Test Report: PMP40939

CISPR 25 Class 5, 2.1-MHz Rated, 15-W Automotive USB Type-C® Charger Reference Design

Description

This reference design is an EMI-optimized design for automotive USB Type-C® charger with 15-W output. The TPS25855-Q1 is used as DC/DC regulator and port controller. The switching frequency is set to 2.1 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.

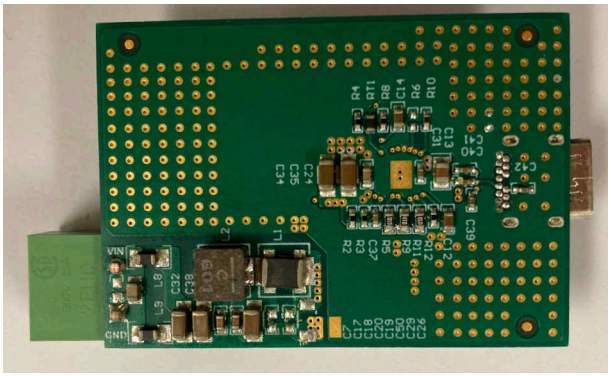
Features

- Passes stringent CISPR 25 Class 5 conducted electromagnetic interference (EMI) standards
- 93.3% peak efficiency with 2.1-MHz frequency
- USB Type-C® charger

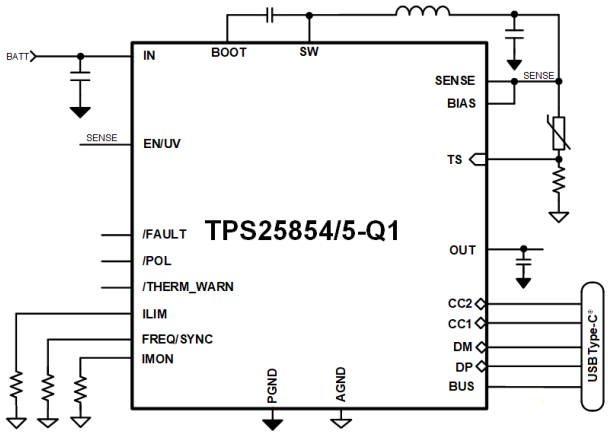
Applications

- Automotive USB charge
- USB Type-C® and USB Power Delivery

Top Photo



Bottom Photo



Block Diagram

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1 Test Prerequisites

1.1 Voltage and Current Requirements

Table 1-1. Voltage and Current Requirements

Parameter	Specifications
Input Voltage	12 VDC
PA_BUS Output Voltage	5.17 VDC
PA_BUS Maximum Output Current	3 A
Switching Frequency	2.1 MHz

1.2 Required Equipment

- Multimeter (current): 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) × 10 mm (height). Ignore J1.

