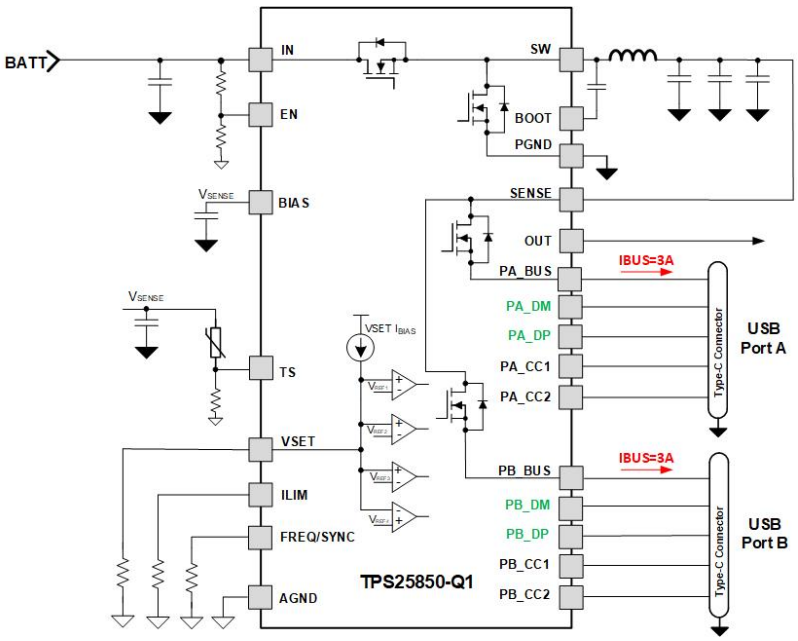
Test Report: PMP40723

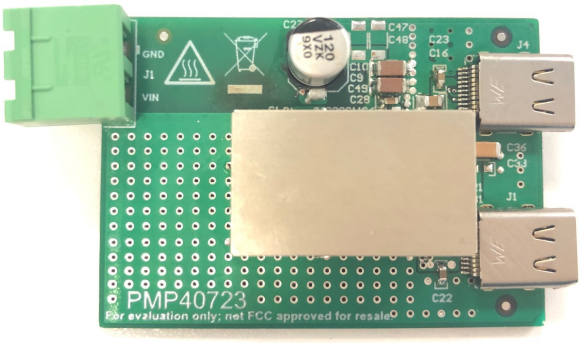
CISPR 25 Class-5 2.2-MHz Rated 30-W Automotive Dual USB Type-C® Charger Reference Design

Description

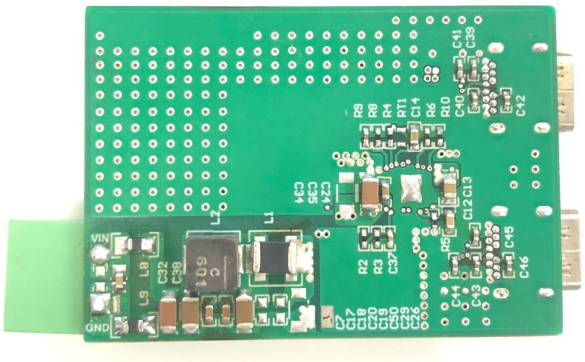
This reference design is an EMI-optimized design for automotive USB Type-C® charger with dual 15-W output. The TPS25850-Q1 device is used as a DC/DC regulator and port controller. The switching frequency is 2.2 MHz. The front-end filter is designed and PCB layout is optimized to pass stringent CISPR 25 Class 5 Conducted Electromagnetic Interference (EMI) standards. This reference design has already been tested to CISPR 25 Class 5 conducted EMI standards, which accelerates customer design time.



Block Diagram



Top



Bottom

1 Test Prerequisites

1.1 Design Requirements

Table 1-1. Design Requirements

Parameter	Specifications
Input Voltage	6-26 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	2.2 MHz

1.2 Required Equipment

- Multimeter (current): Fluke 287C
- Multimeter (voltage): Fluke 287C
- DC Source: Chroma 62006P-100-25
- E-Load: Chroma 63103A module
- Oscilloscope: Tektronix DPO4104B
- Electrical Thermography: Fluke TiS55
- Thermal Data Acquisition: Agilent 34970A

1.3 Dimensions

The board dimensions are 50 mm (length) × 35 mm (width) × 13 mm (height).

