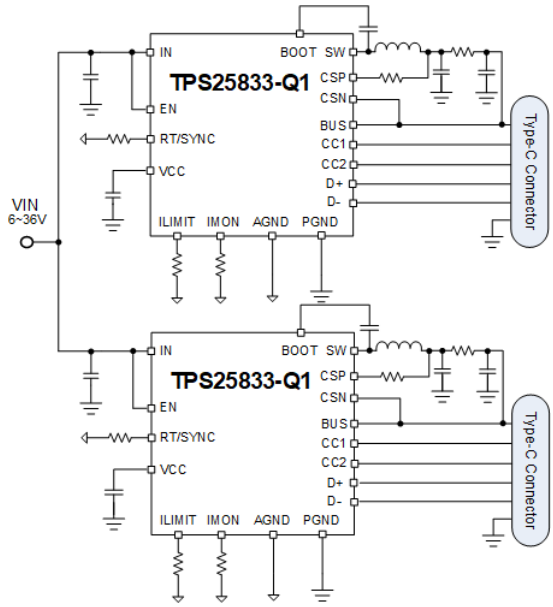
Test Report: PMP40542

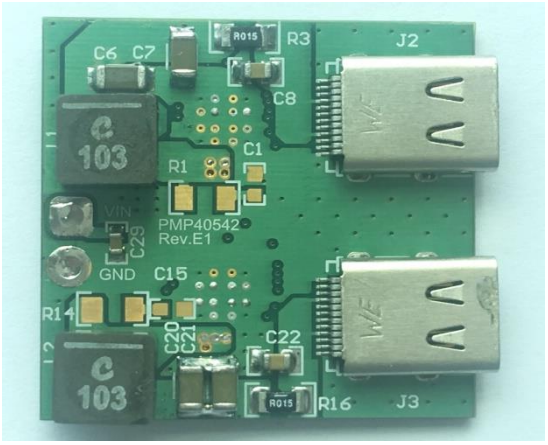
Small Size, Automotive Dual 15-W USB Type-C™ Charger Reference Design

Description

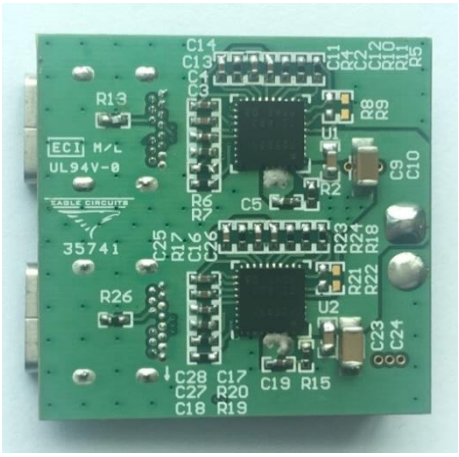
This reference design is for an automotive dual-port USB Type-C charger in 30-mm×30-mm dimension. The TPS25833-Q1 is used in each port as DC-DC regulator and port controller. The efficiency of solution is 92.93% at 2×15-W output, which leads to only 55.9°C temperature rise. In an 85°C environment, the highest temperature on the board is 137°C. Programmable cable droop compensation helps portable devices charge at optimum current and voltage under heavy loads.



Top



Bottom



1 Test Prerequisites

1.1 Voltage and Current Requirements

Table 1. Voltage and Current Requirements

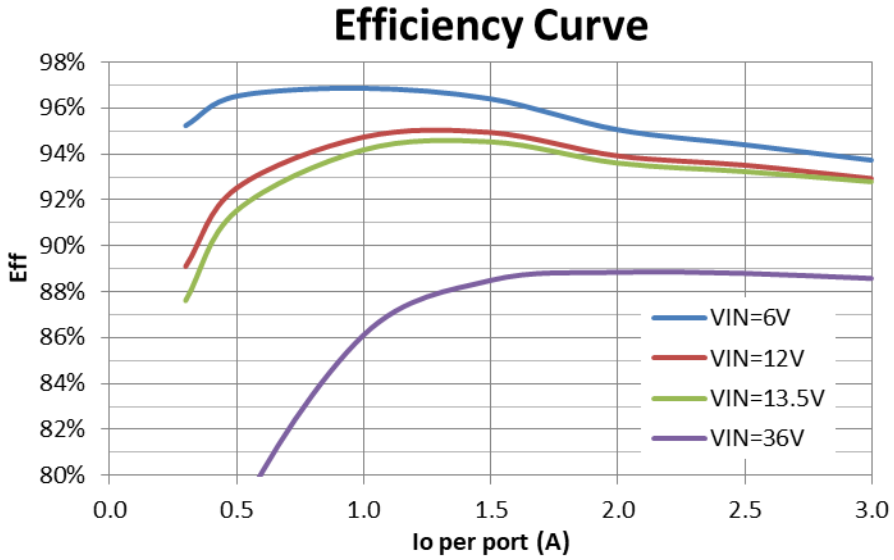
PARAMETER	SPECIFICATIONS
Input Voltage	6~36 Vdc
Port 1 Output Voltage	5 Vdc
Port 1 Maximum Output Current	3 A
Port 2 Output Voltage	5 Vdc
Port 2 Maximum Output Current	3 A
Switching Frequency	400k Hz

