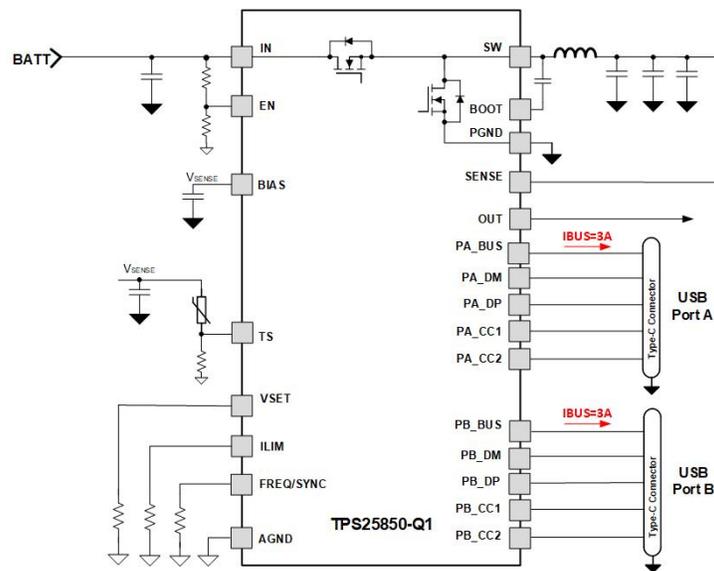


Small Size, Rated 30-W Automotive Dual USB Type-C™ Charger Reference Design

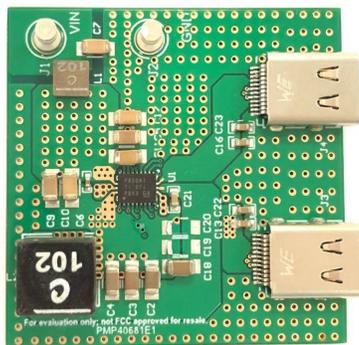


Description

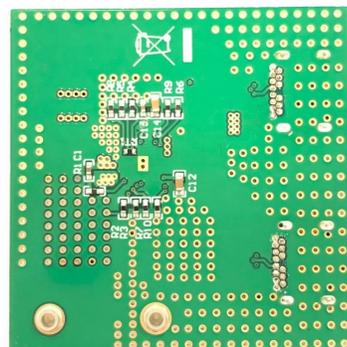
This reference design is a small size design (40 mm × 40 mm) for automotive USB Type-C™ charger with dual 15-W output. The TPS25850-Q1 is used as a DC/DC regulator and port controller. The efficiency of solution is 92.37% at dual 15-W output. Programmable cable droop compensation helps portable devices charge at optimum current and voltage under heavy loads, and a negative temperature coefficient (NTC) thermistor is implemented for intelligent thermal management to reprogram the output voltage in over-temperature condition.



Block Diagram



Top Photo



Bottom Photo

1 Test Prerequisites

1.1 Design Requirements

Table 1-1. Design Requirements

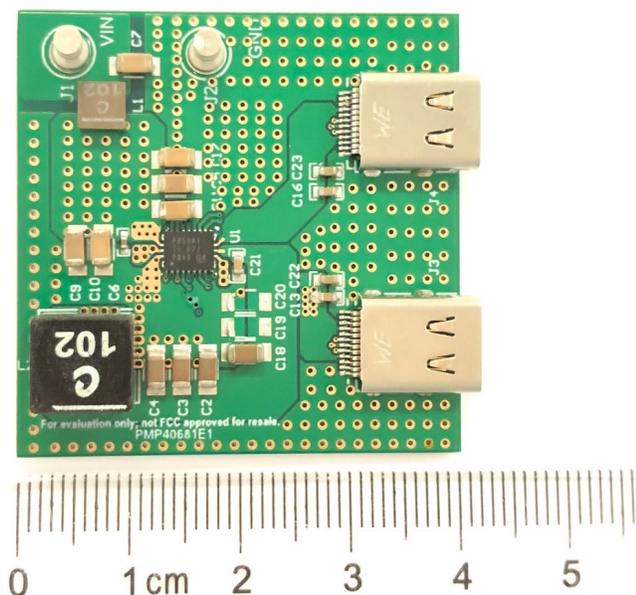
Parameter	Specifications
Input Voltage	13.5 Vdc
PA_BUS Output Voltage	5.17 Vdc
PA_BUS Maximum Output Current	3 A
PB_BUS Output Voltage	5.17 Vdc
PB_BUS Maximum Output Current	3 A
Switching Frequency	2.2MHz