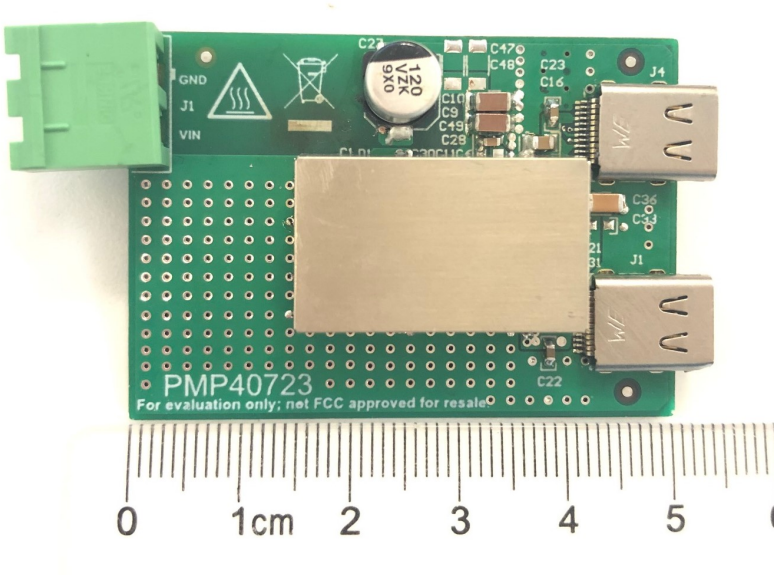


Figure 1-1. Dimension

2 Testing and Results

2.1 Efficiency Graphs

Efficiency is shown in the following figure.

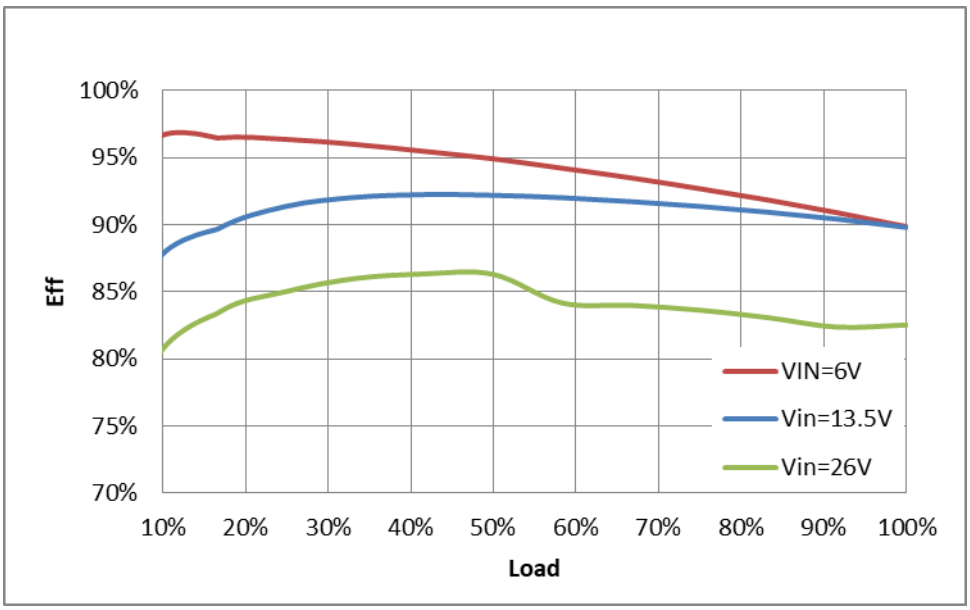


Figure 2-1. Efficiency Graph

2.2 Efficiency Data

Efficiency data is shown in the following table.

V_{IN} (V)	I_{IN} (A)	V_{PA_BUS}(V)	V_{PB_BUS} (V)	I_{PA_BUS}(A)	I_{PB_BUS} (A)	Eff
5.998	0.017	5.163	5.163	0.000	0.000	0.000
5.995	0.451	5.169	5.167	0.249	0.249	0.953
5.991	0.895	5.175	5.170	0.500	0.500	0.965
5.999	1.343	5.180	5.174	0.750	0.750	0.964
5.999	1.798	5.186	5.177	1.000	0.998	0.960
5.999	2.263	5.193	5.181	1.250	1.249	0.955
6.002	2.734	5.199	5.185	1.501	1.499	0.949
6.010	3.210	5.204	5.188	1.750	1.748	0.942
6.000	3.708	5.210	5.192	2.000	1.998	0.935
6.002	4.211	5.216	5.195	2.251	2.249	0.927
6.002	4.720	5.217	5.194	2.500	2.498	0.918
6.004	5.240	5.213	5.187	2.751	2.748	0.909
5.998	5.782	5.209	5.179	3.001	2.999	0.899
13.496	0.025	5.160	5.160	0.000	0.000	0.000
13.498	0.223	5.167	5.165	0.249	0.250	0.858
13.497	0.427	5.170	5.166	0.500	0.500	0.897
13.495	0.629	5.175	5.168	0.750	0.750	0.914
13.494	0.832	5.179	5.170	1.000	0.999	0.920
13.492	1.040	5.183	5.171	1.250	1.249	0.922
13.491	1.249	5.187	5.173	1.501	1.499	0.922
13.499	1.460	5.192	5.175	1.750	1.748	0.920
13.499	1.675	5.196	5.177	2.000	1.998	0.917