1.2 Required Equipment

- Multi-meter (current): Fluke 287C
- Multi-meter (voltage): Fluke 287C
- DC Source: Chroma 62006P-100-25
- E-Load: Chroma 63105A module
- Oscilloscope: Tektronix DPO3054
- Electrical Thermography: Fluke TiS55
- Thermal Data Acquisition: Agilent 34970A

2 Testing and Results

2.1 Efficiency Graphs

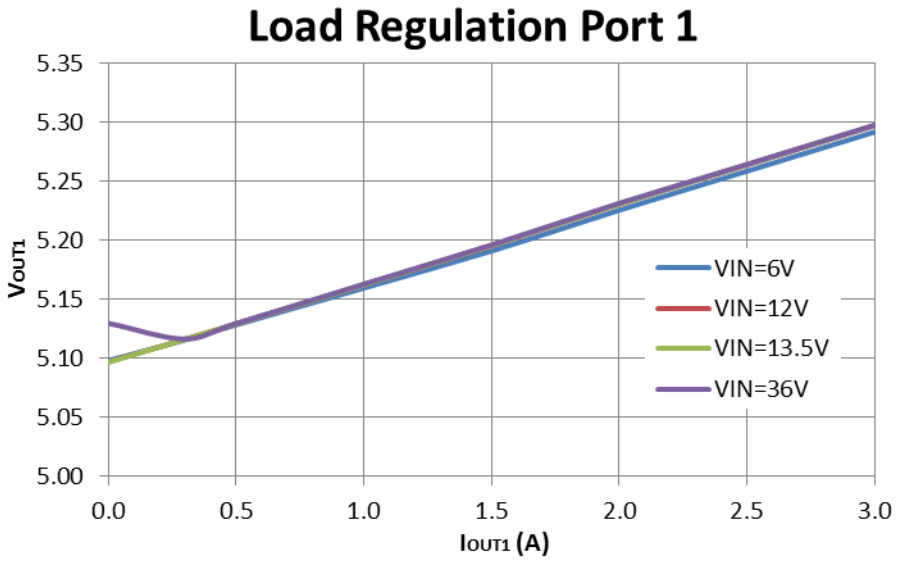


2.2 Efficiency Data

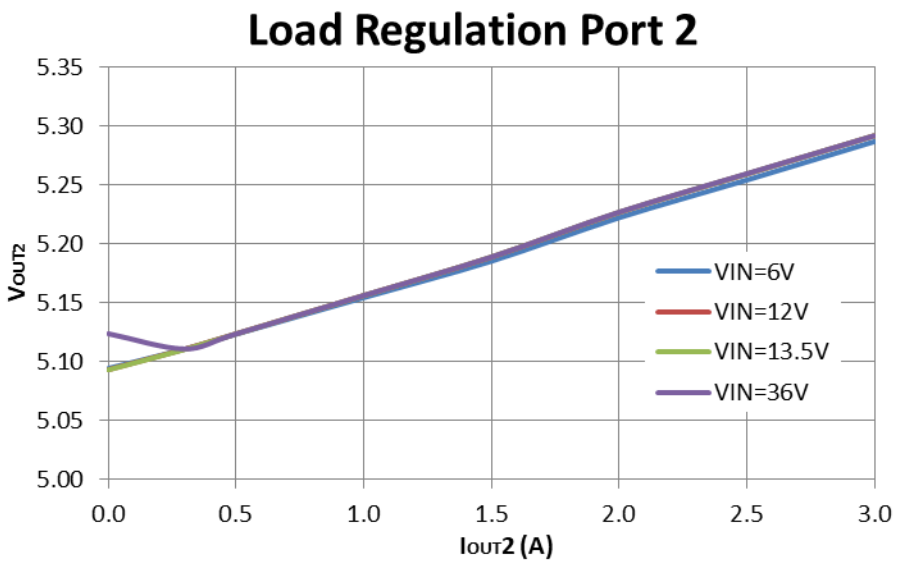
V_{IN} (V)	I_{IN} (A)	V_{OUT1} (V)	I_{OUT1} (A)	V_{OUT2} (V)	I_{OUT2} (A)	Eff
5.993	5.639	5.292	2.997	5.287	2.991	**93.73%**
5.993	4.634	5.258	2.497	5.254	2.492	**94.40%**
5.996	3.657	5.225	1.997	5.222	1.994	**95.06%**
5.997	2.687	5.191	1.498	5.185	1.495	**96.40%**
5.998	1.770	5.159	0.998	5.154	0.996	**96.86%**
5.998	0.883	5.128	0.499	5.123	0.498	**96.51%**
5.993	0.536	5.116	0.300	5.111	0.299	**95.23%**
6.003	0.020	5.098	0.000	5.094	0.000	
11.996	2.844	5.297	2.997	5.292	2.991	**92.93%**
11.996	2.340	5.264	2.497	5.259	2.492	**93.51%**
11.998	1.852	5.230	1.997	5.227	1.993	**93.92%**
11.991	1.365	5.195	1.498	5.189	1.495	**94.94%**
11.999	0.905	5.162	0.998	5.156	0.996	**94.73%**
11.994	0.461	5.129	0.499	5.124	0.498	**92.50%**
11.997	0.286	5.116	0.300	5.111	0.299	**89.10%**
12.001	0.029	5.097	0.000	5.093	0.000	