1.2 Required Equipment

- Multi-meter (current): Fluke 287C
- Multi-meter (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 40mm (length)*40mm (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.

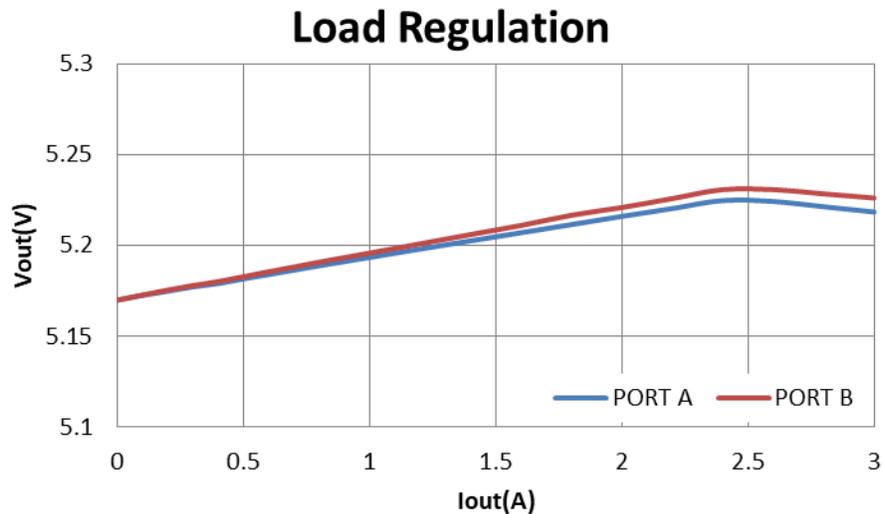


Figure 2-2. Load Regulation

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.

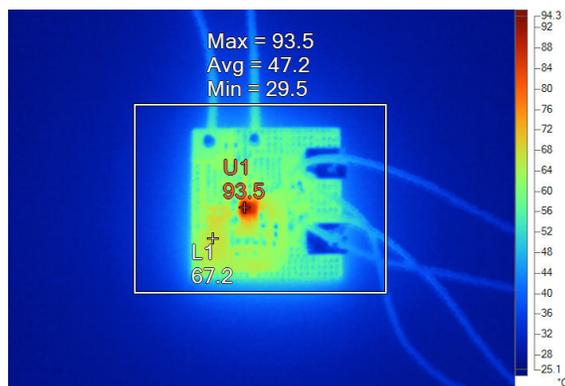


Figure 2-3. Top side

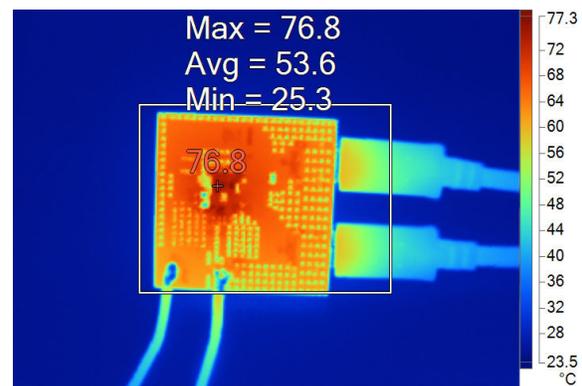
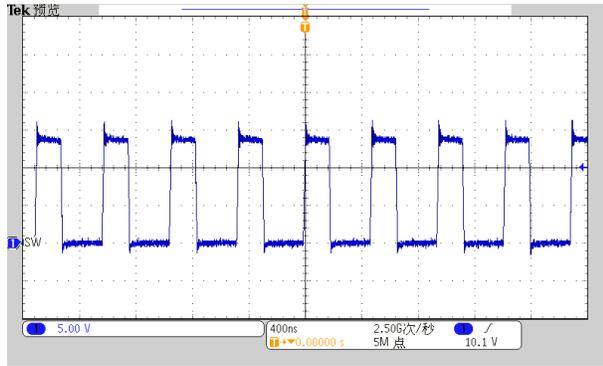