V_{IN} (V)	I_{IN} (A)	V_{PA_BUS}(V)	V_{PB_BUS} (V)	I_{PA_BUS}(A)	I_{PB_BUS} (A)	Eff
13.500	1.894	5.201	5.179	2.251	2.249	0.914
13.499	2.114	5.203	5.178	2.500	2.498	0.909
13.498	2.336	5.198	5.171	2.751	2.748	0.904
13.499	2.563	5.192	5.162	3.002	2.999	0.898
25.997	0.028	5.179	5.179	0.000	0.000	0.000
25.990	0.127	5.174	5.172	0.249	0.249	0.783
25.997	0.238	5.173	5.168	0.500	0.500	0.834
25.997	0.351	5.177	5.170	0.750	0.750	0.850
25.997	0.463	5.181	5.172	1.000	0.999	0.860
25.995	0.577	5.186	5.174	1.250	1.249	0.863
25.995	0.693	5.190	5.176	1.501	1.499	0.863
25.995	0.829	5.195	5.178	1.750	1.748	0.842
25.993	0.951	5.199	5.179	2.000	1.999	0.840
25.992	1.075	5.203	5.181	2.251	2.249	0.836
25.992	1.201	5.203	5.177	2.500	2.498	0.831
25.991	1.331	5.197	5.168	2.751	2.748	0.824
25.990	1.448	5.193	5.160	3.001	3.000	0.825

2.3 Load Regulation

Load regulation is shown in the following figure.

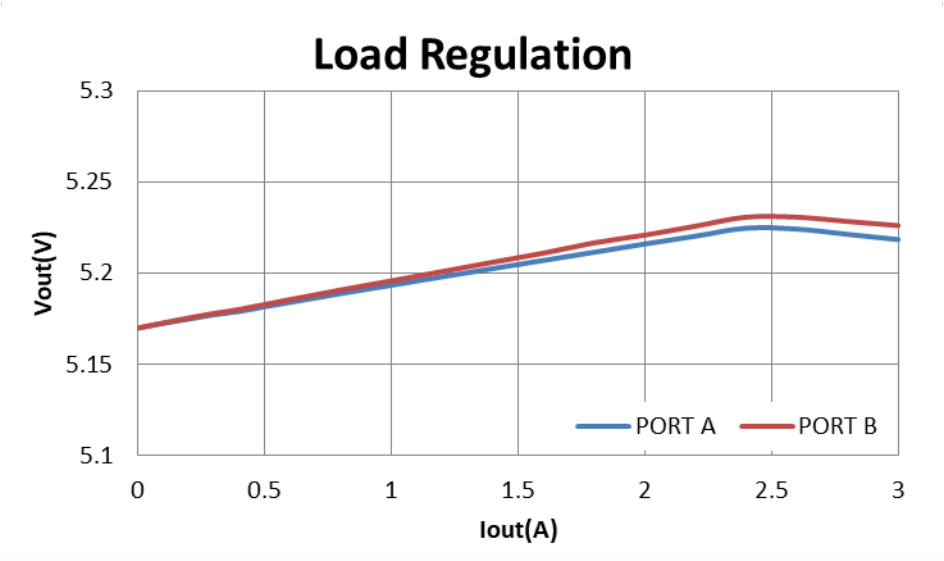


Figure 2-2. Load Regulation

2.4 Thermal Images

Thermal images are shown in the following figures. The ambient temperature is 25°C. The thermal image is taken at the steady state with 13.5 V in and all outputs at a full load of 5.17 V and 3 A.