13.496	2.532	5.297	2.997	5.292	2.992	**92.79%**
13.497	2.086	5.264	2.497	5.259	2.492	**93.24%**
13.497	1.652	5.230	1.997	5.227	1.994	**93.60%**
13.497	1.218	5.195	1.498	5.189	1.495	**94.53%**
13.499	0.809	5.162	0.998	5.156	0.996	**94.17%**
13.492	0.414	5.129	0.499	5.123	0.498	**91.52%**
13.495	0.259	5.116	0.300	5.110	0.299	**87.61%**
13.498	0.030	5.097	0.000	5.093	0.000	
35.998	0.994	5.297	2.997	5.292	2.992	**88.58%**
35.998	0.821	5.264	2.497	5.259	2.492	**88.80%**
35.998	0.652	5.231	1.997	5.227	1.994	**88.85%**
35.991	0.488	5.196	1.498	5.189	1.496	**88.49%**
35.994	0.332	5.163	0.998	5.156	0.996	**86.09%**
35.996	0.182	5.129	0.499	5.123	0.498	**78.01%**
35.997	0.122	5.116	0.300	5.111	0.299	**69.65%**
35.999	0.002	5.130	0.000	5.124	0.000	

2.3 Load Regulation



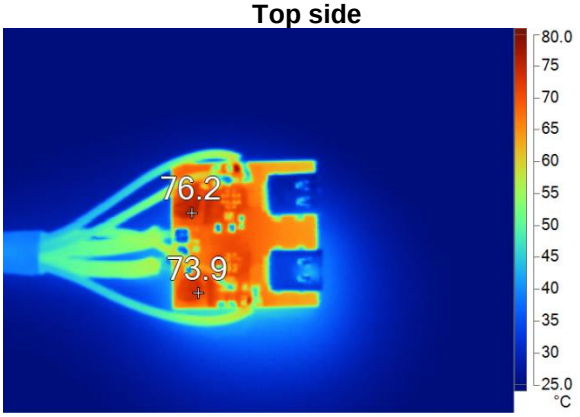
(A 2.74KΩ resistor on IMON pin for cable droop compensation.)



(A 2.74KΩ resistor on IMON pin for cable droop compensation.)

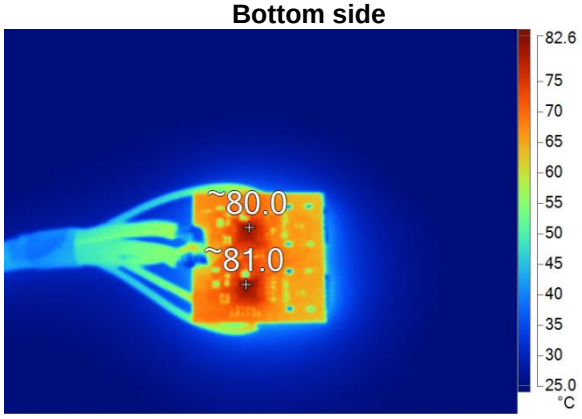
2.4 Thermal Images

Ta=25.1°C, 12 V input, 3A+3A output
(4-layer PCB, 2 oz copper on top and bottom layers, 1 oz copper on middle layers.)
Top side



