Test Report: PMP40960

CISPR 25 Class 5 and Toyota TSC, 400-kHz Rated, 15-W Automotive USB Type-C Charger Reference Design

Description

This reference design is an EMI-optimized design for an automotive USB Type-C® charger with 15-W output. The TPS25854-Q1 is used as a DC/DC regulator and port controller. The switching frequency is 400 kHz. The front-end filter is designed and PCB layout is optimized to pass stringent CISPR 25 Class 5 and Toyota TSC 0505G:2019 conducted Electromagnetic Interference (EMI) standards. This reference design has already been tested to CISPR 25 Class 5 and Toyota TSC 0505G:2019 conducted EMI standards, which accelerates customer design time.

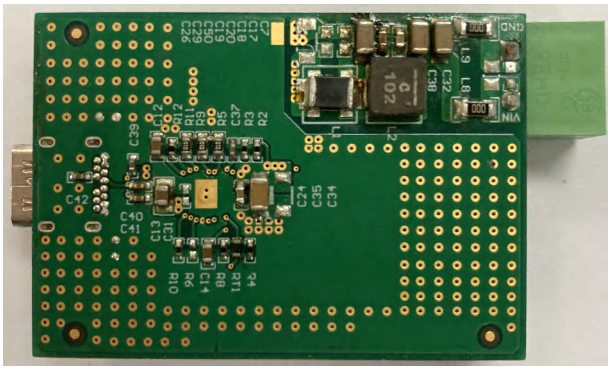
Features

- Passes stringent CISPR 25 Class 5 and Toyota TSC 0505G:2019 conducted electromagnetic interference (EMI) standards
- 95.1% peak efficiency
- USB Type-C® charger

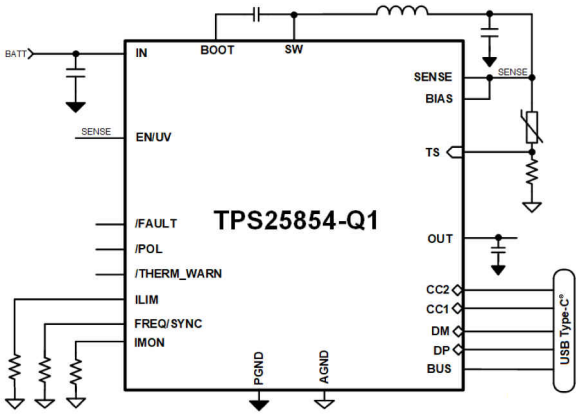
Applications

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

Top Photo



Bottom Photo



Block Diagram

1 Test Prerequisites

1.1 Voltage and Current Requirements

Table 1-1. Voltage and Current Requirements

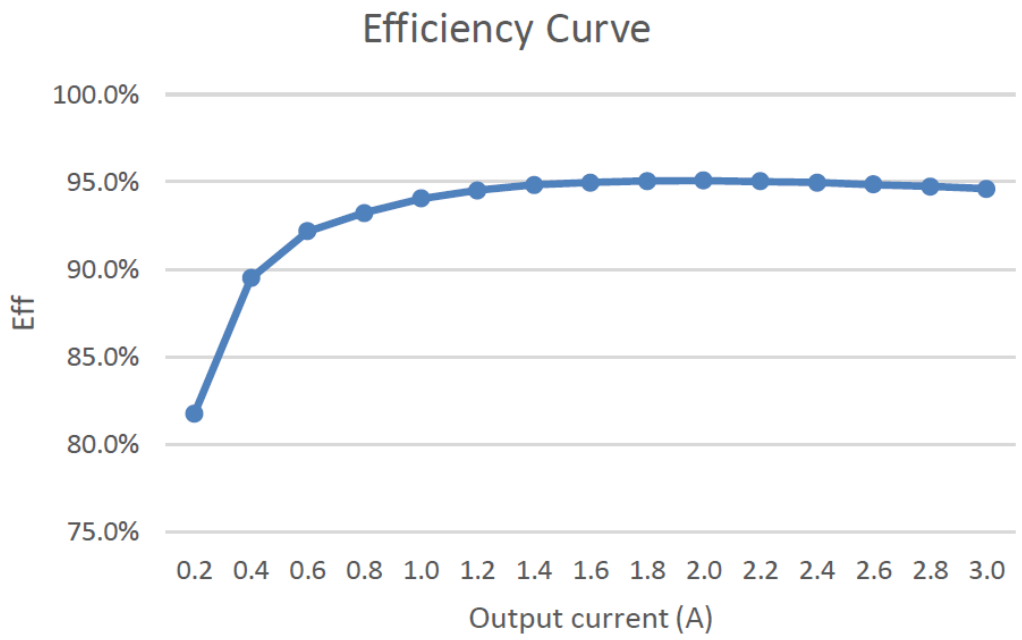
Parameter	Specifications
Input Voltage	12 Vdc
PA_BUS Output Voltage	5.17 Vdc
PA_BUS Maximum Output Current	3 A
Switching Frequency	400 kHz

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

2 Testing and Results

2.1 Efficiency Graphs



2.2 Efficiency Data

Efficiency data is shown in the following table.

V_{IN} (V)	I_{IN} (A)	V_{PA_BUS} (V)	I_{PA_BUS} (A)	Eff
12.0200	0.0217	5.0913	0.0000	0.0%
12.0150	0.1037	5.1050	0.1995	81.8%
12.0360	0.1894	5.1213	0.3984	89.5%
12.0500	0.2774	5.1367	0.5999	92.2%
12.0150	0.3661	5.1525	0.7958	93.2%
12.0020	0.4576	5.1663	0.9999	94.1%
12.0390	0.5458	5.1814	1.1986	94.5%
12.0260	0.6381	5.1963	1.4003	94.8%
12.0130	0.7303	5.2100	1.5991	95.0%
12.0000	0.8249	5.2263	1.8003	95.1%
12.0220	0.9169	5.2425	1.9991	95.1%
12.0070	1.0139	5.2575	2.2005	95.0%
11.9940	1.1105	5.2713	2.3994	95.0%
11.9800	1.2099	5.2863	2.6009	94.9%
12.0040	1.3034	5.3000	2.7969	94.7%
12.0150	1.4035	5.3150	3.0013	94.6%