Figure 2-4. Bottom side

3 Waveforms

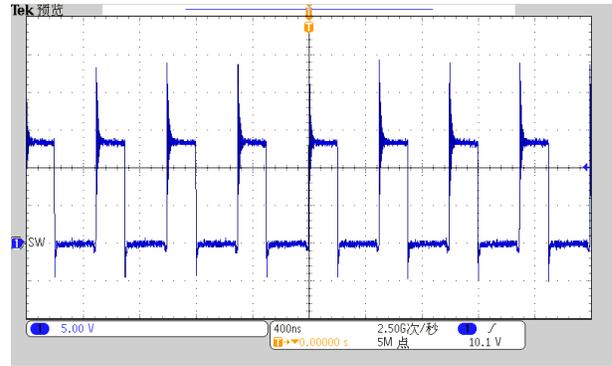
3.1 Switching

Switching behavior is shown in the following figures.



CH1: V_{sw}

Figure 3-1. 13.5V input, 5.17V no-load

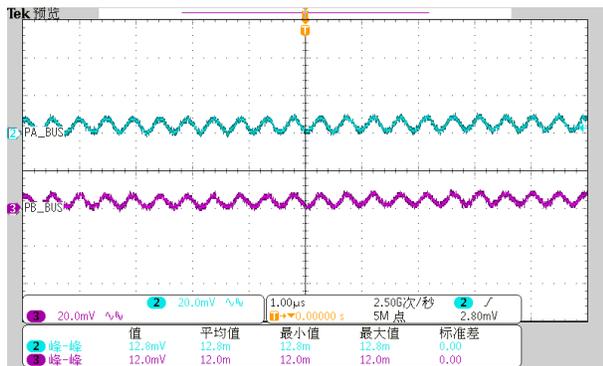


CH1: V_{sw}

Figure 3-2. 13.5V input, 5.17V full-load

3.2 Output Voltage Ripple

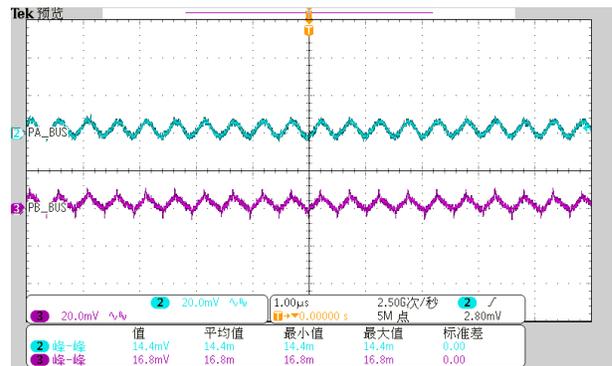
Output voltage ripple is shown in the following figures.