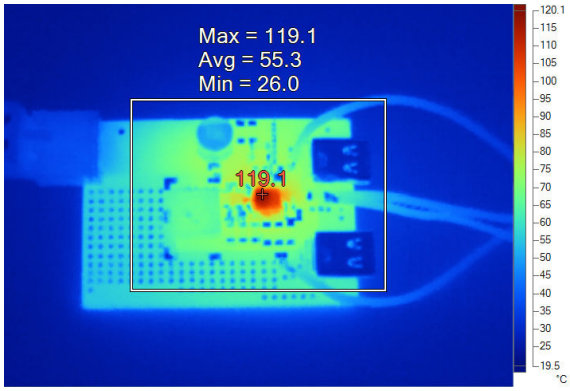


Figure 2-3. Top Side

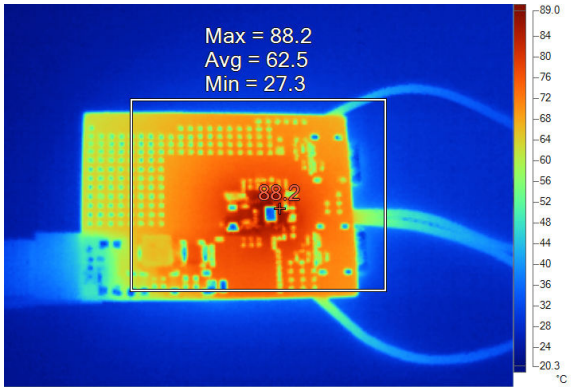
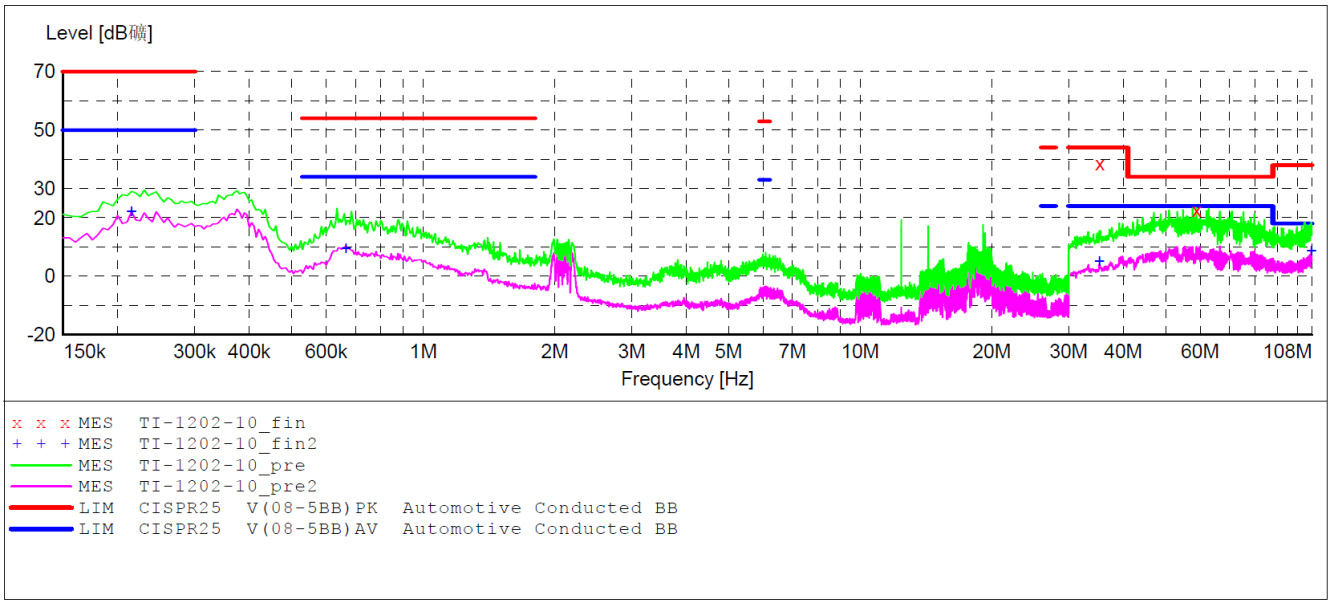


Figure 2-4. Bottom Side

2.5 EMI

The conducted emissions are tested to the CISPR 25 class 5 standards. The CISPR 25 class 5 compliance was achieved without a common-mode choke. EMI is shown in the following figure.



Green: Peak Detection Result

Purple: Average Detection Result

Red: CISPR 25 Class 5 Peak Limits

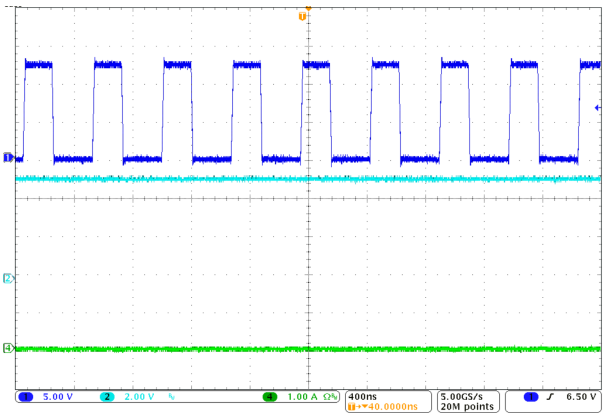
Blue: CISPR 25 Class 5 Average Limits

Figure 2-5. EMI Performance From 150 kHz to 108 MHz

3 Waveforms

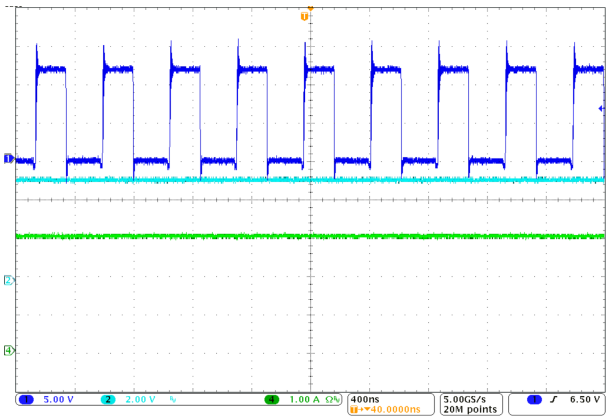
3.1 Switching

Switching behavior is shown in the following figures.