2.3 Thermal Image

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

- T_a = 25°C
- 12-V input
- 3-A output

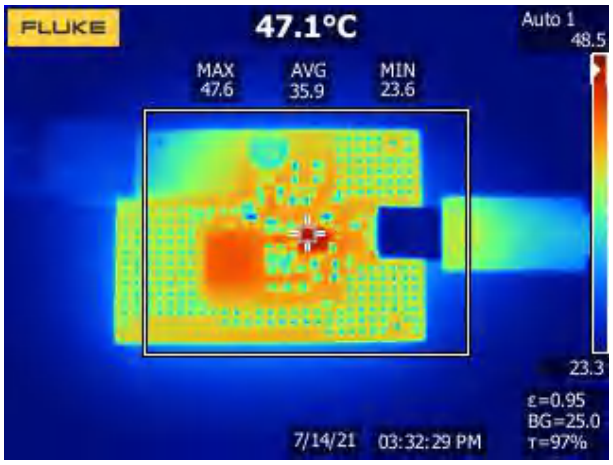


Figure 2-1. Top Side

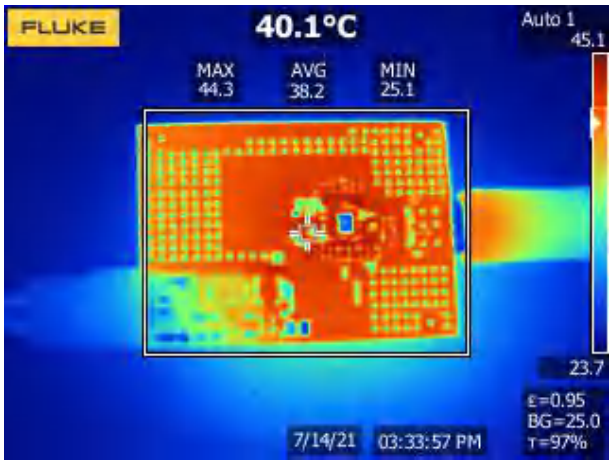


Figure 2-2. Bottom Side

2.4 Dimensions

The dimension of this board is 50 mm (length) × 35 mm (width) × 10 mm (height). Ignore J1 in Figure 2-3.

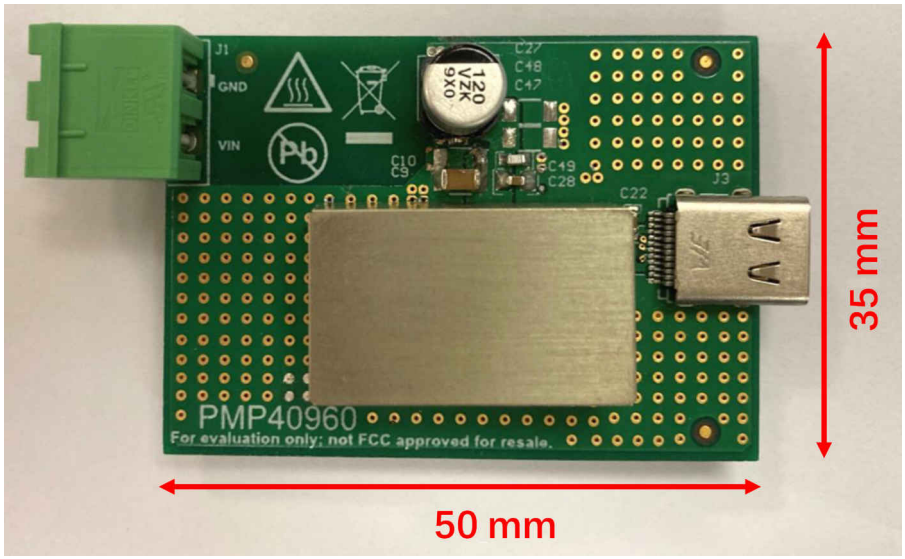


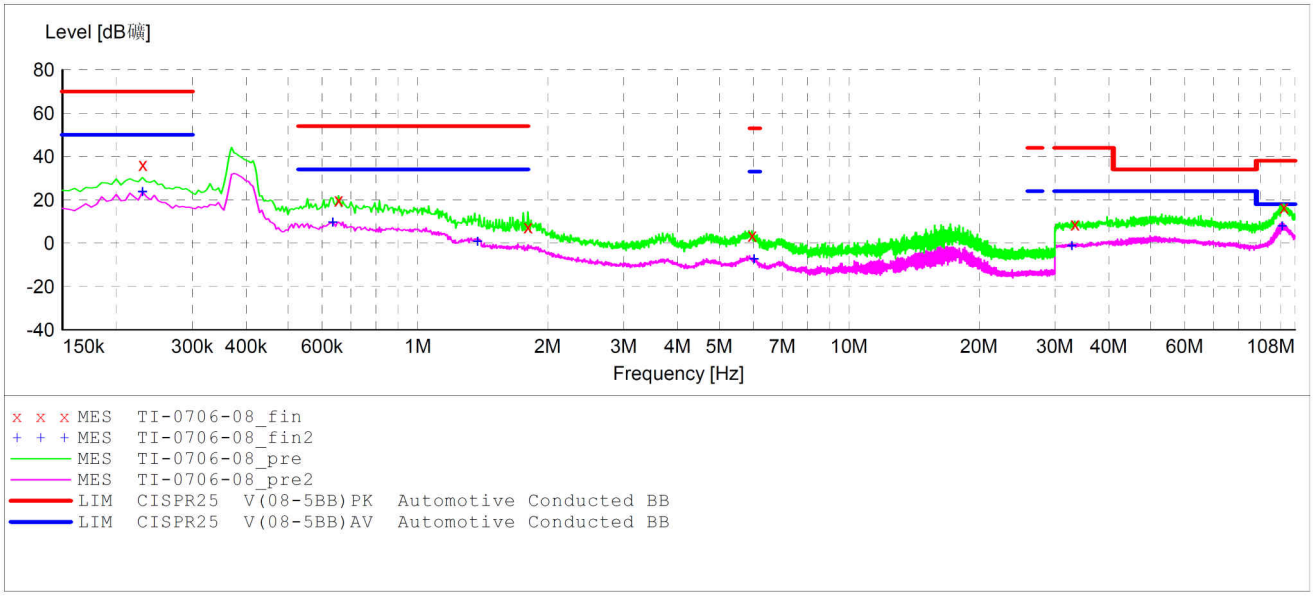
Figure 2-3. Board Dimensions

2.5 EMI

The conducted emissions are tested to the CISPR 25 class 5 and Toyota TSC 0505G:2019 standards. The CISPR 25 class 5 and Toyota TSC 0505G:2019 compliance were achieved without a common-mode choke. The waveforms of EMI test results are shown in following images.

Figure 2-4 and Figure 2-5 illustrate CISPR 25 Class 5 EMI performance from 150 kHz to 108 MHz, and the data was also collected under the following conditions:

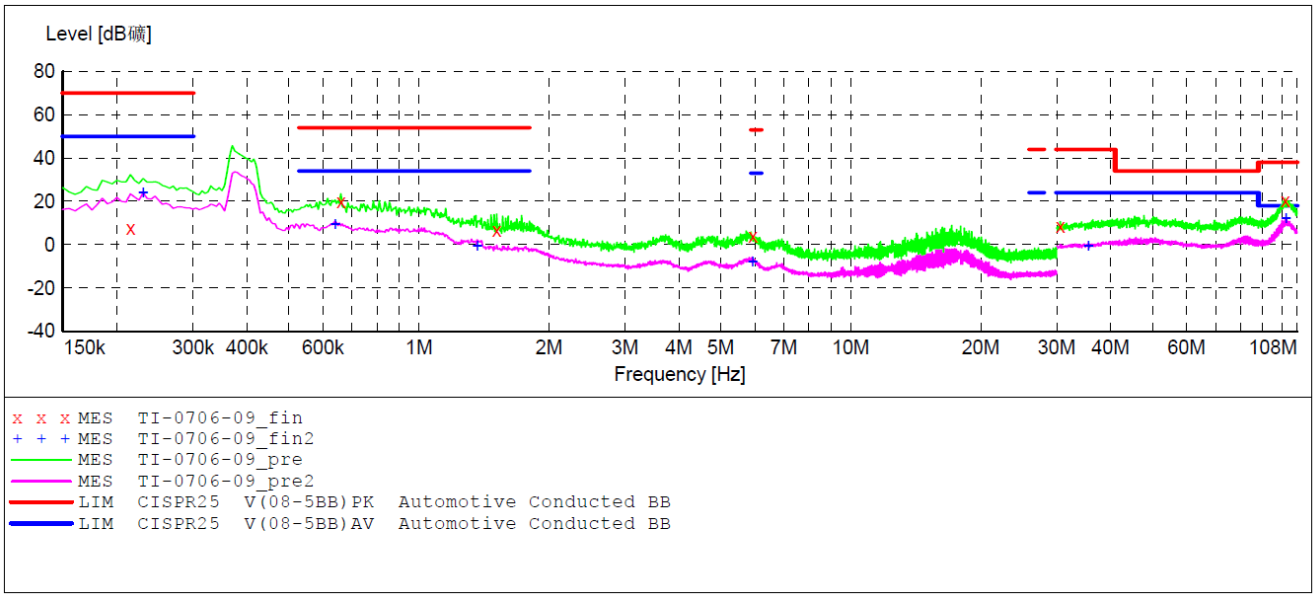
- V_{IN} = 12 V
- I_O = 3 A



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+



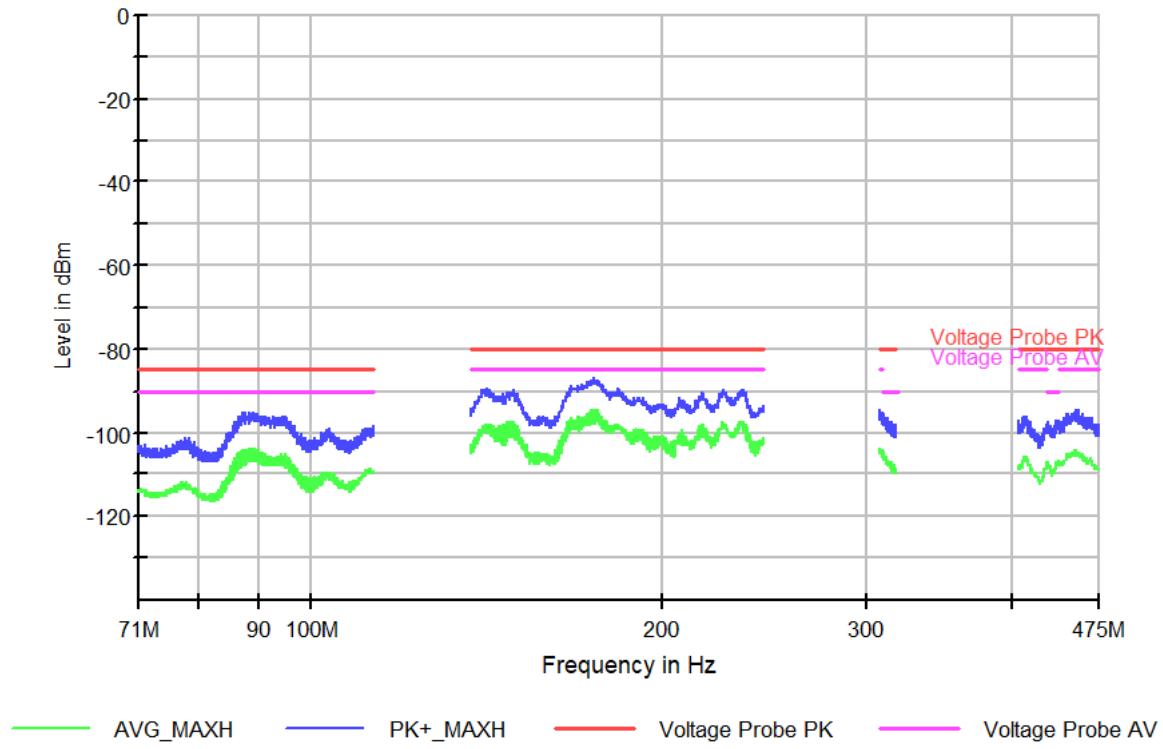
Green: peak detection result; Purple: average detection result

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

Figure 2-5. DC–

Figure 2-6 and Figure 2-7 Toyota TSC 0505G:2019 EMI performance from 71 MHz to 475 MHz, and the data was also collected under the following conditions:

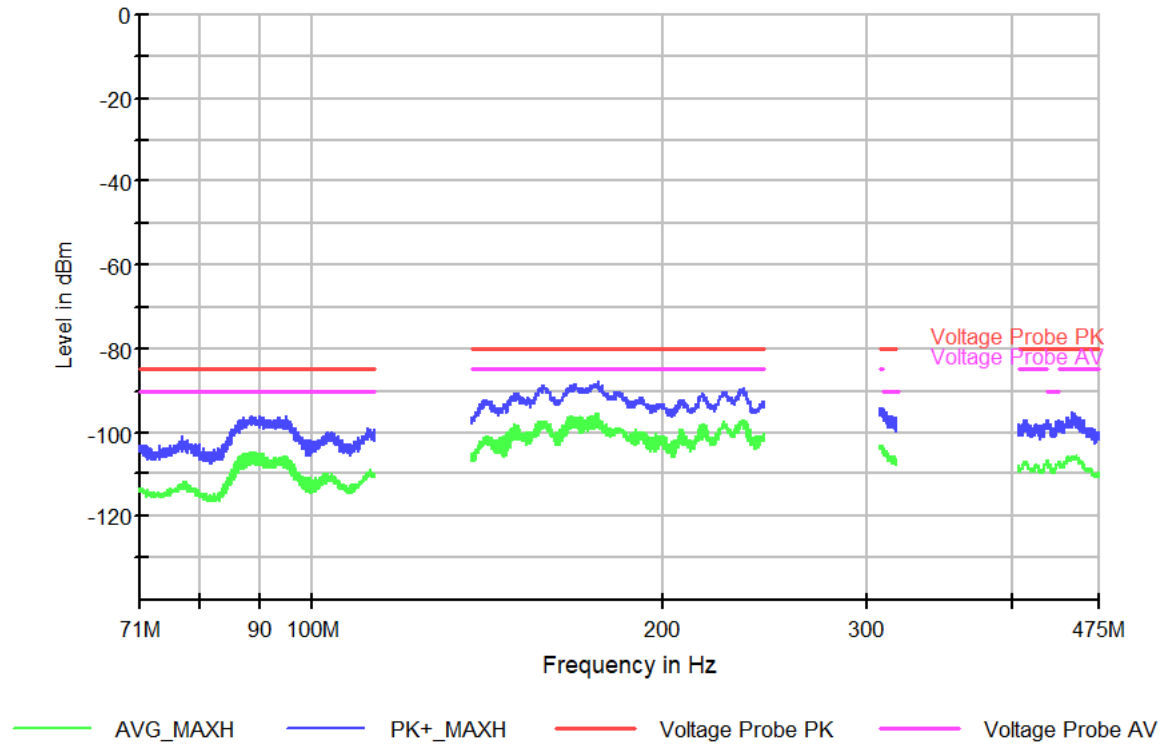
- V_{IN} = 12 V
- I_O = 3 A



Blue: peak detection result; Green: average detection result

Red: Toyota TSC 0505G:2019 peak limits; Purple: Toyota TSC 0505G:2019 average limits