CH2: V_{PA_BUS}

CH3: V_{PB_BUS}

Figure 3-3. 13.5V input, 5.17V no-load



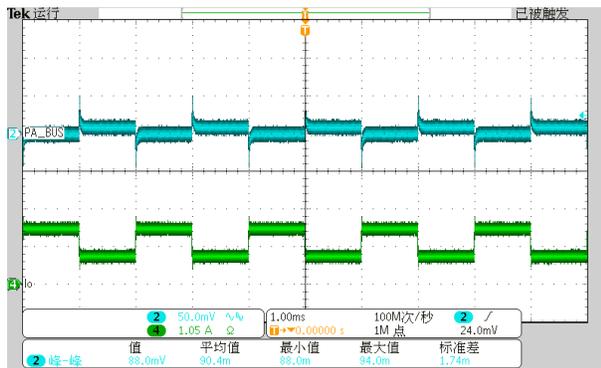
CH2: V_{PA_BUS}

CH3: V_{PB_BUS}

Figure 3-4. 13.5V input, 5.17V full-load

3.3 Load Transients

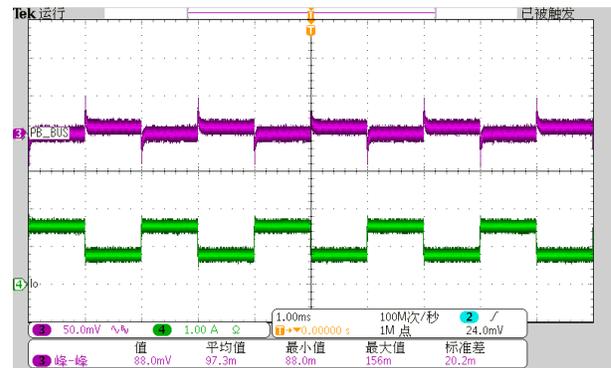
Load transient response is shown in the following figures. The slew rate is set to 0.4A/us for the test.



CH2: V_{PA_BUS}

CH4: I_{PA_BUS}

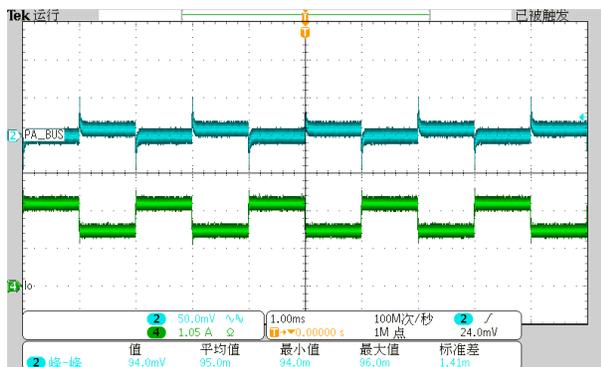
Figure 3-5. PA_BUS 13.5V input, 0.75A→1.5A



CH3: V_{PB_BUS}

CH4: I_{PB_BUS}

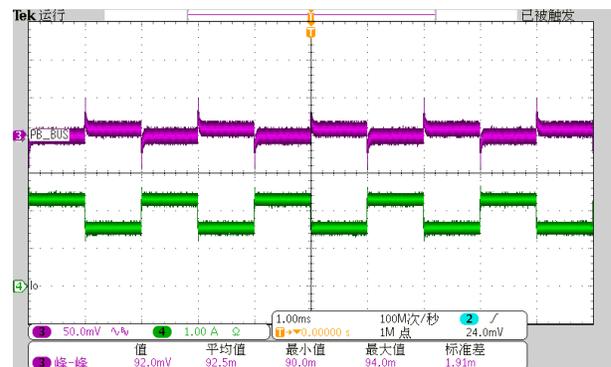
Figure 3-6. PB_BUS 13.5V input, 0.75A→1.5A



CH2: V_{PA_BUS}

CH4: I_{PA_BUS}

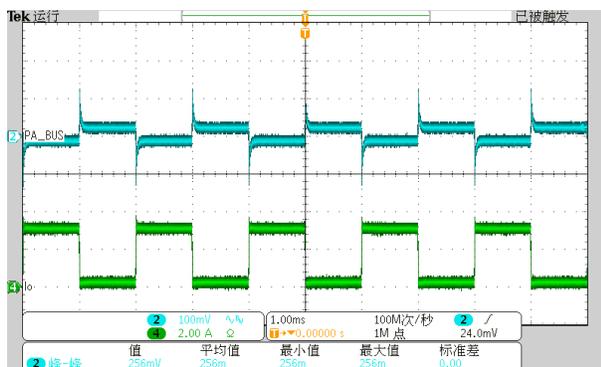
Figure 3-7. PA_BUS 13.5V input, 1.5A→2.25A