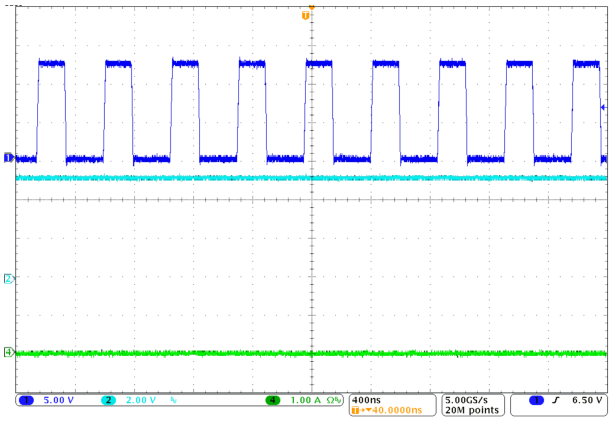
CH1: V_{SW} CH2: V_{PA_BUS} CH4: I_{PA_BUS}

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



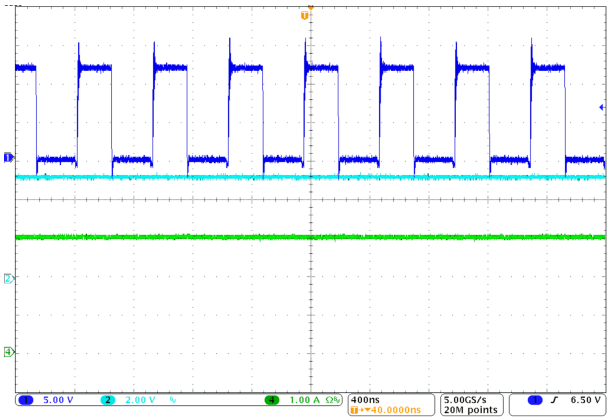
CH1: V_{SW} CH2: V_{PA_BUS} CH4: I_{PA_BUS}

Figure 3-2. PA_BUS 13.5-V Input, 5.17 V, 3-A Load



CH1: V_{SW} CH2: V_{PB_BUS} CH4: I_{PB_BUS}

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

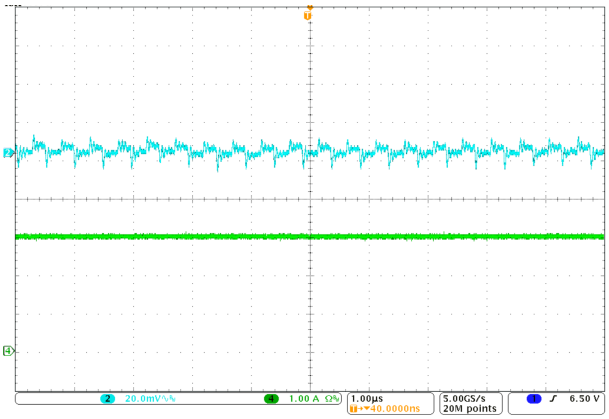


CCH1: V_{SW} CH2: V_{PB_BUS} CH4: I_{PB_BUS}

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

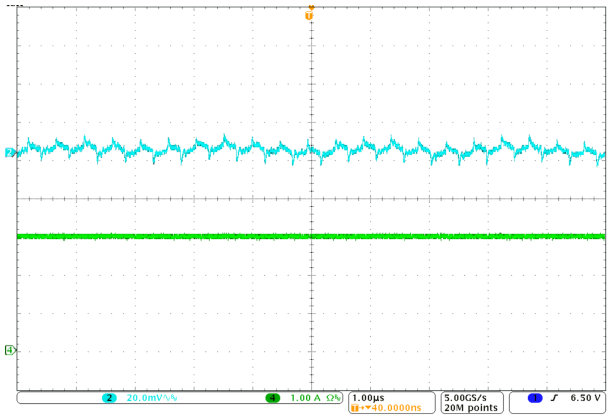
3.2 Output Voltage Ripple

Output voltage ripple is shown in the following figures.