Figure 2-6. DC+



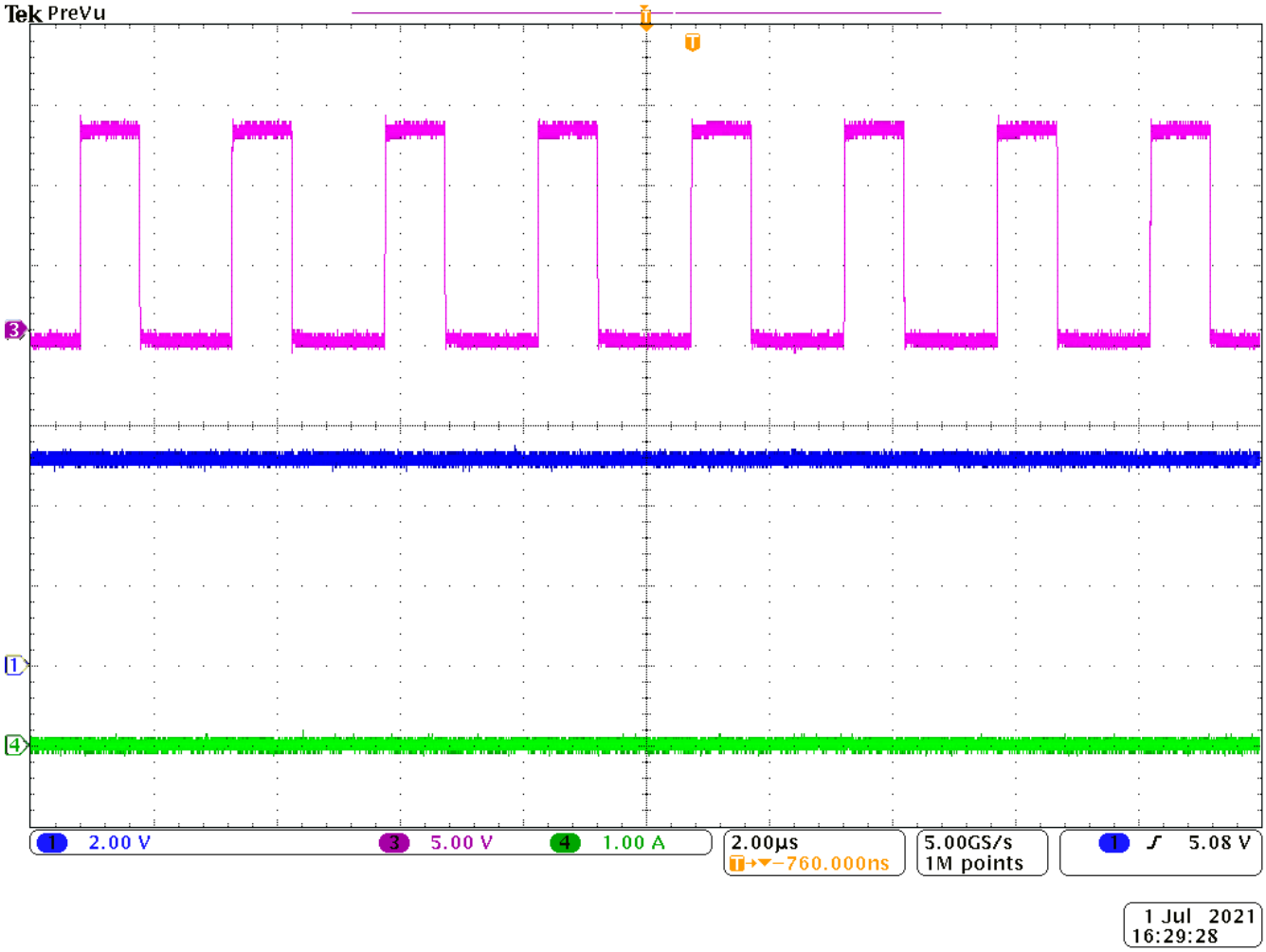
Blue: peak detection result; Green: average detection result
Red: Toyota TSC 0505G:2019 peak limits; Magenta: Toyota TSC 0505G:2019 average limits

