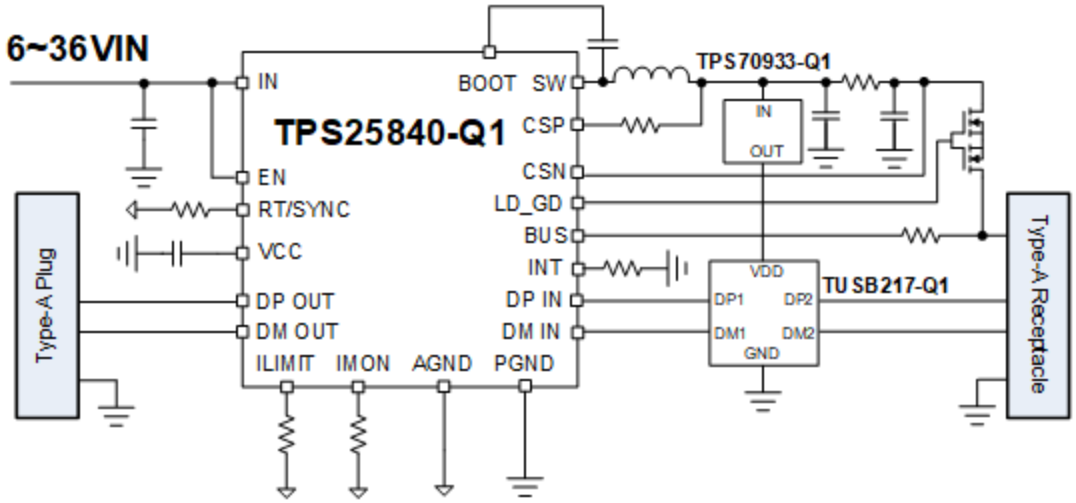
Test Report: PMP40544

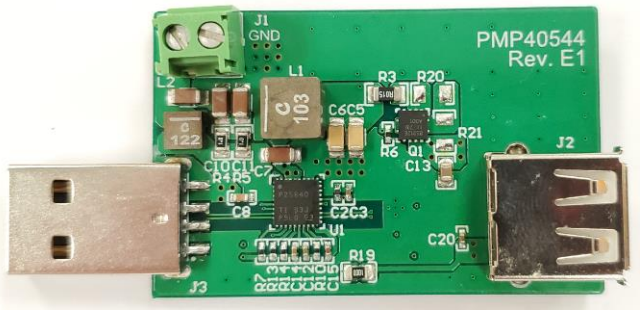
Automotive USB Type-A Charger Reference Design With 3-m USB-IF Near-End Compliant

Description

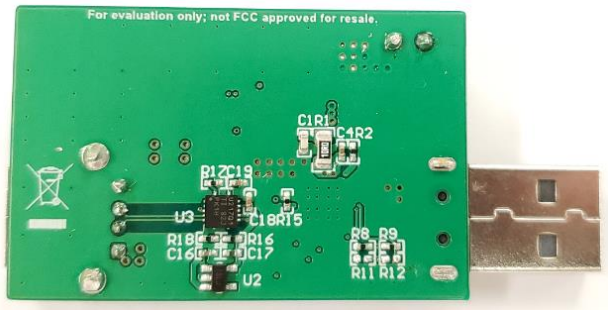
This reference design is for an automotive USB Type-A charger with 3 meters USB-IF near-end compliant. The TPS25840-Q1 is used as DC-DC regulator and data switch and TUSB217-Q1 is used as high speed signal conditioner to improve signal quality. The efficiency of the solution is 93.3% at a 12-W output, which leads to only 20.5°C temperature rise. Programmable cable droop compensation helps portable devices charge at optimum current and voltage under heavy loads. USB 2.0 high-speed near-end eye compliance test is passed on the design with a cable as long as 3 meters.



Top



Bottom



1 Test Prerequisites

1.1 Voltage and Current Requirements

Table 1. Voltage and Current Requirements

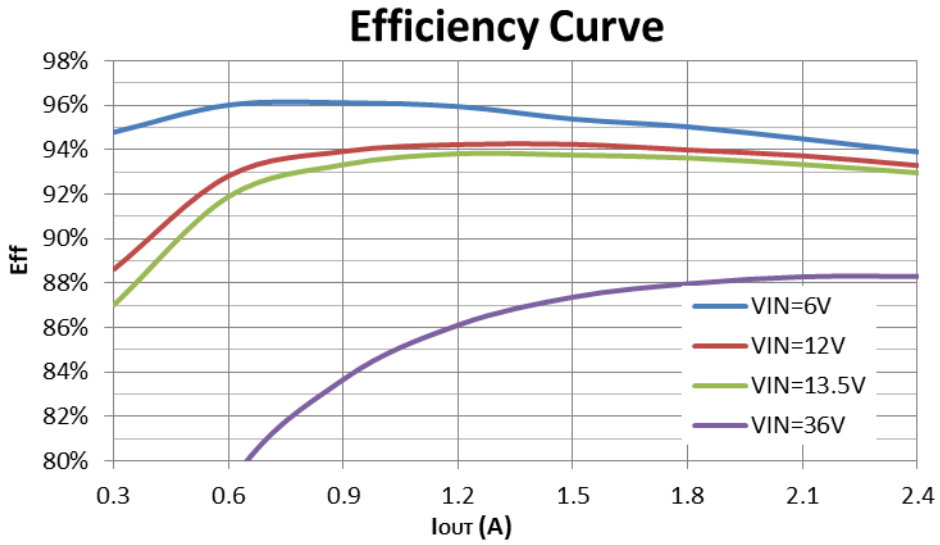
PARAMETER	SPECIFICATIONS
Input Voltage	6~36 Vdc
Output Voltage	5 Vdc
Maximum Output Current	2.4 A
Switching Frequency	400k Hz