CH3: V_{PB_BUS}

CH4: I_{PB_BUS}

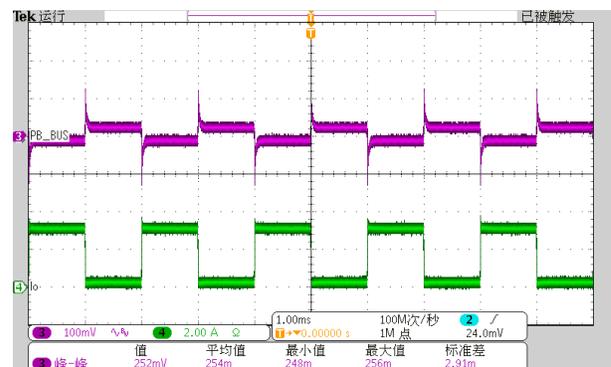
Figure 3-8. PB_BUS 13.5V input, 1.5A→2.25A



CH2: V_{PA_BUS}

CH4: I_{PA_BUS}

Figure 3-9. PA_BUS 13.5V input, 0.15A→3A



CH3: V_{PB_BUS}

CH4: I_{PB_BUS}

Figure 3-10. PB_BUS 13.5V input, 0.15A→3A

3.4 Start-up Sequence

Start-up behavior is shown in the following figures.