Figure 2-7. DC–

3 Waveforms

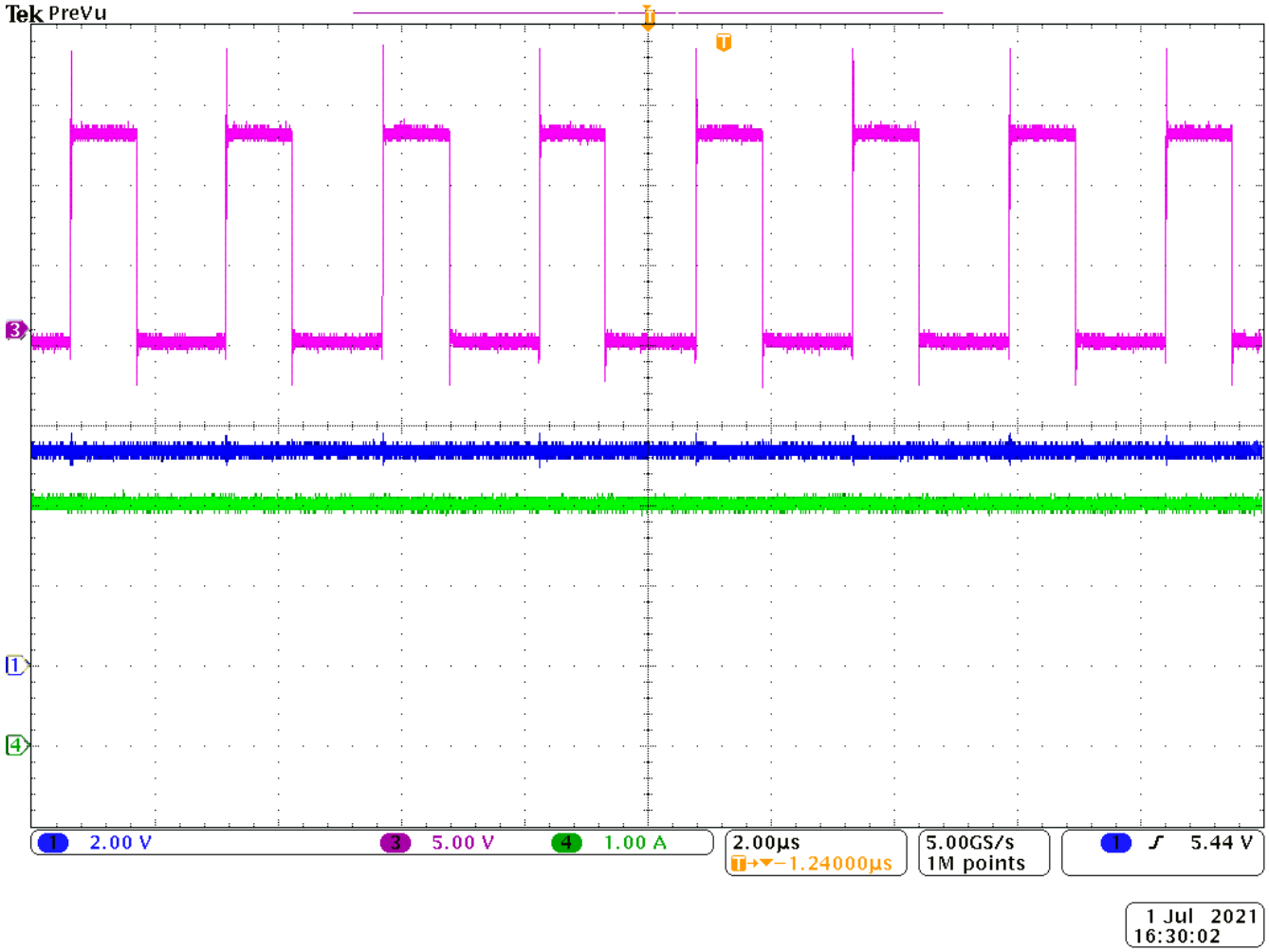
3.1 Switching

The waveforms of switching nodes at no load and full load condition are shown in following images.