T_{L_max}**=76.2°C,** ΔT**=51.1°C**

Bottom side



T_{case_max}**=81.0°C,** ΔT**=55.9°C**

2.5 High Temp Test

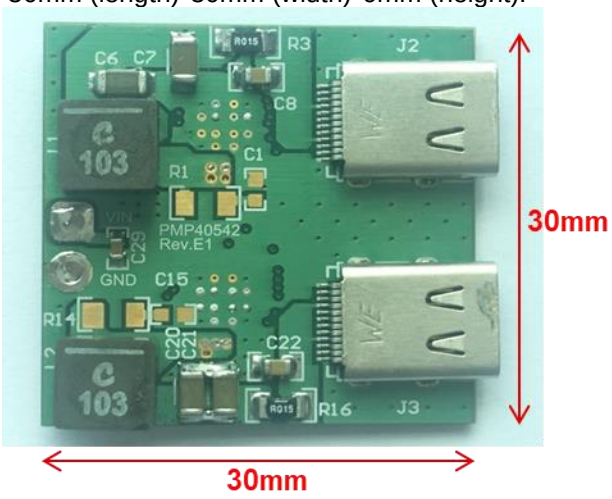
Run the board in the 85°C test chamber; detect the temperature of IC and inductors with thermocouple to 34970A.

Ta=85°C Chamber, 12V input, 3A+3A output

Component	T_{CASE}	ΔT
U1	**137.0°C**	52.0°C
L1	**132.1°C**	47.1°C
U2	**135.0°C**	50.0°C
L2	**131.9°C**	46.9°C

2.6 Dimensions

The dimension of this board is 30mm (length)*30mm (width)*6mm (height).

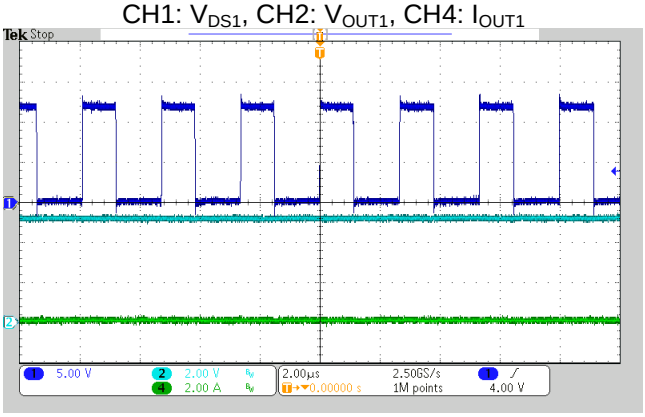


3 Waveforms

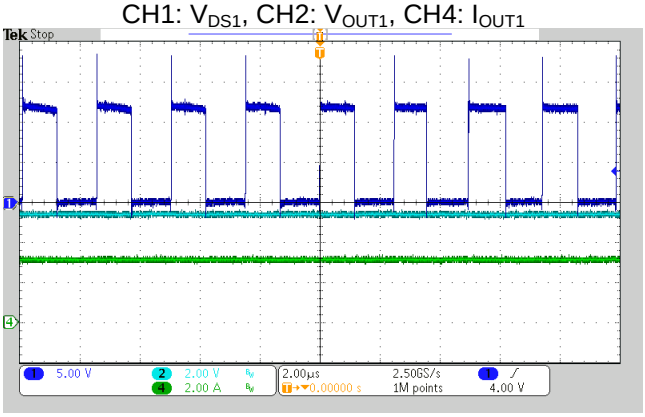
3.1 Switching

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

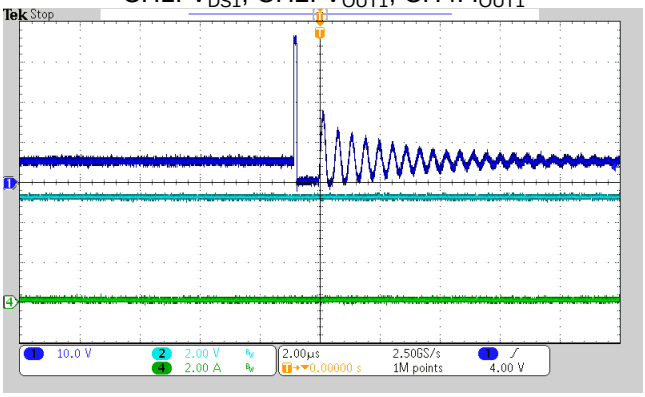
U1, 12V input, 5V no-load
CH1: V_{DS1}, CH2: V_{OUT1}, CH4: I_{OUT1}