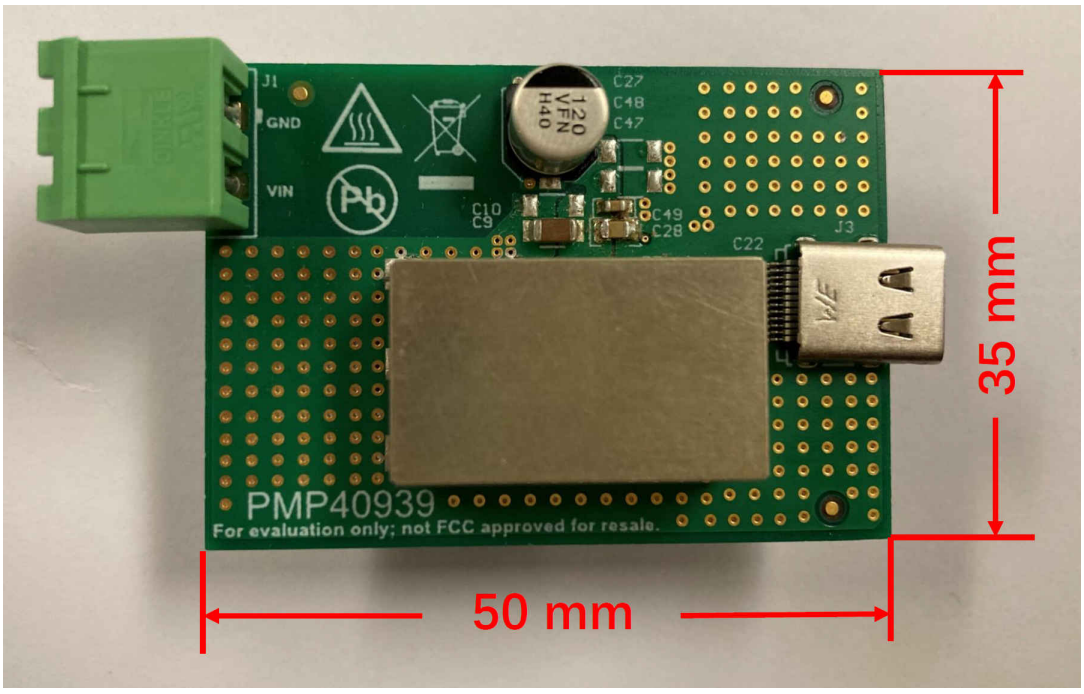

Figure 1-1. Board Dimensions

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2 Testing and Results

2.1 Efficiency Graphs

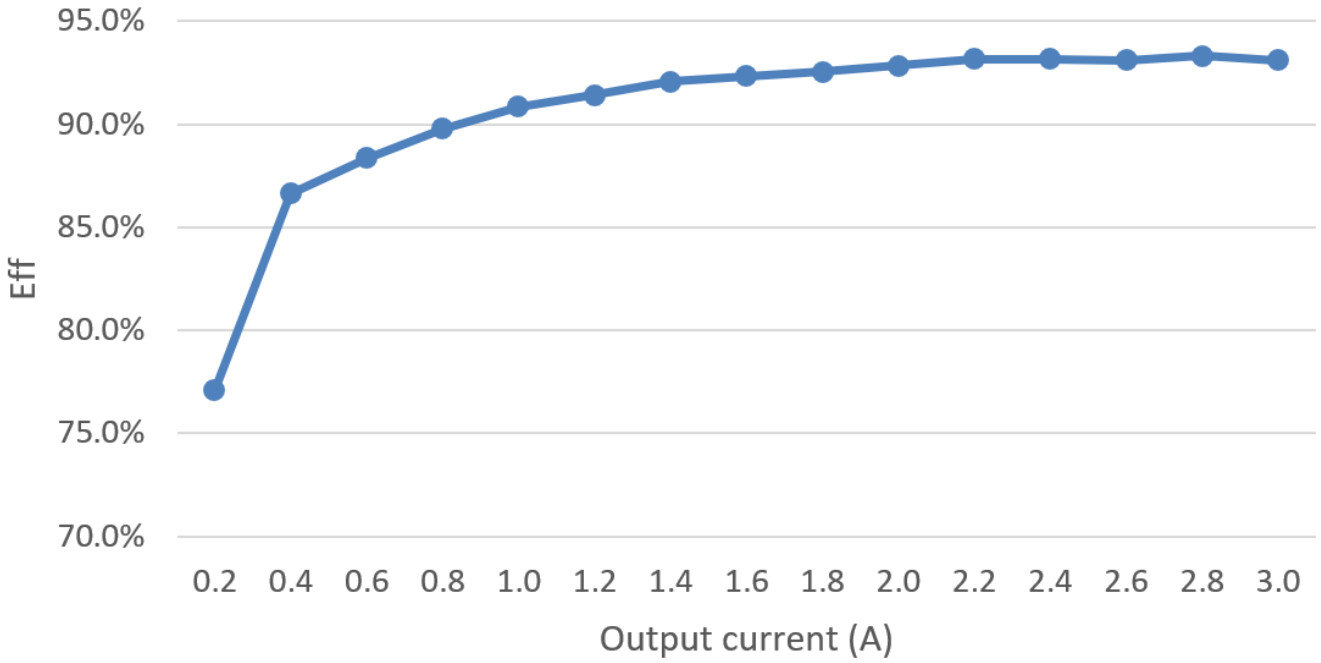

Figure 2-1. Efficiency Graph

2.2 Efficiency Data

Efficiency data is shown in the following table.

V_{IN} (V)	IIN (A)	VPA_BUS (V)	IPA_BUS (A)	Eff
12.0002	0.0251	5.0903	0.0000	0.0000
12.0009	0.1103	5.1022	0.2	77.1%
12.0080	0.1967	5.1168	0.4	86.7%
12.0070	0.2902	5.1321	0.6	88.4%
12.0210	0.3791	5.1144	0.8	89.8%
12.0015	0.4731	5.1571	1.0	90.8%
12.0012	0.5657	5.1717	1.2	91.4%
12.0014	0.6567	5.1854	1.4	92.1%
12.0210	0.7494	5.1992	1.6	92.3%
12.0005	0.8451	5.2141	1.8	92.5%
12.0030	0.9381	5.2278	2.0	92.9%
12.0020	1.0312	5.2415	2.2	93.2%
12.0120	1.1271	5.2563	2.4	93.2%
12.0012	1.2261	5.2699	2.6	93.1%
12.0021	1.3210	5.2836	2.8	93.3%
12.0021	1.4223	5.2984	3.0	93.1%