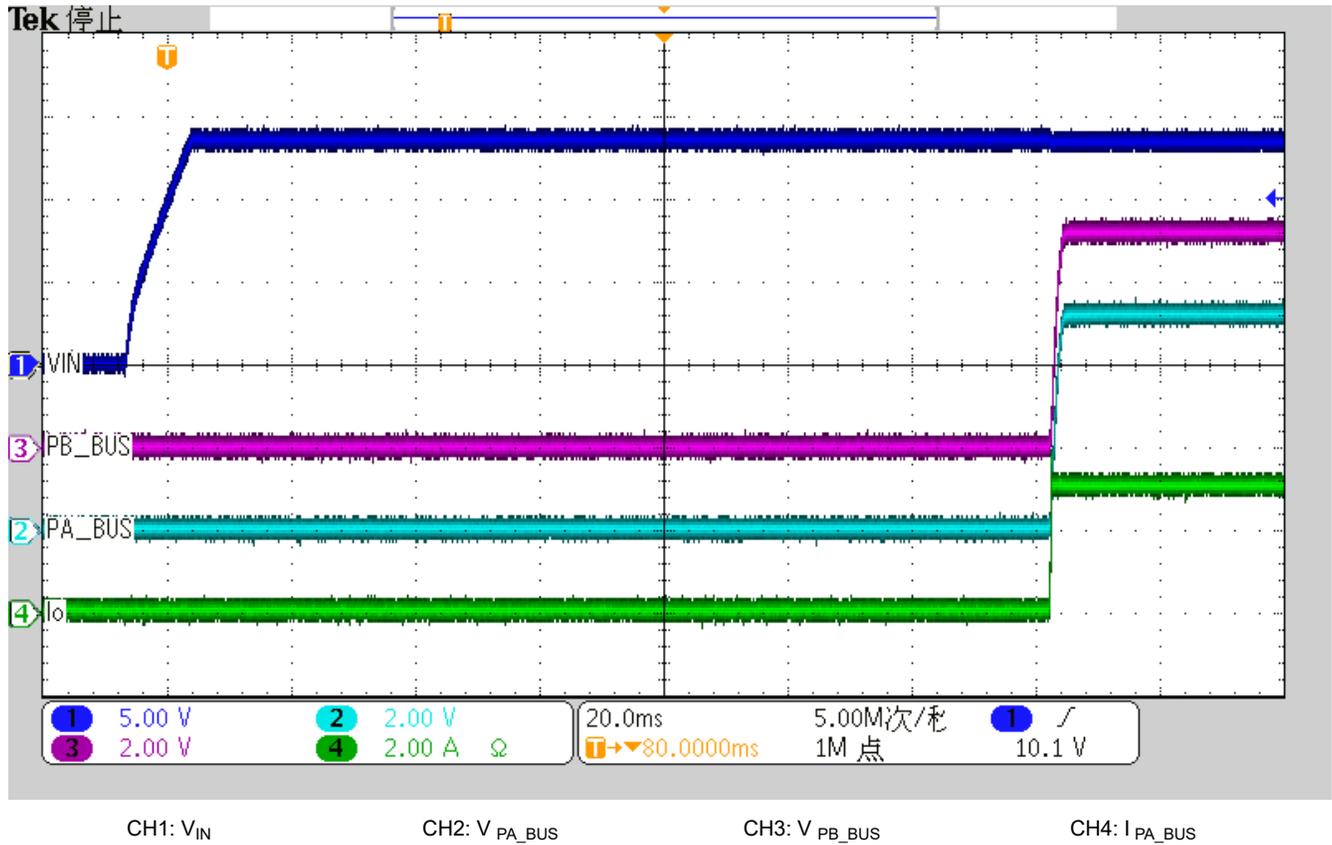


Figure 3-11. Power on

3.5 Undervoltage Protection

Undervoltage protection is shown in the following figures.

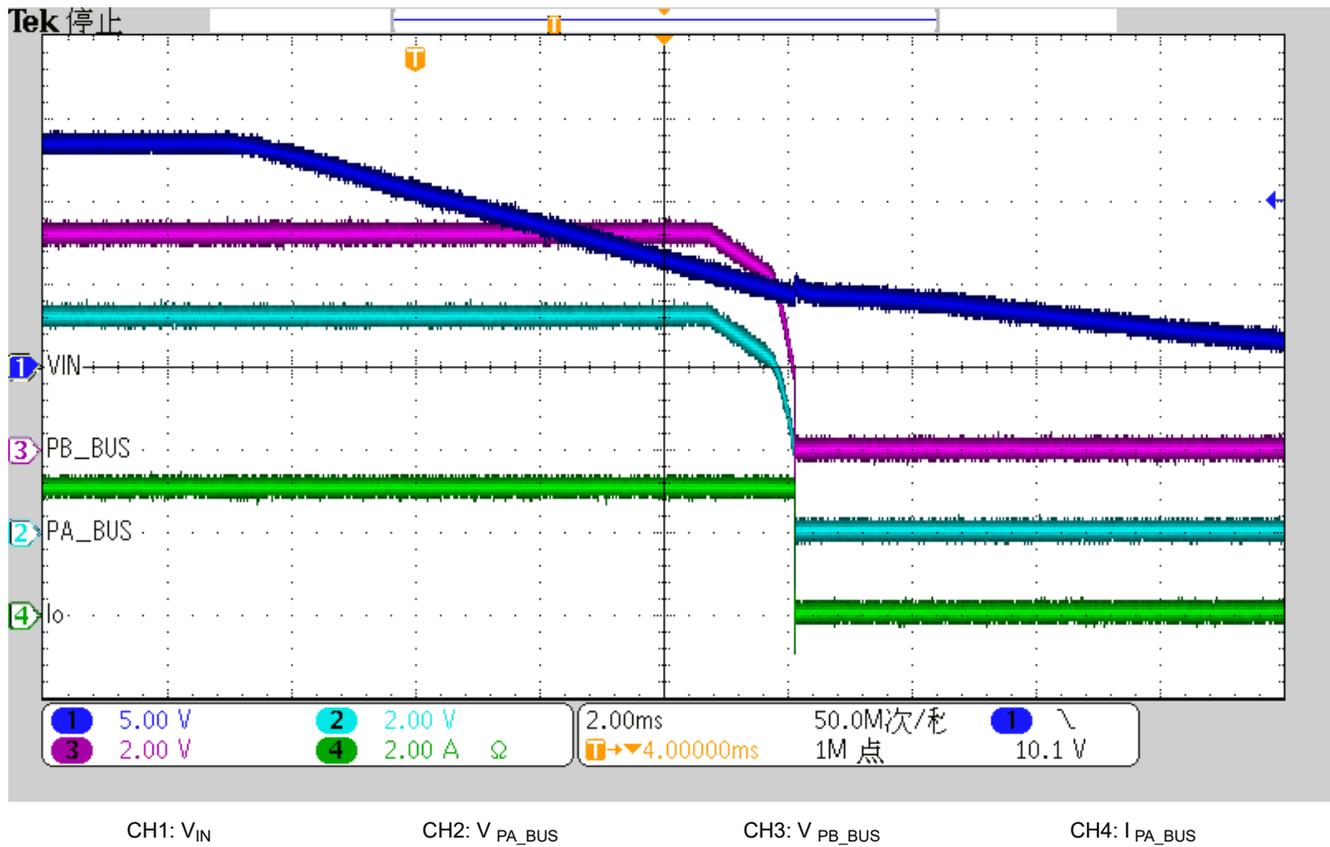
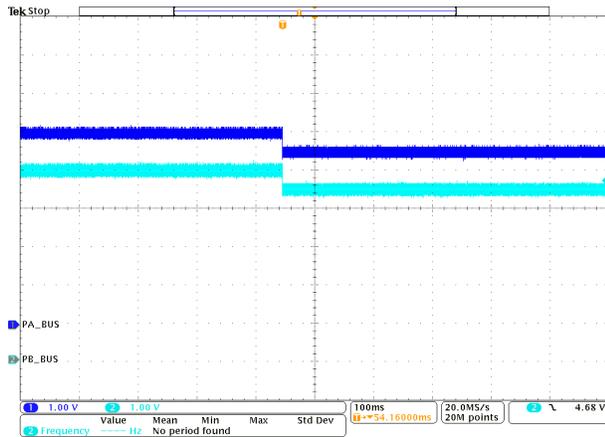