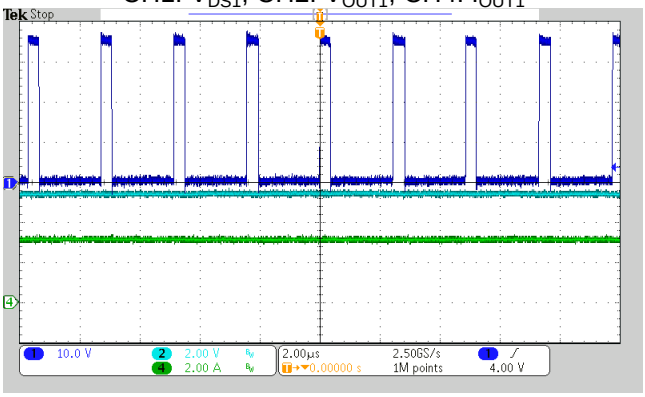
U1, 12V input, 5V 3A
CH1: V_{DS1}, CH2: V_{OUT1}, CH4: I_{OUT1}



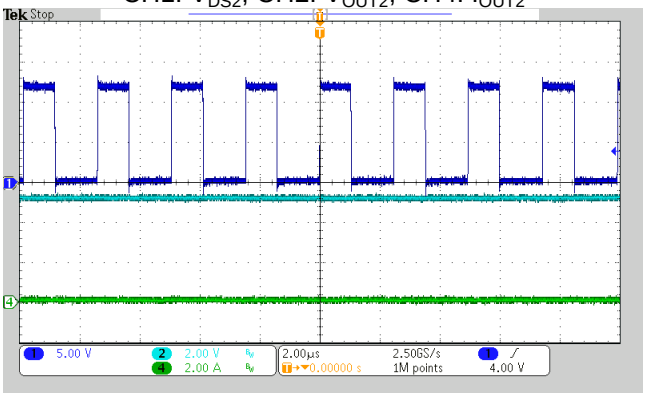
36V input, U1, 5V no-load
CH1: V_{DS1}, CH2: V_{OUT1}, CH4: I_{OUT1}



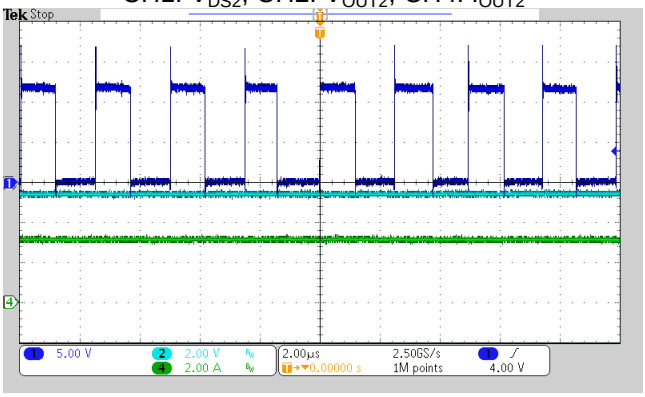
36V input, U1, 5V 3A
CH1: V_{DS1}, CH2: V_{OUT1}, CH4: I_{OUT1}



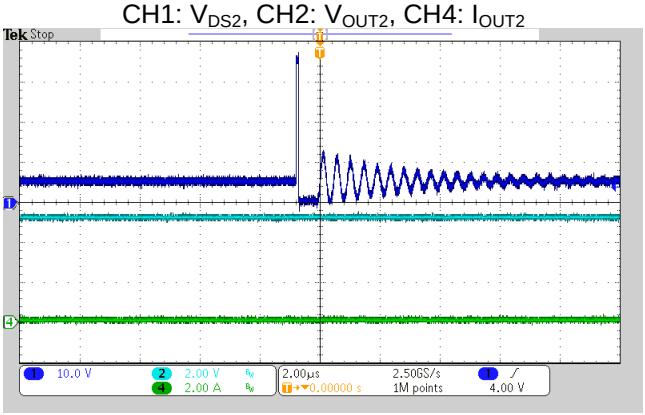
U2, 12V input, 5V no-load
CH1: V_{DS2}, CH2: V_{OUT2}, CH4: I_{OUT2}