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

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

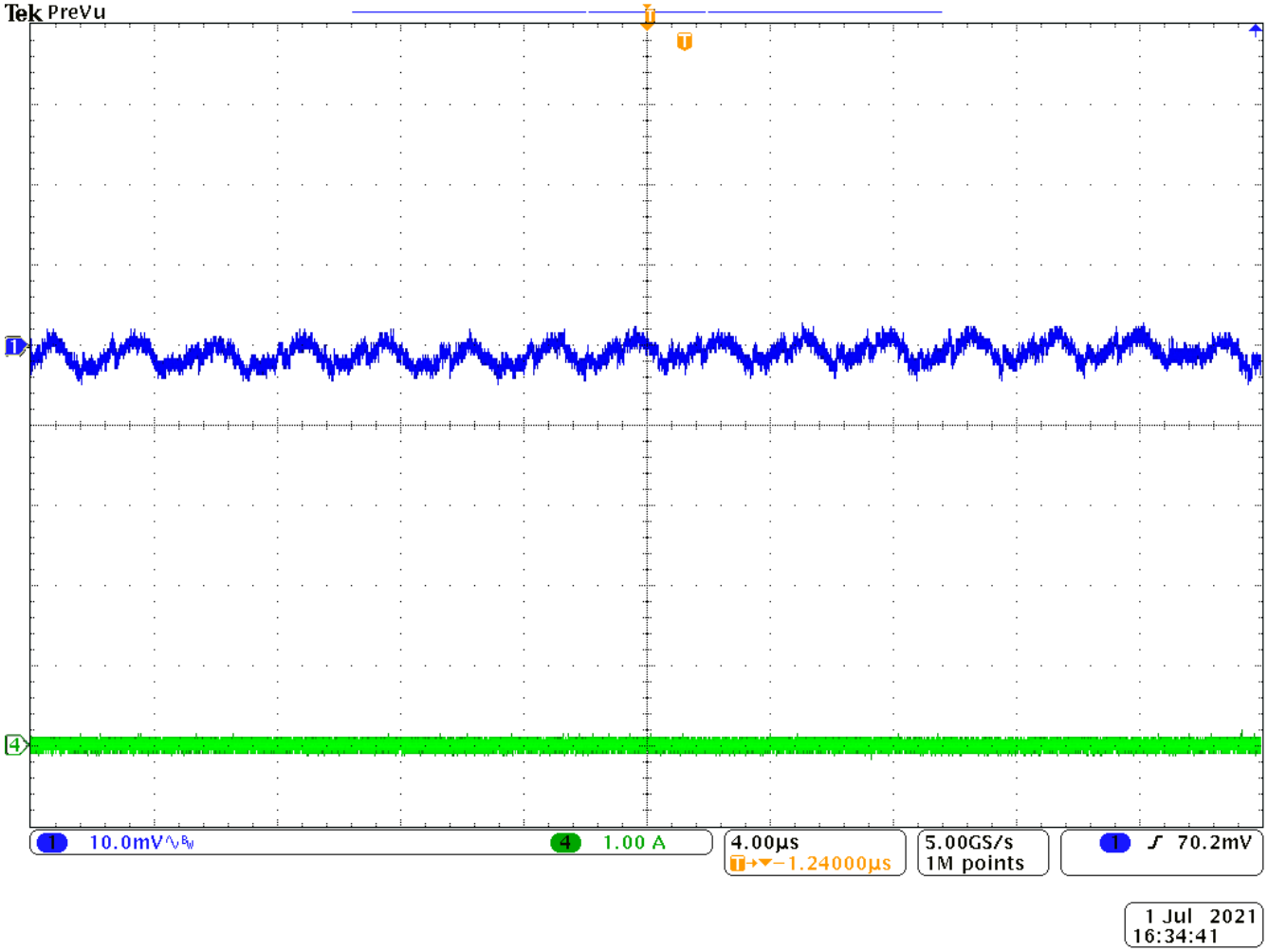


CH1: V_{PA_BUS}, CH3: V_{SW}, CH4: I_{PA_BUS}

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

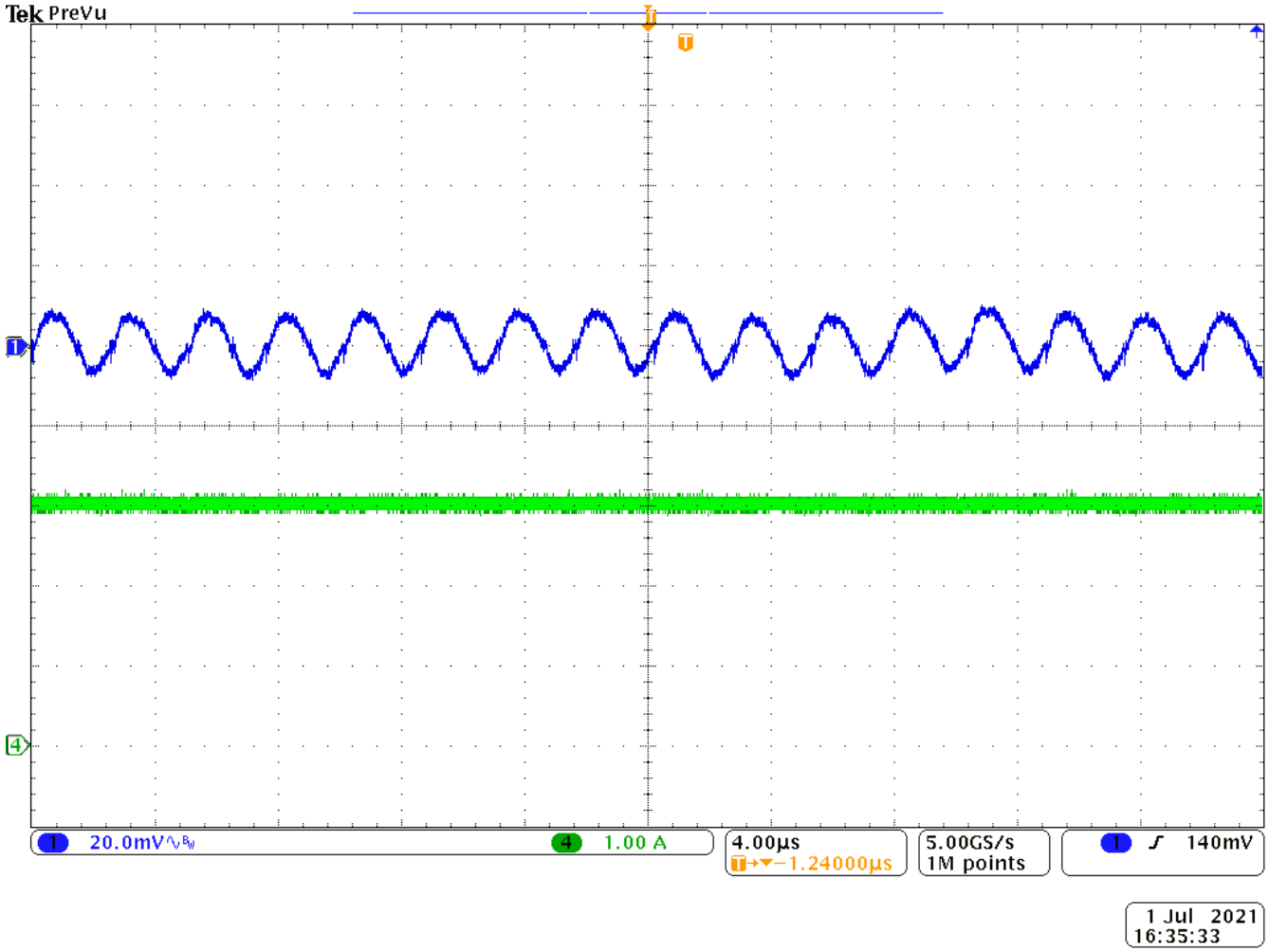
3.2 Output Voltage Ripple

The waveforms of output AC ripples at no load and full load conditions are shown in following images.