CH2: V_{PA_BUS} CH4: I_{PA_BUS}

Figure 3-5. PA_BUS 13.5-V Input, 5.17 V, 3-A Load

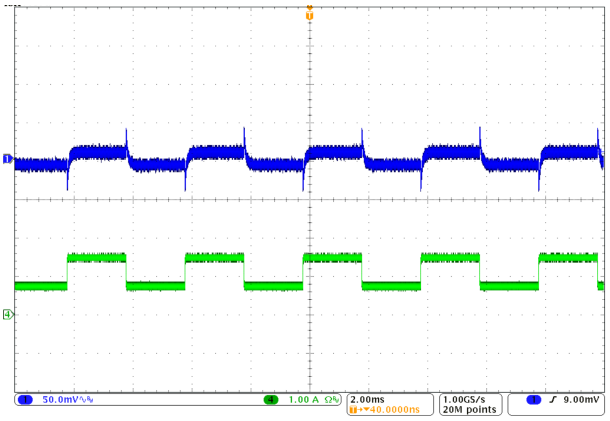


CH2: V_{PB_BUS} CH4: I_{PB_BUS}

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

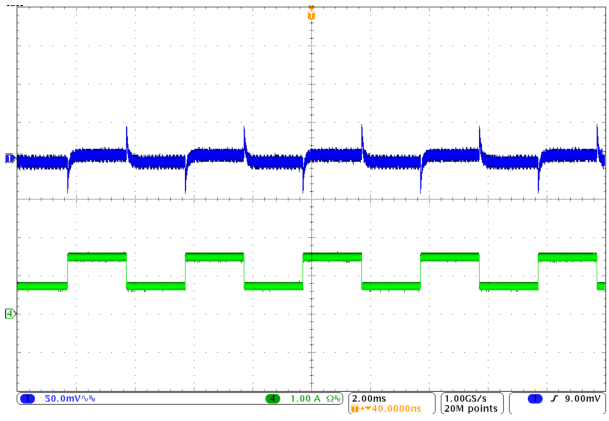
3.3 Load Transients

Load transient response is shown in the following figures.