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2.3 Thermal Images

The following thermal images of the 4-layer PCB, 2-oz copper boards are taken under the following conditions:

Figure 2-2. Top Side

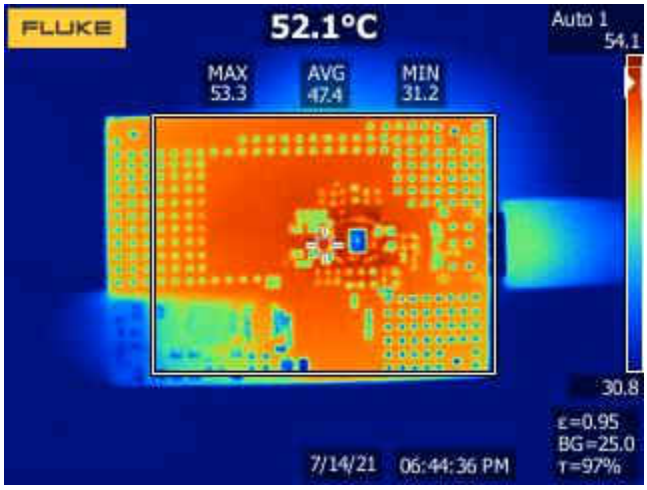

Figure 2-3. Bottom Side

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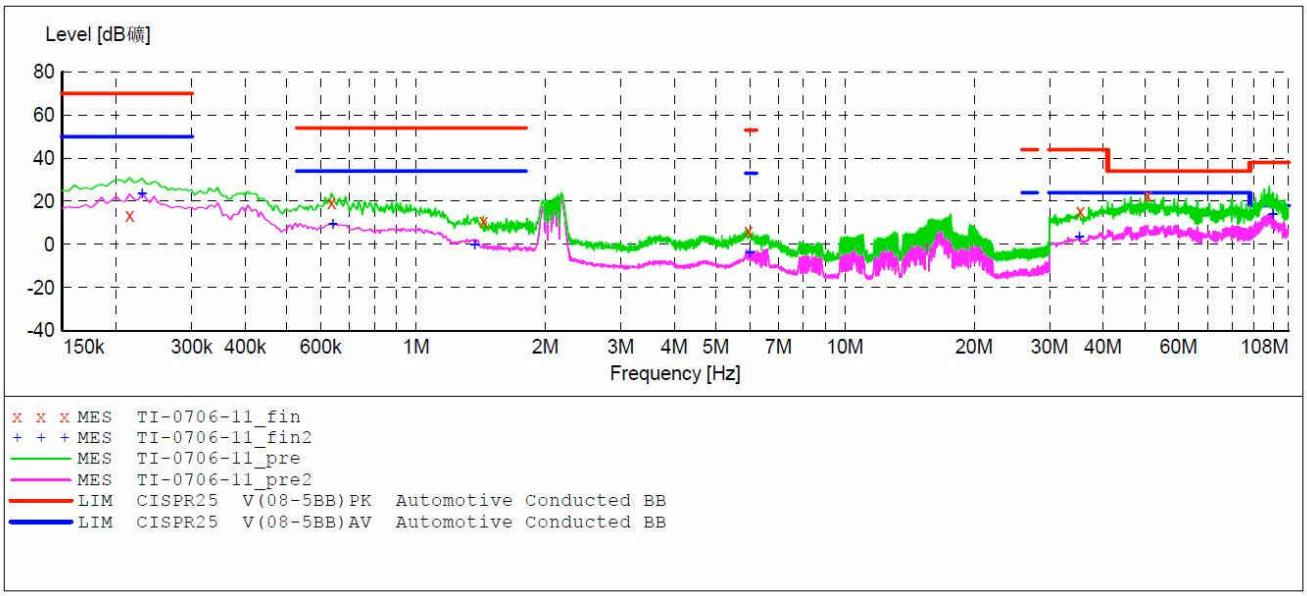
2.4 EMI

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. The waveforms of EMI test results are shown in following images.