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

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

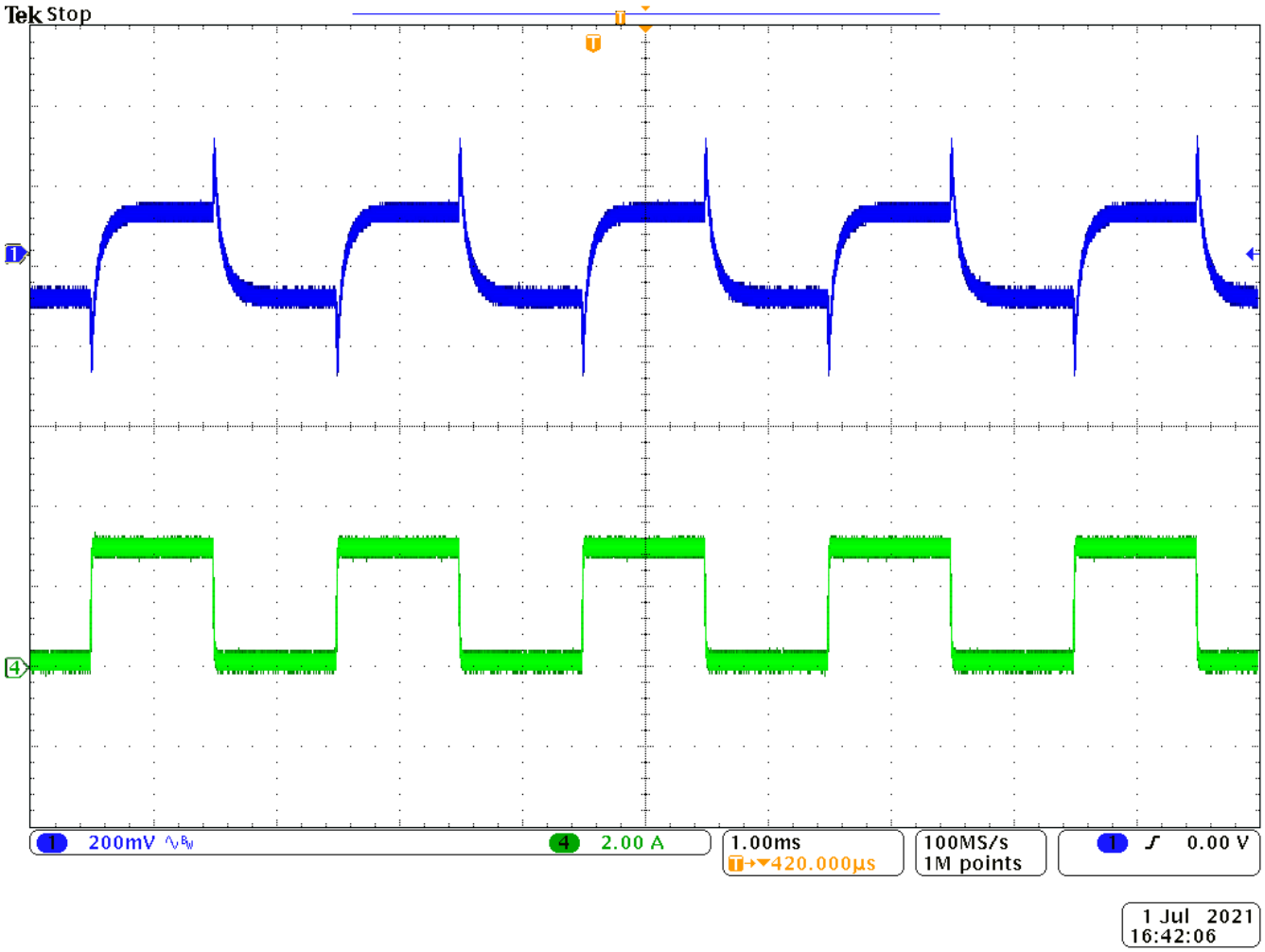


CH1: V_{PA_BUS}, CH4: I_{PA_BUS}

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

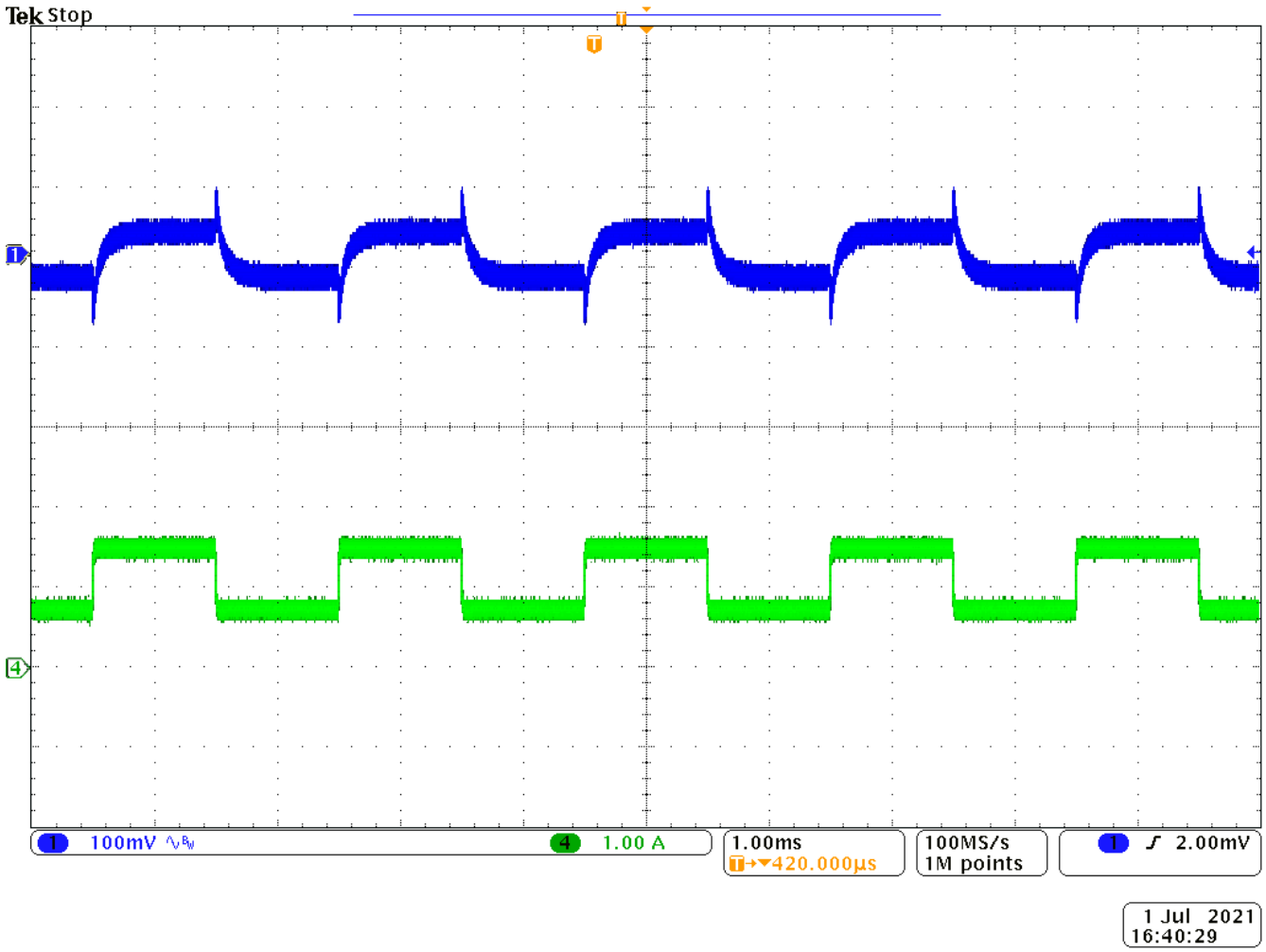
3.3 Load Transients

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.



