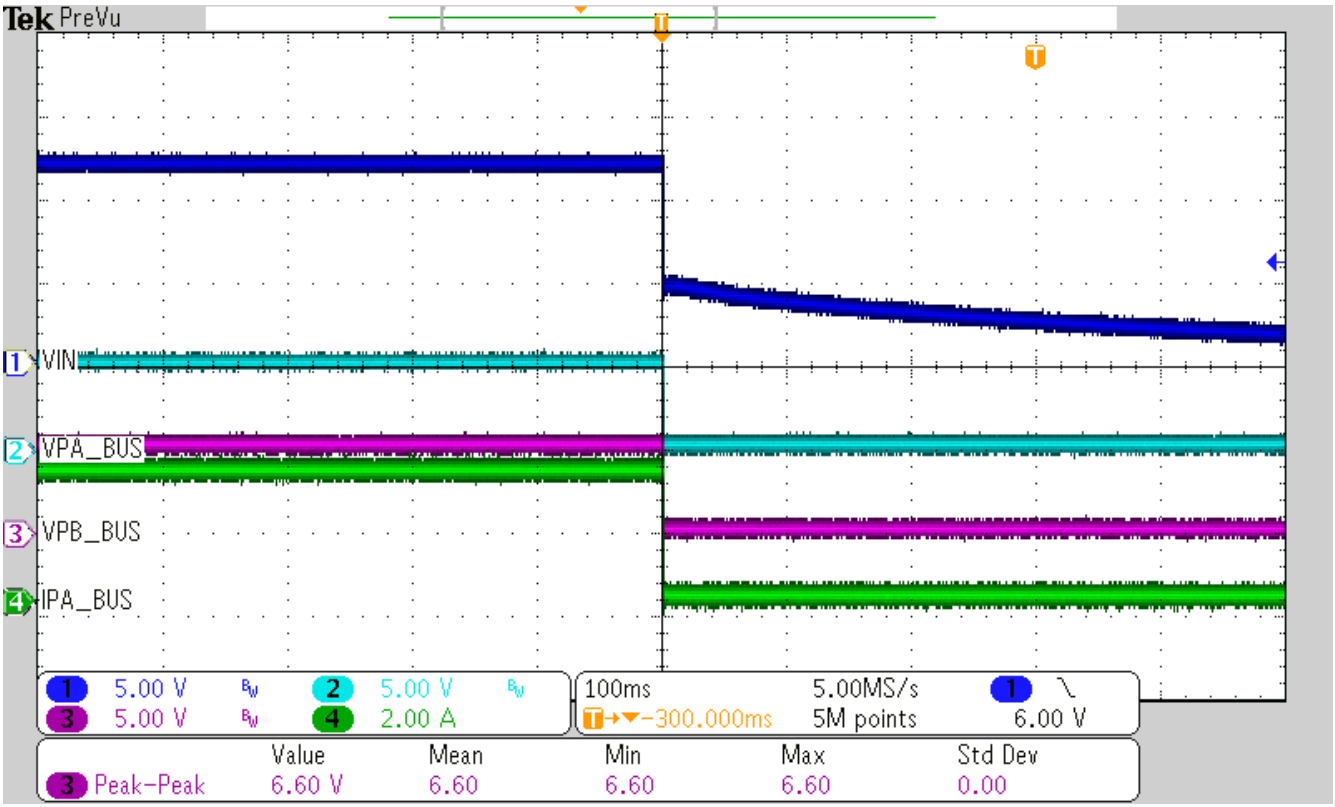


CH1: V_{IN} CH2: V_{PA_BUS} CH3: V_{PB_BUS} CH4: I_{PA_BUS}

Figure 3-13. Power on

3.5 Undervoltage Protection

Undervoltage protection is shown in the following figure.

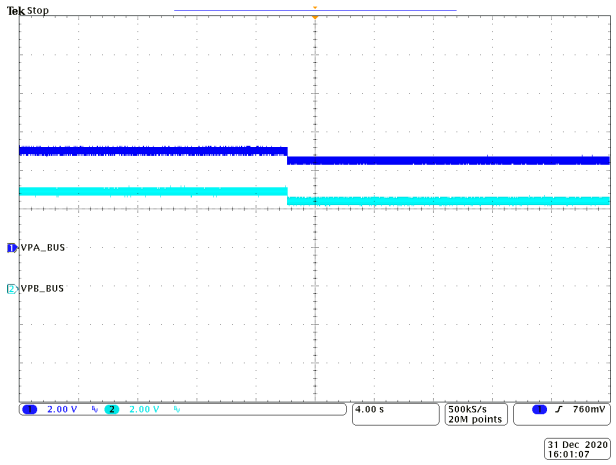


CH1: V_{IN} CH2: V_{PA_BUS} CH3: V_{PB_BUS} CH4: I_{PA_BUS}

Figure 3-14. Power off

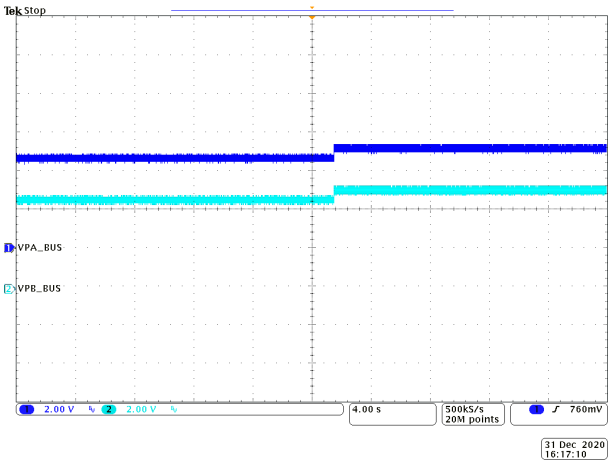
3.6 Thermal Management

The waveforms of thermal management are shown in following images. The temperature chamber is used to control the actual chip temperature, The thermal management function is triggered when the NTC temperature reaches 109.1°C (the chip temperature reaches 119.4°C), and the output voltage will reduce to 4.77 V. The thermal management function is turned off when the NTC resistor temperature drops to 93°C, and the output voltage will increase to 5.17 V.



CH1: V_{PA_BUS} CH2: V_{PB_BUS}

Figure 3-15. Thermal Management Function Turn on



CH1: V_{PA_BUS} CH2: V_{PB_BUS}

Figure 3-16. Thermal Management Function Turn off

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATA SHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES “AS IS” AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI’s products are provided subject to TI’s Terms of Sale or other applicable terms available either on ti.com or provided in conjunction with such TI products. TI’s provision of these resources does not expand or otherwise alter TI’s applicable warranties or warranty disclaimers for TI products.

TI objects to and rejects any additional or different terms you may have proposed.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265