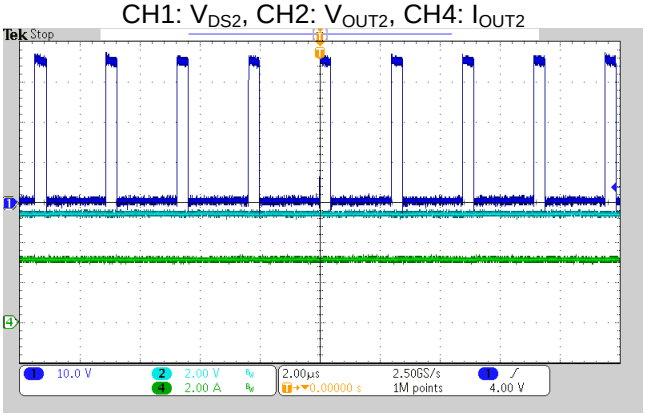
U2, 12V input, 5V 3A
CH1: V_{DS2}, CH2: V_{OUT2}, CH4: I_{OUT2}



U2, 36V input, 5V no-load
CH1: V_{DS2}, CH2: V_{OUT2}, CH4: I_{OUT2}



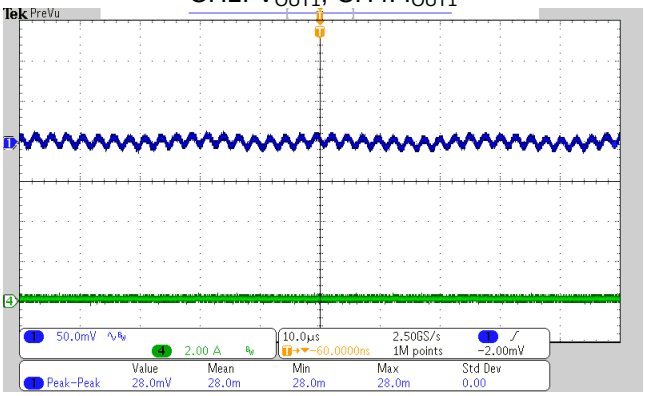
U2, 36V input, 5V 3A
CH1: V_{DS2}, CH2: V_{OUT2}, CH4: I_{OUT2}



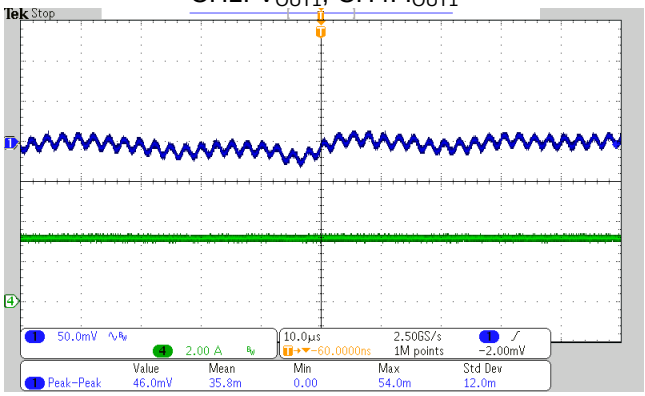
3.2 Output Voltage Ripple

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

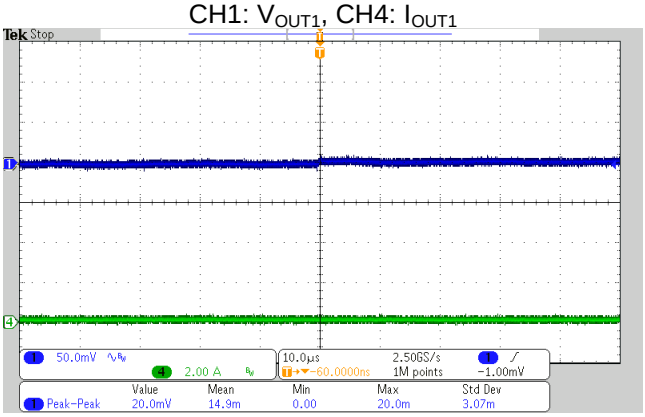
Port 1, 12V input, 5V no-load
CH1: V_{OUT1}, CH4: I_{OUT1}



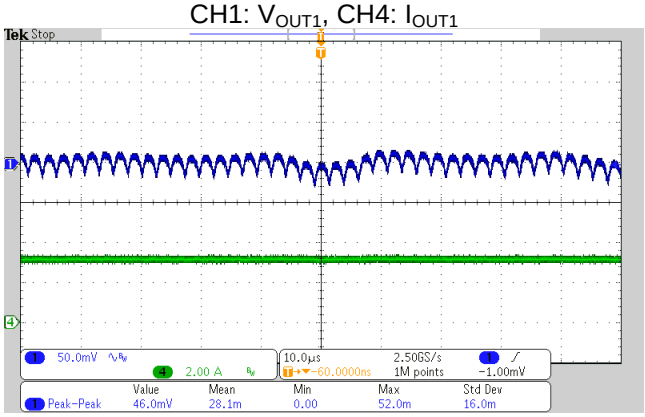
Port 1, 12V input, 5V 3A
CH1: V_{OUT1}, CH4: I_{OUT1}