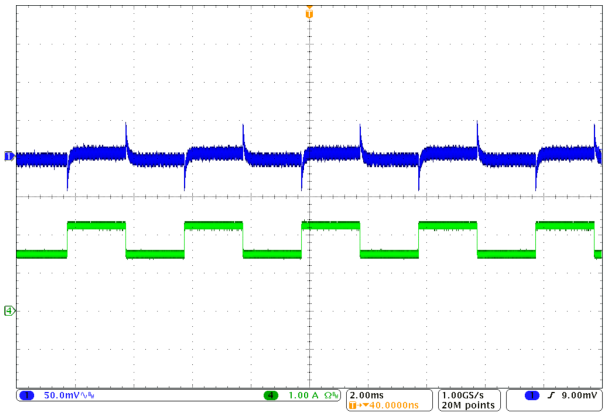
CH1: V_{PA_BUS} CH4: I_{PA_BUS}

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



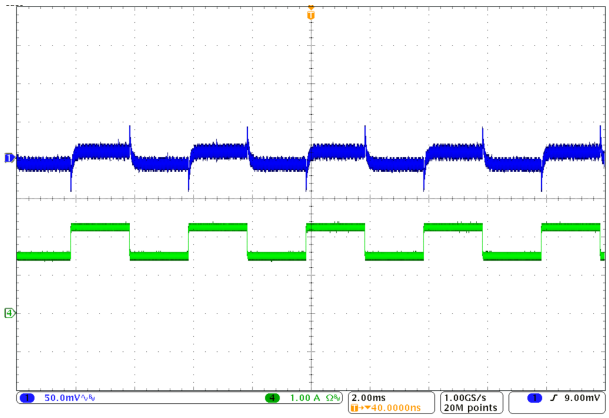
CH1: V_{PB_BUS} CH4: I_{PB_BUS}

Figure 3-8. PB_BUS 13.5-V Input, 0.75 A→1.5 A



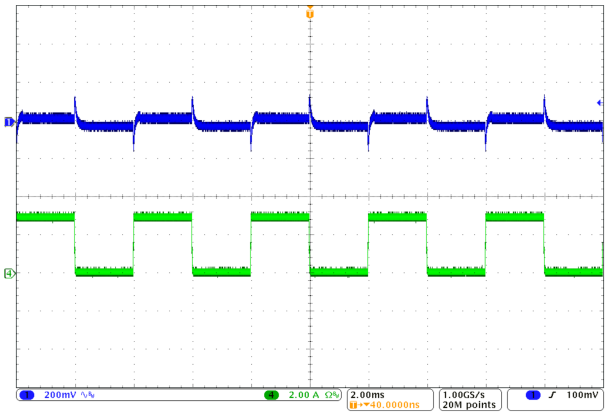
CH1: V_{PA_BUS} CH4: I_{PA_BUS}

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



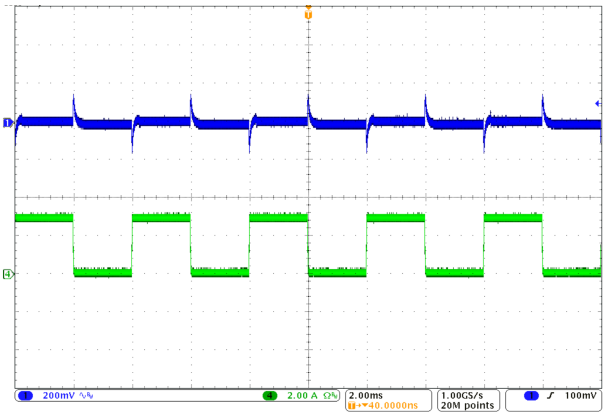
CH1: V_{PB_BUS} CH4: I_{PB_BUS}

Figure 3-10. PB_BUS 13.5-V Input, 1.5 A→2.25 A



CH1: V_{PA_BUS} CH4: I_{PA_BUS}

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

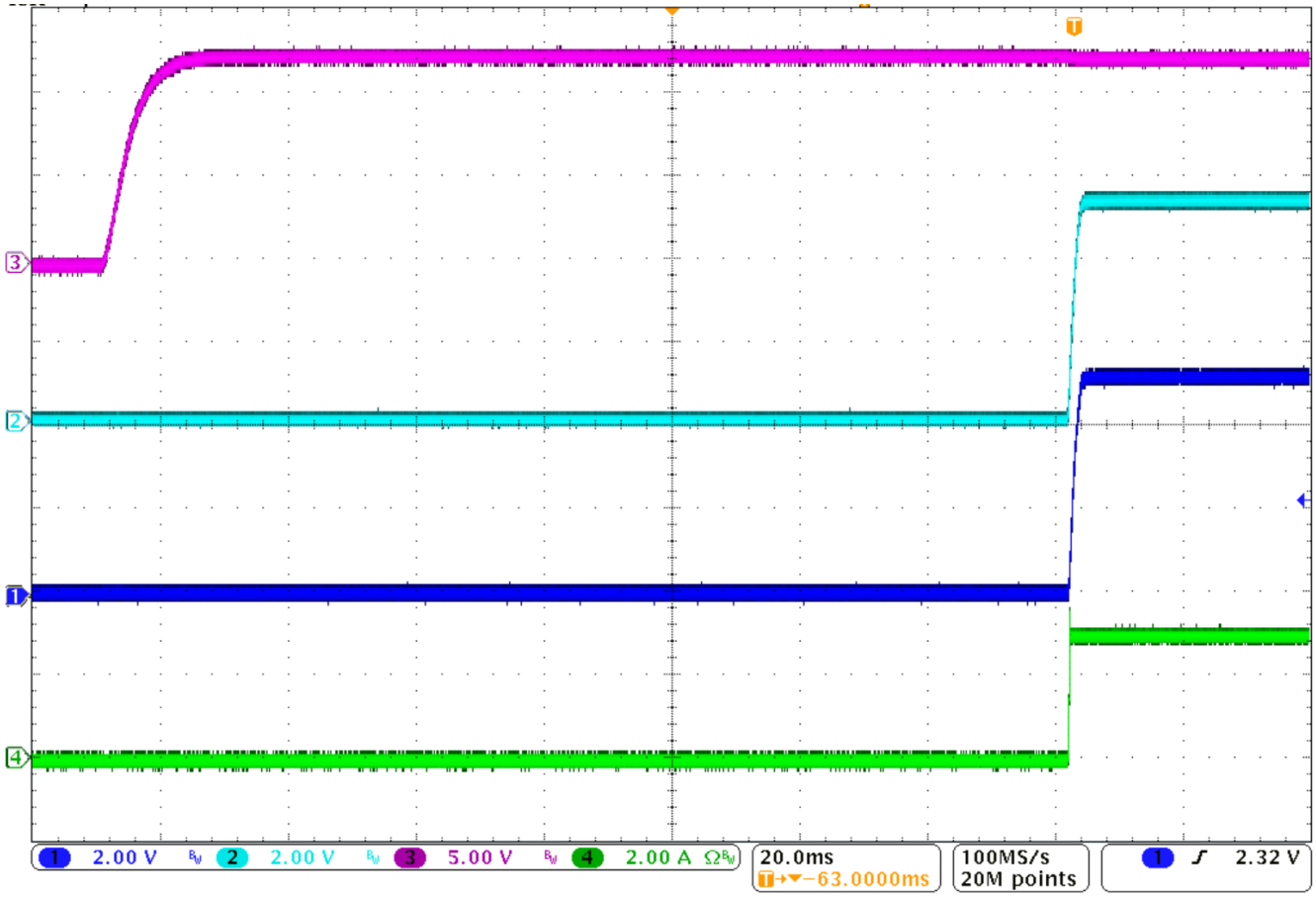


CH1: V_{PB_BUS} CH4: I_{PB_BUS}

Figure 3-12. PB_BUS 13.5-V Input, 0.15 A→3 A

3.4 Start-up Sequence

Start-up behavior is shown in the following figures.