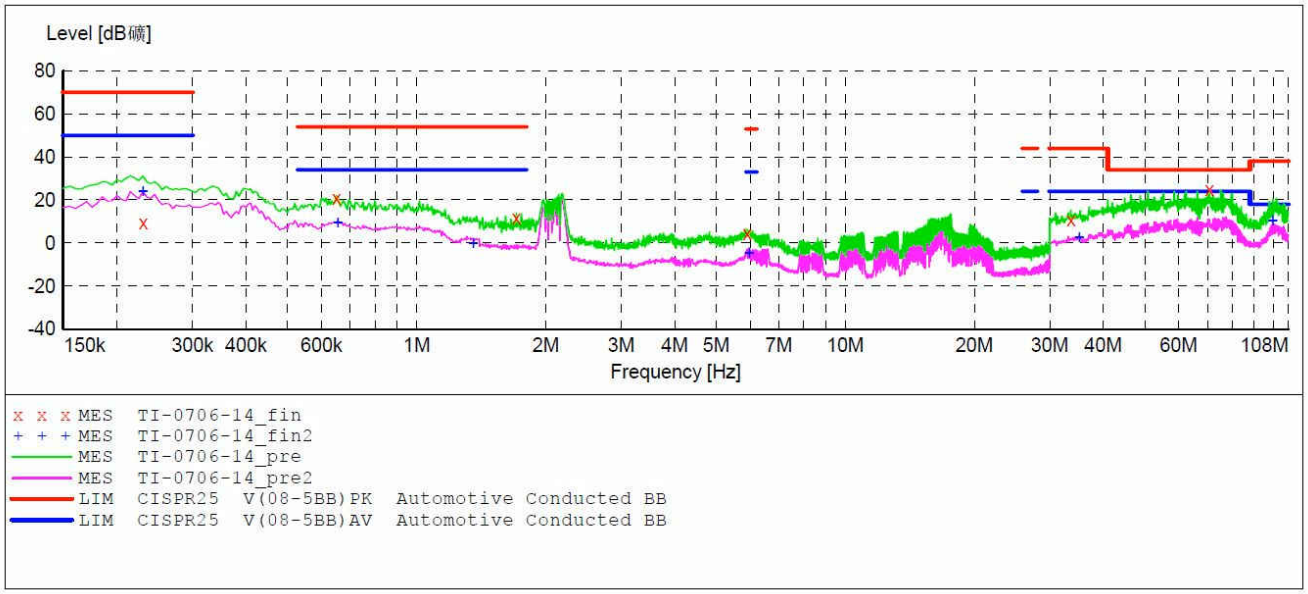
Test condition: V_{IN} = 12 V, I_O = 3 A



Green: peak detection result; Purple: average detection result

Red: CISPR 25 Class 5 peak limits; Blue: CISPR 25 Class 5 average limits

Figure 2-4. DC+



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. DC–

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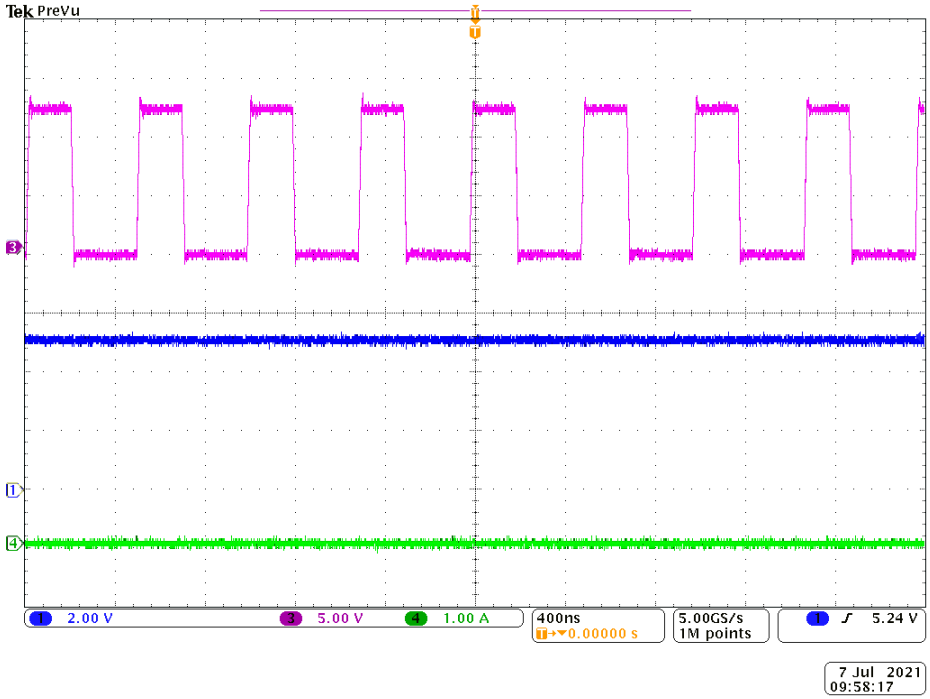
3 Waveforms