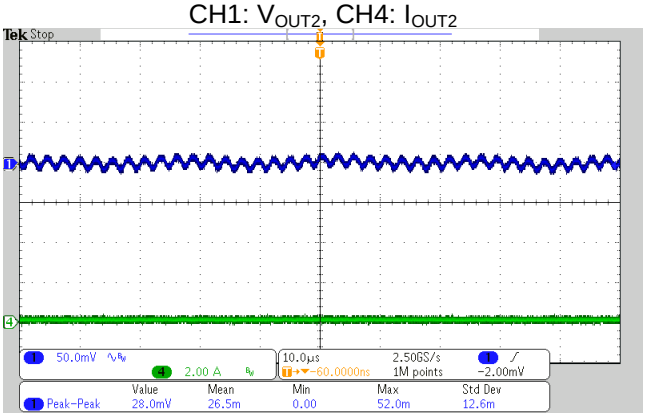
Port 1, 36V input, 5V no-load
CH1: V_{OUT1}, CH4: I_{OUT1}



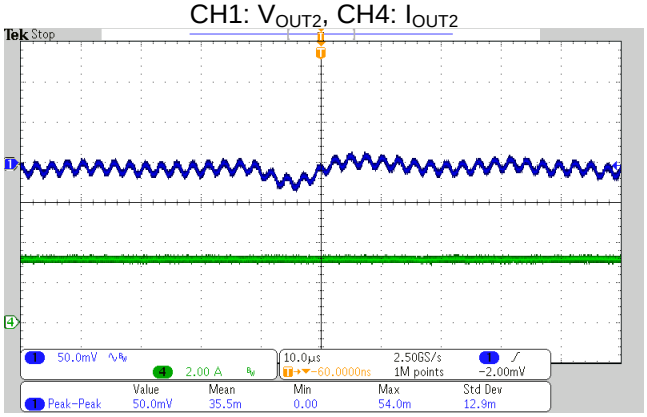
Port 1, 36V input, 5V 3A
CH1: V_{OUT1}, CH4: I_{OUT1}



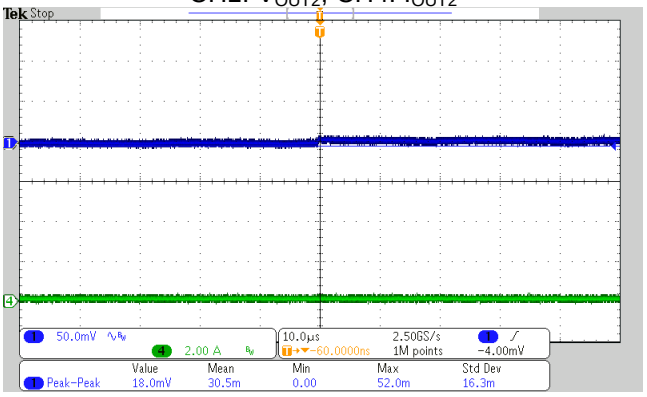
Port 2, 12V input, 5V no-load
CH1: V_{OUT2}, CH4: I_{OUT2}



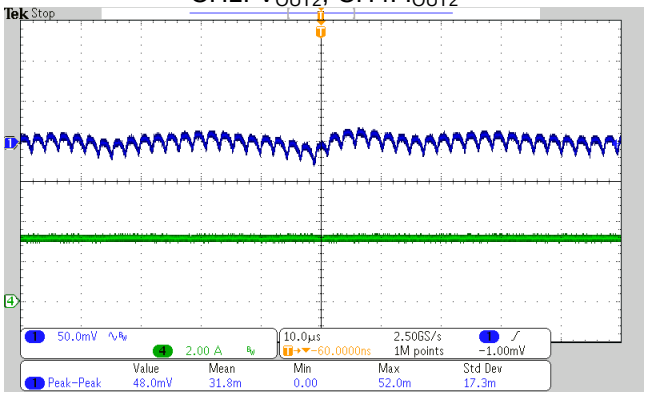
Port 2, 12V input, 5V 3A
CH1: V_{OUT2}, CH4: I_{OUT2}