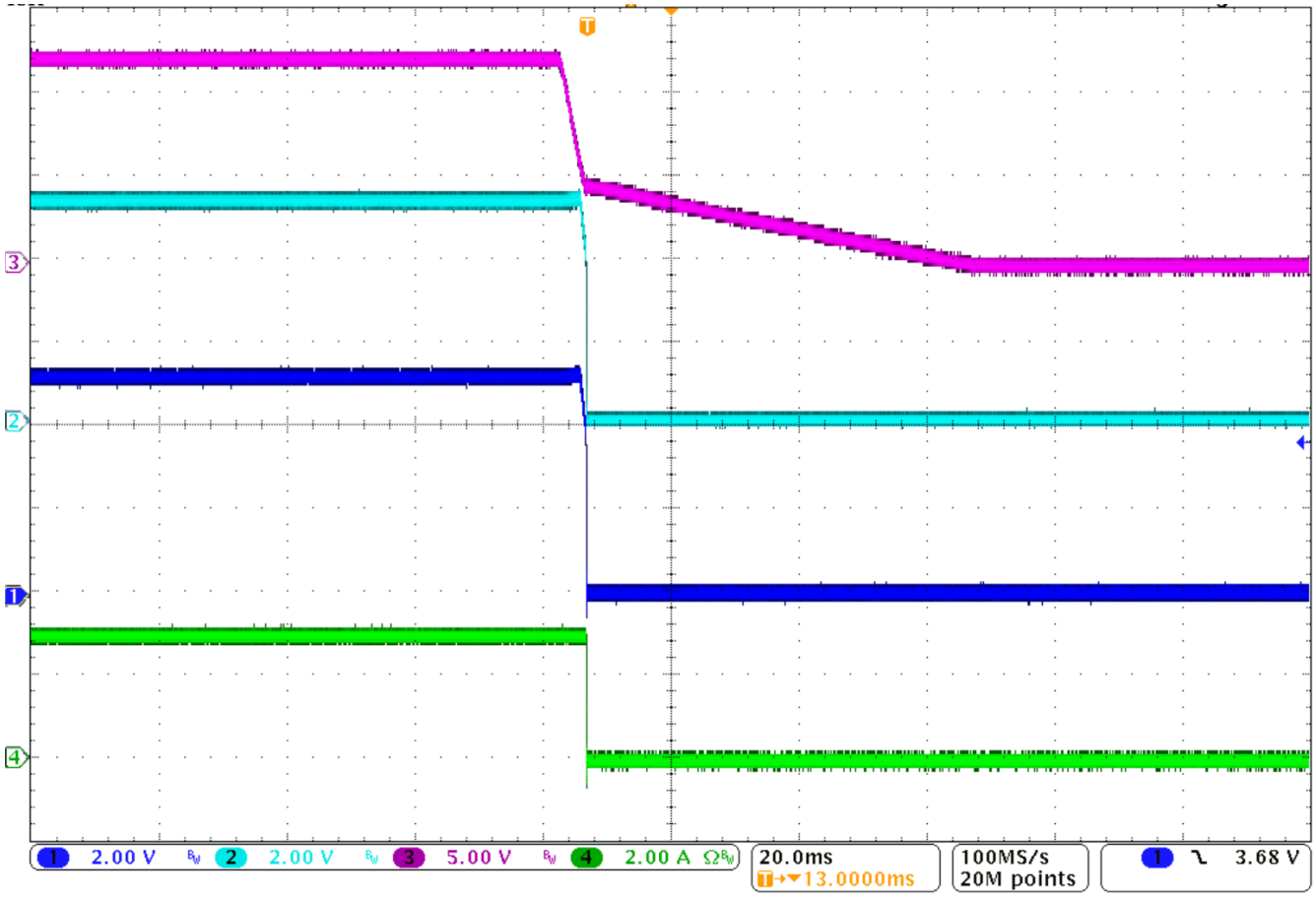


CH1: V_{PA_BUS} CH2: V_{PB_BUS} CH3: V_{IN} CH4: I_{PA_BUS}

Figure 3-13. Power on

3.5 Undervoltage Protection

Undervoltage protection is shown in the following figures.



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

Figure 3-14. Power off

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