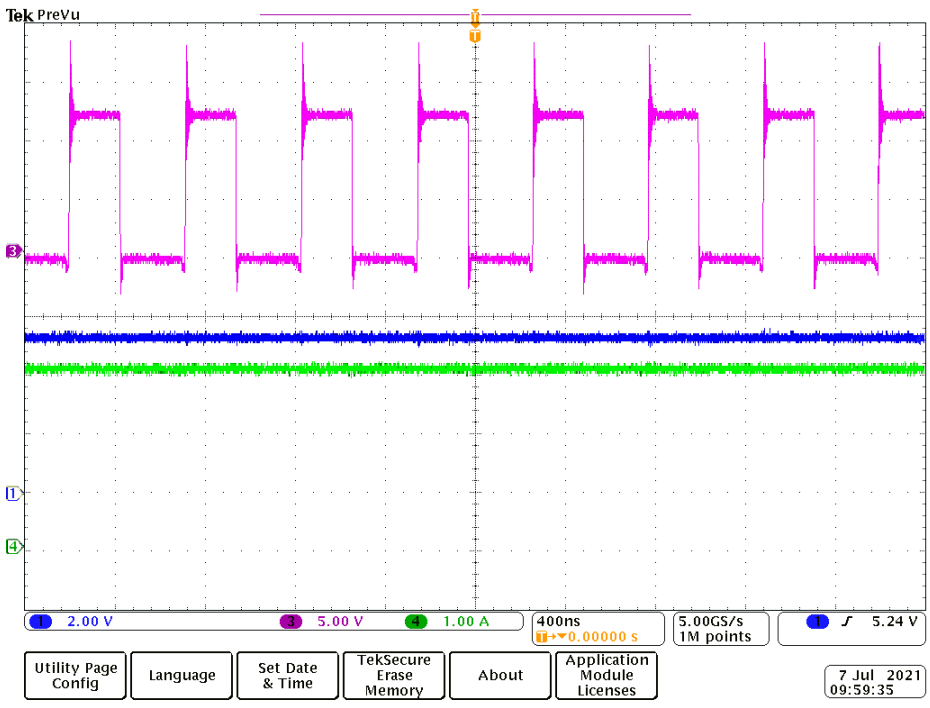
3.1 Switching

Switching behavior is shown in the following figures.



CH1: V_{PA_BUS}, CH3: V_{SW}, CH4: I_{PA_BUS}

Figure 3-1. Switching Waveform, 12-V Input, No Load



CH1: V_{PA_BUS}, CH3: V_{SW}, CH4: I_{PA_BUS}

Figure 3-2. Switching Waveform, 12-V Input, 3-A Load

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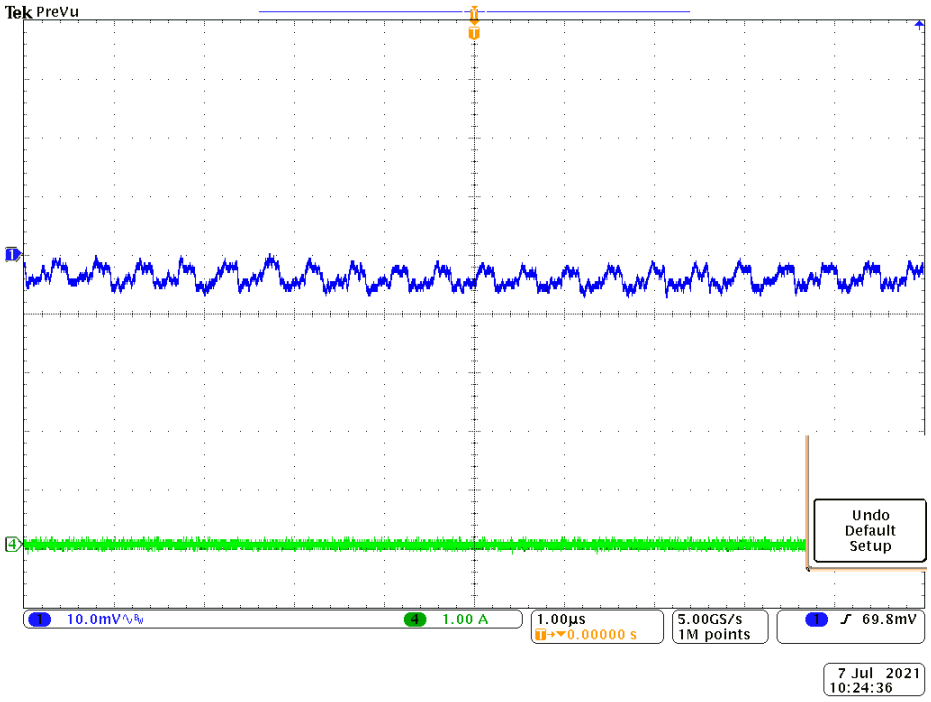
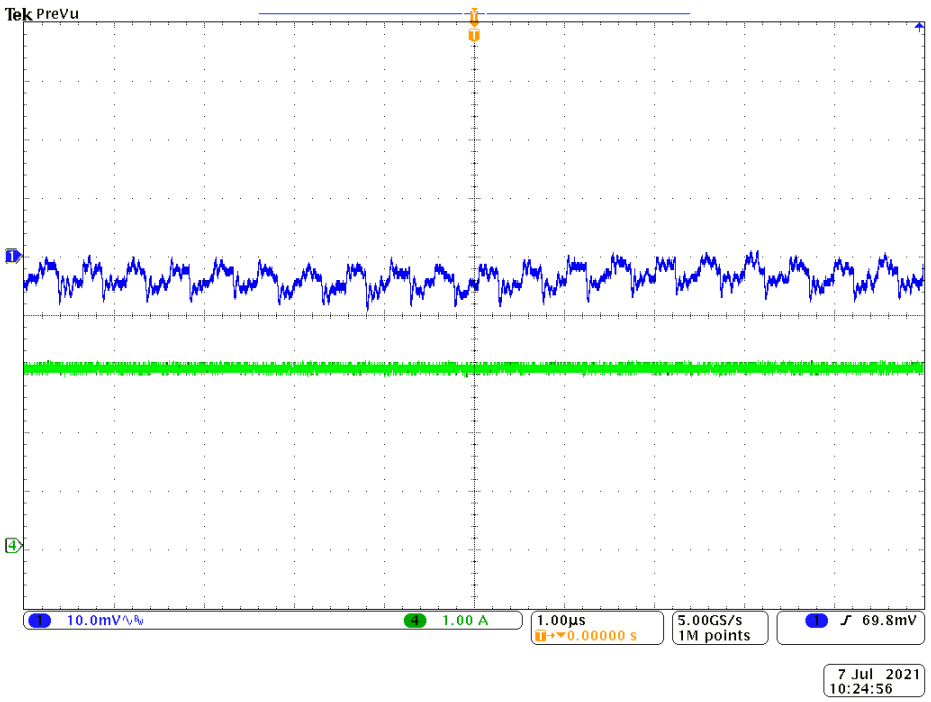
3.2 Output Voltage Ripple