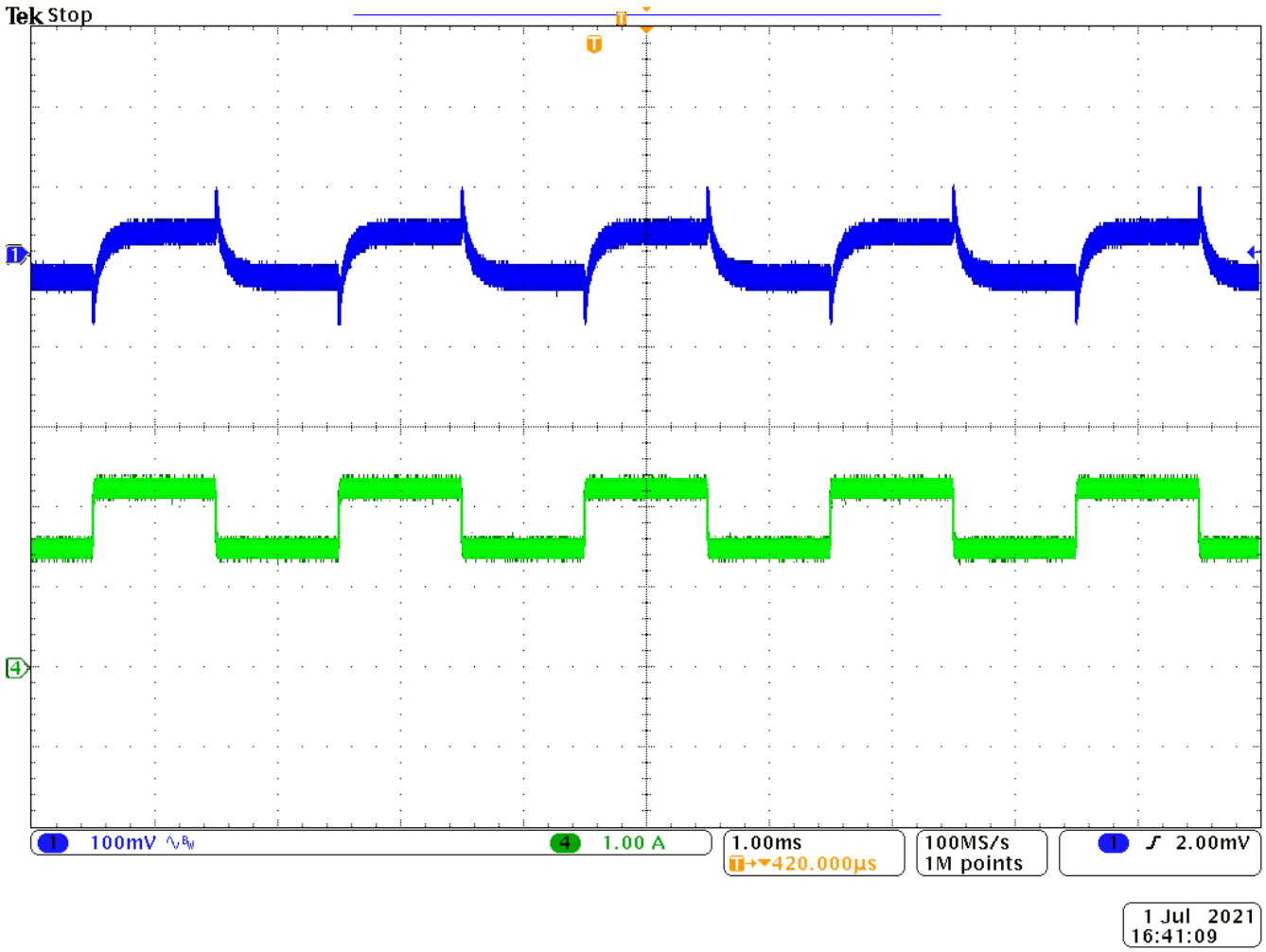
CH1: V_{PA_BUS}, CH4: I_{PA_BUS}

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

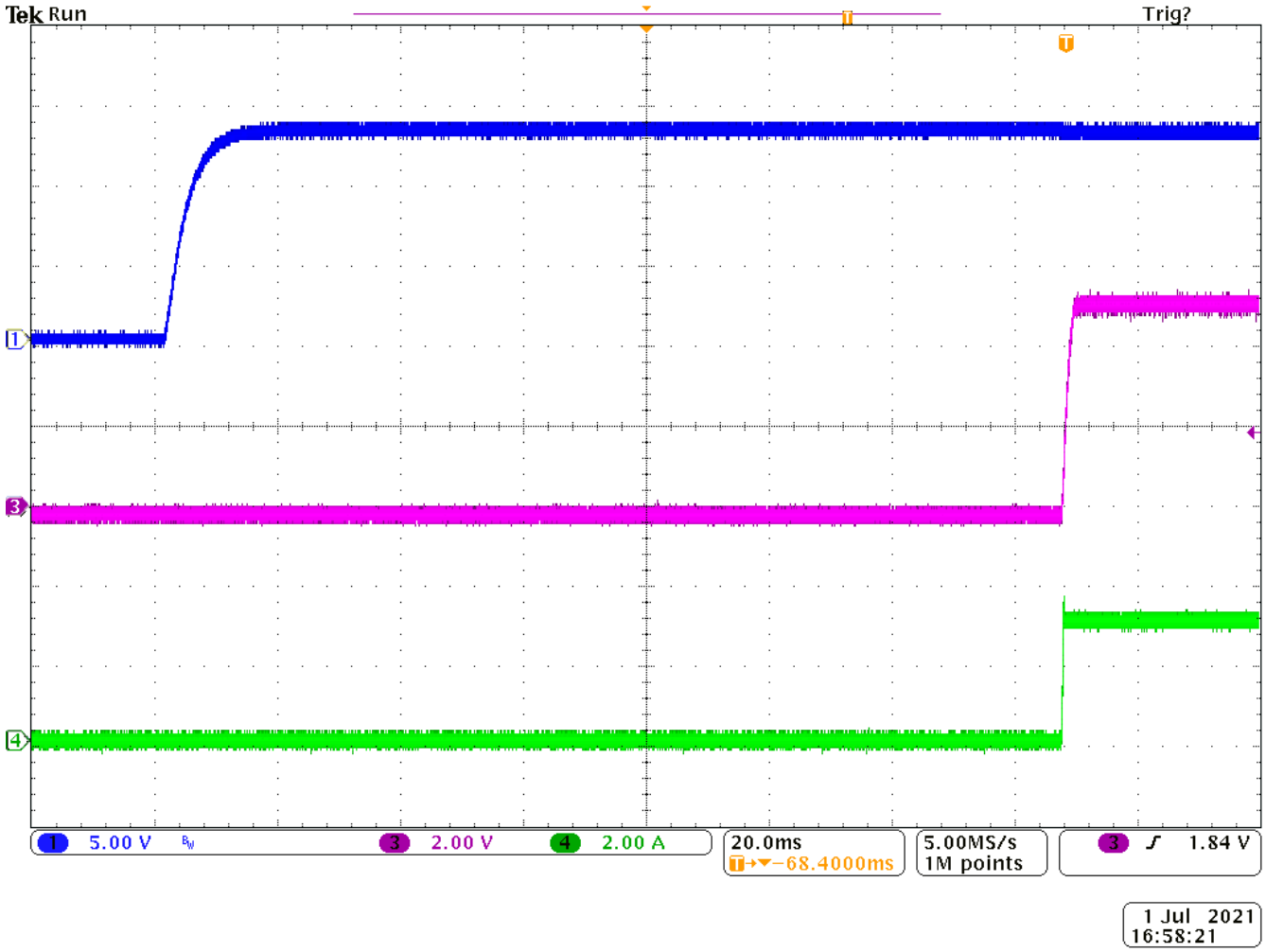


CH1: V_{PA_BUS}, CH4: I_{PA_BUS}

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

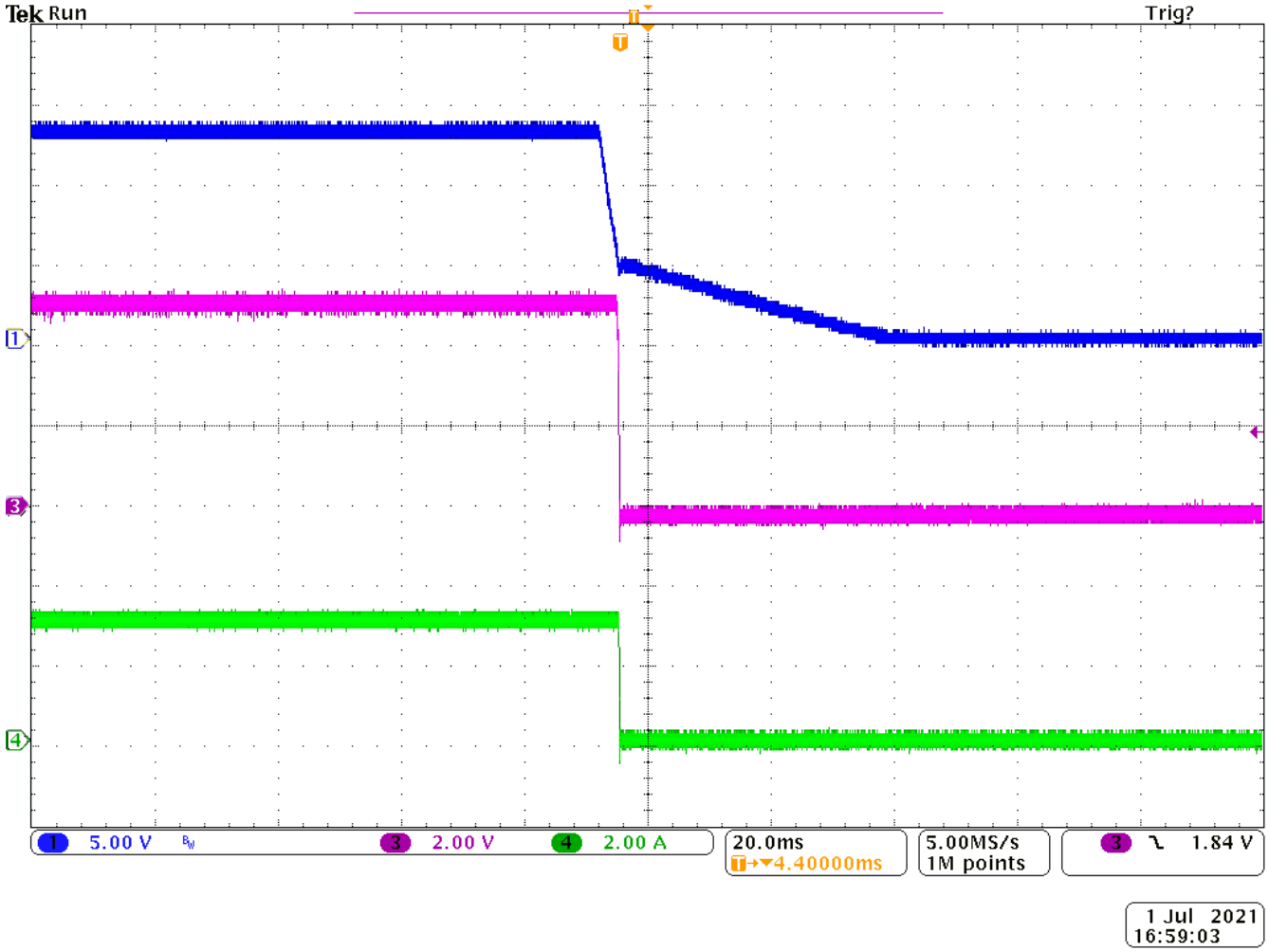
3.4 Power On and Power Off

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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