Port 2, 36V input, 5V no-load
CH1: V_{OUT2}, CH4: I_{OUT2}



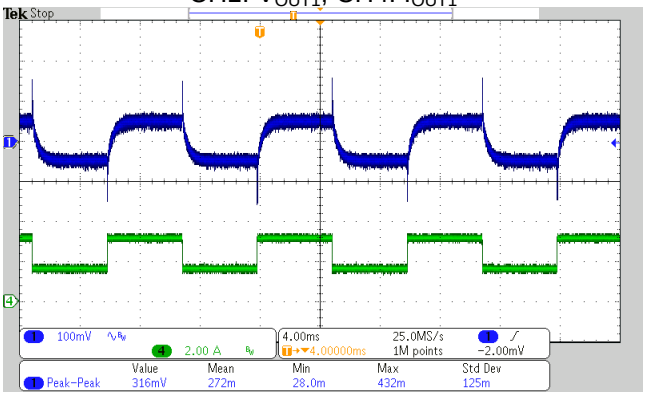
Port 2, 36V input, 5V 3A
CH1: V_{OUT2}, CH4: I_{OUT2}



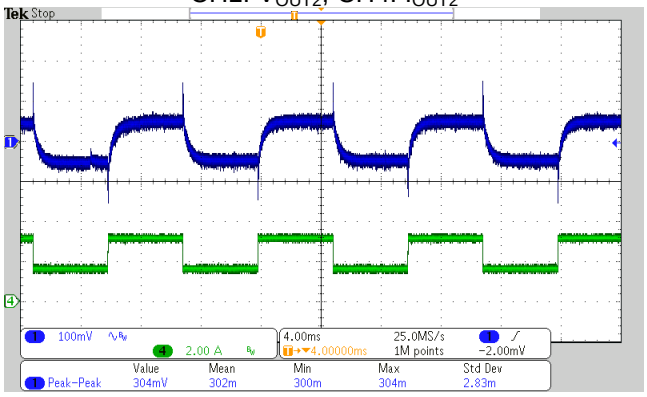
3.3 Load Transient

The waveforms of output AC ripples at load transient are shown in following pictures. The high current level is 3A for 5ms; the low current level is 1.5A for 5ms, with a slew rate of 0.1A/us.

Port 1, 12V input, 1.5A->3A
CH1: V_{OUT1}, CH4: I_{OUT1}



Port 2, 12V input, 1.5A->3A
CH1: V_{OUT2}, CH4: I_{OUT2}

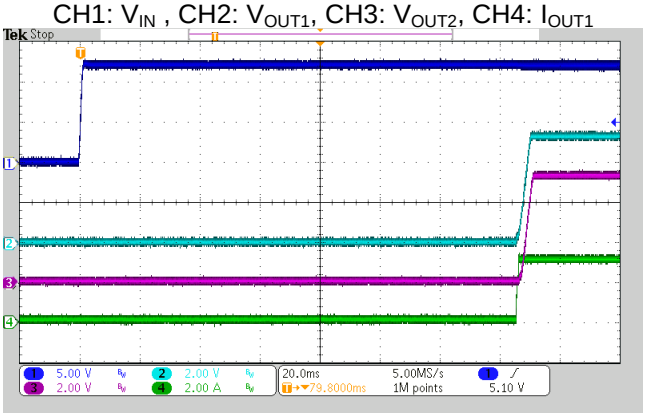


3.4 Power on/off

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

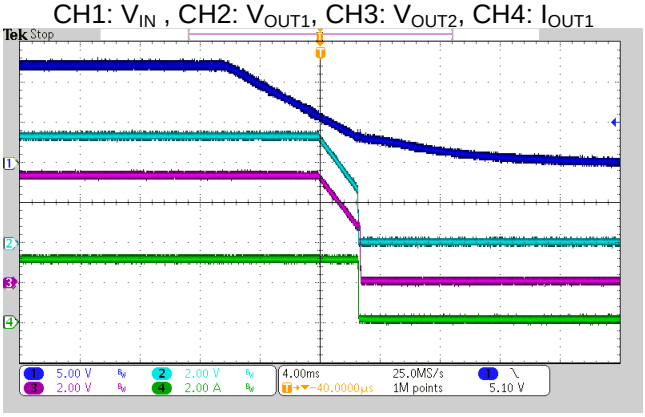
Power on

CH1: V_{IN} , CH2: V_{OUT1}, CH3: V_{OUT2}, CH4: I_{OUT1}



Power off

CH1: V_{IN} , CH2: V_{OUT1}, CH3: V_{OUT2}, CH4: I_{OUT1}



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