Output voltage ripple is shown in the following figures.



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

Figure 3-3. Output Voltage Ripple, 12-V Input, No Load



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

Figure 3-4. Output Voltage Ripple, 12-V Input, 3-A Load

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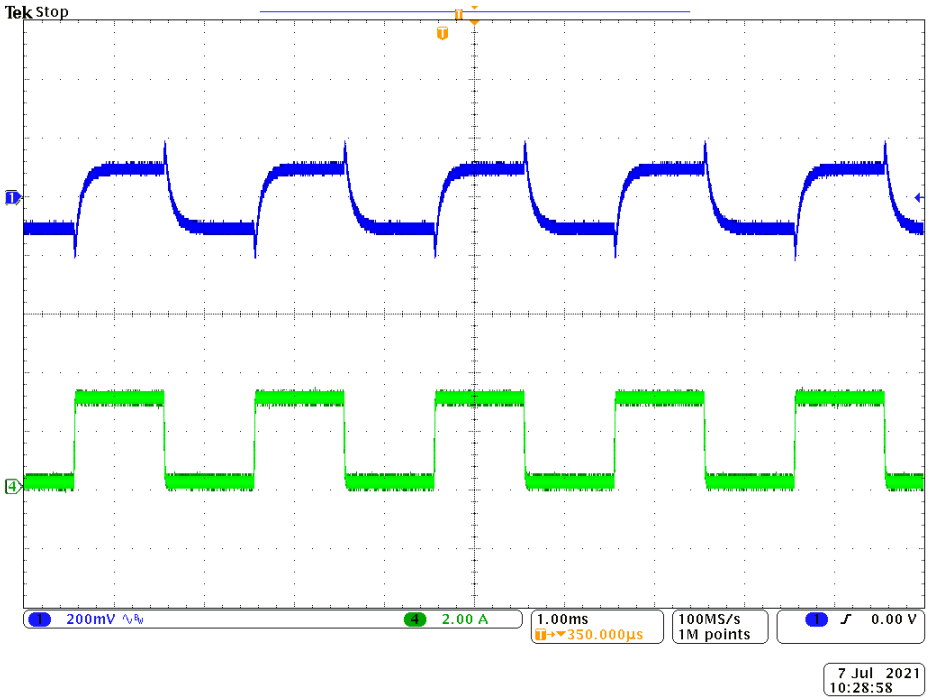
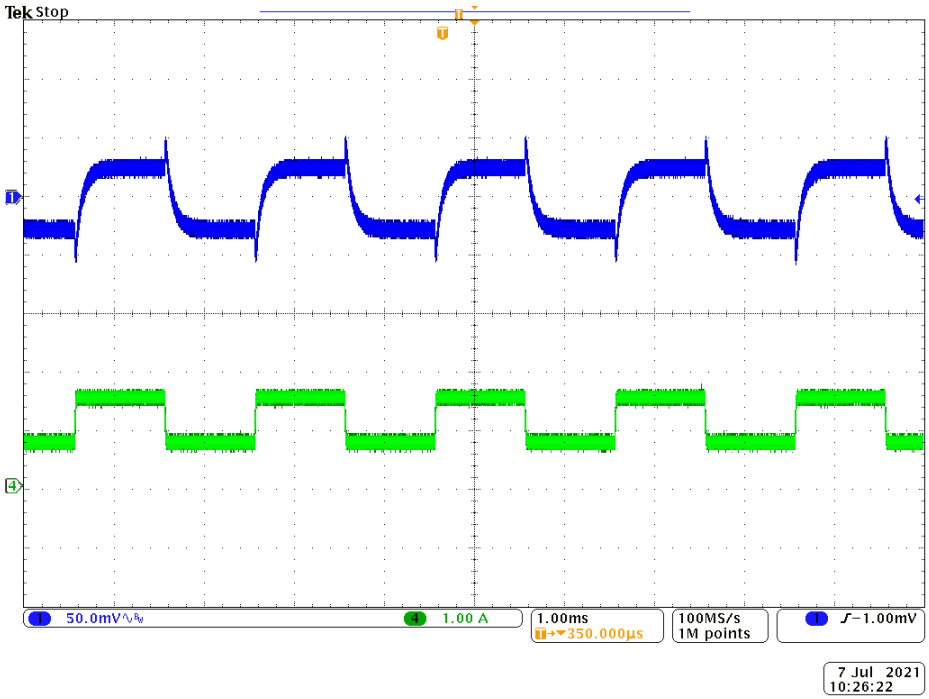
3.3 Load Transients