Figure 3-12. Power off

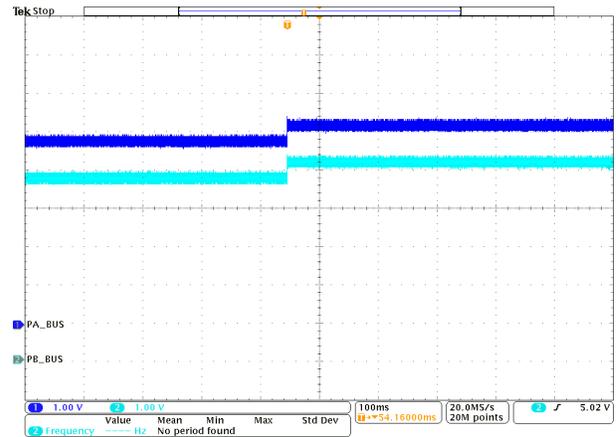
3.6 Thermal Management

The waveforms of thermal management are shown in following figures. The temperature chamber is used to control the actual chip temperature. The Thermal management function is triggered when the NTC thermistor temperature reaches 110°C (the chip temperature reaches 132°C) and the output voltage is reduced to 4.77 V. The thermal management function will be turned off when the NTC thermistor temperature drops to 95°C (the chip temperature drops to 110°C), and the output voltage is recovered to 5.17 V.



CH1: V_{PA_BUS}

CH2: V_{PB_BUS}



CH1: V_{PA_BUS}

CH2: V_{PB_BUS}

Figure 3-13. Thermal management function turn on **Figure 3-14. Thermal management function turn off**

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