The waveforms of output AC ripples at load transient are shown in following images. The slew rate is set to 2.5 A/µs for the test.



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

Figure 3-5. Load Transient Waveform, 12-V Input, 0.15 A to 3 A



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

Figure 3-6. Load Transient Waveform, 12-V Input, 0.75 A to 1.5 A

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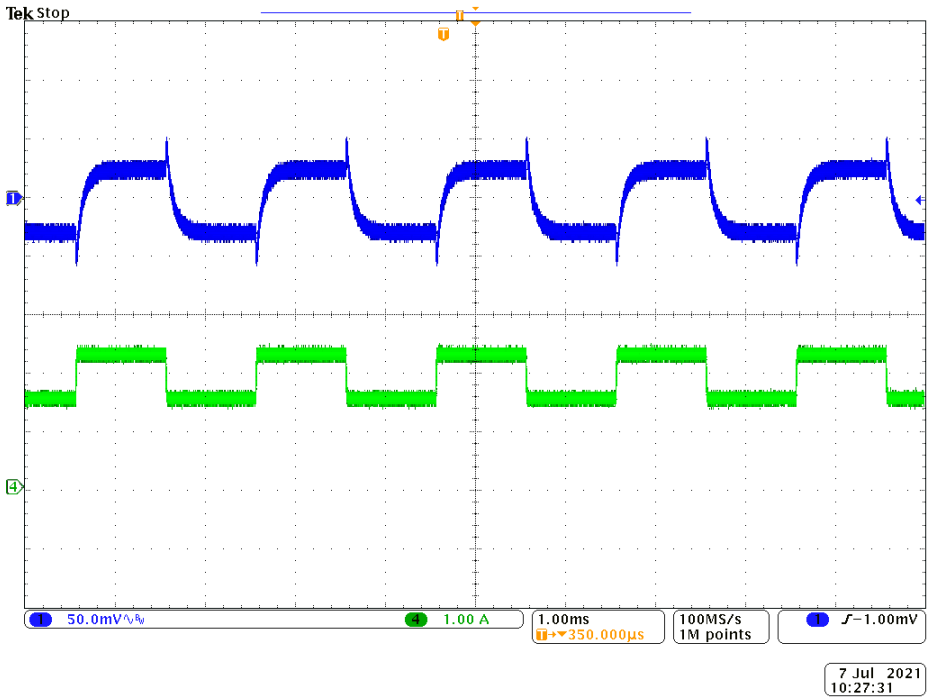

CH1: V_{PA_BUS}, CH4: I_{PA_BUS}

Figure 3-7. Load Transient Waveform, 12-V Input, 1.5 A to 2.25 A

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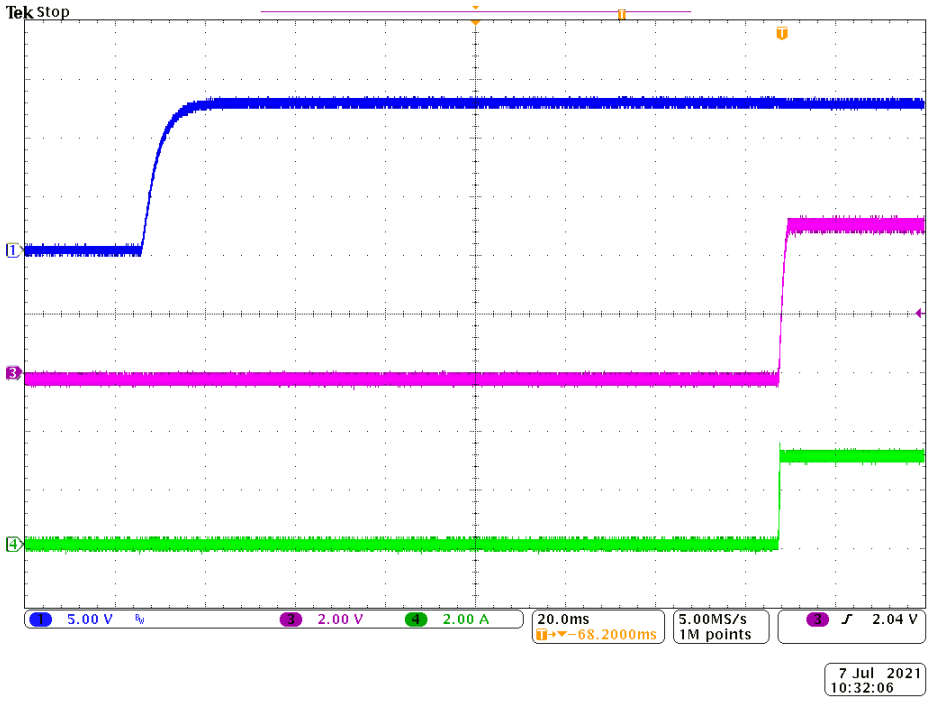
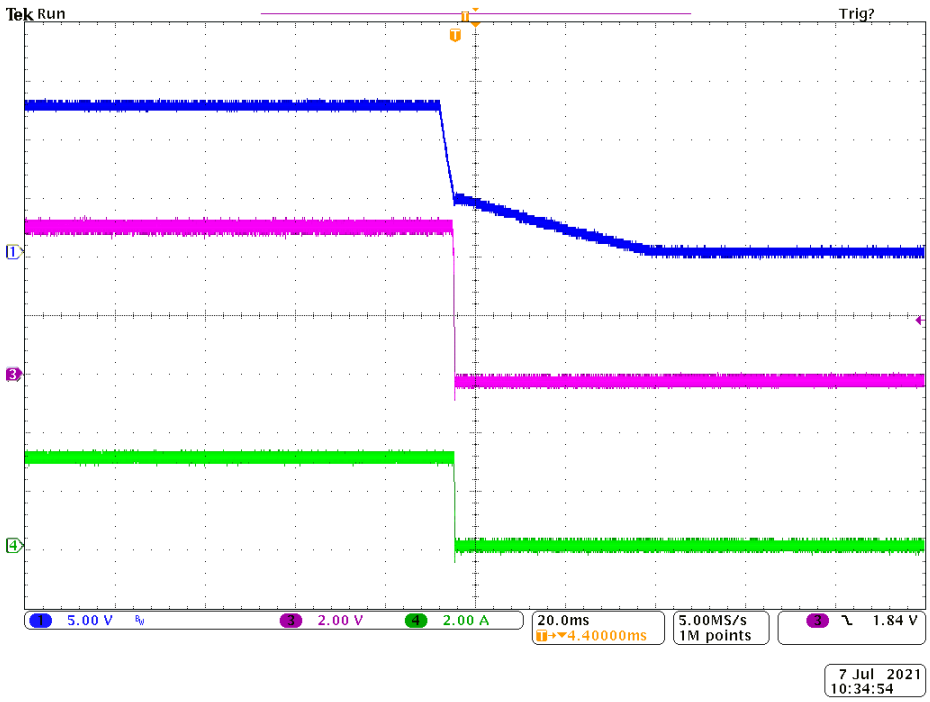
3.4 Power On and Power Off

The waveforms of system power on and off with full load outputs are shown in following images.



CH1: V_{IN}, CH3: V_{PA_BUS}, CH4: I_{PA_BUS}

Figure 3-8. Power On Waveform



CH1: V_{IN}, CH3: V_{PA_BUS}, CH4: I_{PA_BUS}

Figure 3-9. Power Off Waveform

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