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, DPO5204B
- Electrical Thermography: Fluke TiS65

2 Testing and Results

2.1 Efficiency Graphs

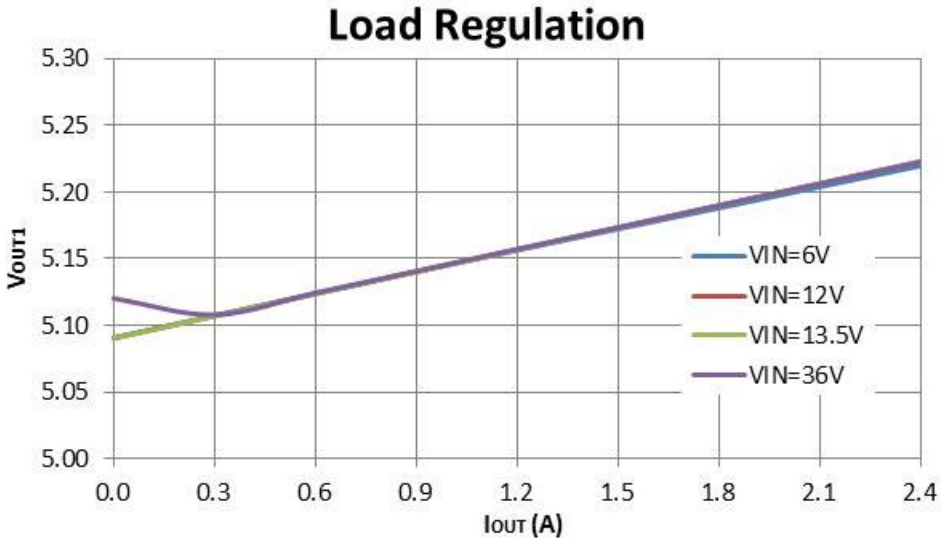


2.2 Efficiency Data

V_{IN} (V)	I_{IN} (A)	P_{IN} (W)	V_{OUT} (V)	I_{OUT} (A)	P_{OUT} (W)	Eff
5.996	2.2266	13.3507	5.2198	2.4018	12.5369	**93.90%**
5.997	1.9302	11.5754	5.2040	2.1018	10.9378	**94.49%**
6.001	1.6392	9.8368	5.1882	1.8019	9.3485	**95.04%**
6.005	1.3558	8.1416	5.1724	1.5014	7.7658	**95.38%**
6.006	1.0748	6.4552	5.1564	1.2012	6.1939	**95.95%**
6.009	0.8022	4.8204	5.1403	0.9014	4.6335	**96.12%**
6.001	0.5348	3.2093	5.1241	0.6014	3.0816	**96.02%**
6.003	0.2707	1.6250	5.1075	0.3016	1.5404	**94.79%**
6.006	0.0108	0.0651	5.0907	0.0000	0.0000	
12.000	1.1205	13.4460	5.2230	2.4018	12.5446	**93.30%**
11.995	0.9733	11.6747	5.2065	2.1018	10.9430	**93.73%**
12.001	0.8288	9.9464	5.1900	1.8014	9.3493	**94.00%**
11.998	0.6868	8.2402	5.1734	1.5012	7.7663	**94.25%**
12.004	0.5476	6.5734	5.1569	1.2012	6.1945	**94.24%**
12.001	0.4110	4.9324	5.1404	0.9013	4.6330	**93.93%**
11.996	0.2767	3.3193	5.1238	0.6014	3.0815	**92.83%**
12.002	0.1448	1.7379	5.1072	0.3016	1.5403	**88.63%**
12.008	0.0157	0.1883	5.0905	0.0000	0.0000	

13.496	0.9998	13.4933	5.2228	2.4018	12.5441	**92.97%**
13.501	0.8684	11.7243	5.2064	2.1019	10.9433	**93.34%**
13.497	0.7398	9.9851	5.1899	1.8015	9.3496	**93.64%**
13.502	0.6135	8.2835	5.1734	1.5013	7.7668	**93.76%**
13.497	0.4892	6.6027	5.1569	1.2013	6.1950	**93.82%**
13.501	0.3677	4.9643	5.1403	0.9014	4.6335	**93.34%**
13.498	0.2484	3.3529	5.1237	0.6014	3.0814	**91.90%**
13.503	0.1312	1.7716	5.1071	0.3019	1.5418	**87.03%**
13.507	0.0162	0.2185	5.0904	0.0000	0.0000	
36.000	0.3946	14.2056	5.2227	2.4018	12.5439	**88.30%**
36.002	0.3443	12.3955	5.2063	2.1019	10.9431	**88.28%**
36.004	0.2952	10.6284	5.1900	1.8015	9.3498	**87.97%**
36.006	0.2469	8.8899	5.1735	1.5013	7.7670	**87.37%**
36.008	0.1998	7.1944	5.1573	1.2013	6.1955	**86.12%**
36.010	0.1538	5.5383	5.1408	0.9014	4.6339	**83.67%**
36.012	0.1085	3.9073	5.1245	0.6014	3.0819	**78.87%**
36.014	0.0630	2.2689	5.1080	0.3019	1.5421	**67.97%**
36.017	0.0012	0.0447	5.1203	0.0000	0.0000	

2.3 Load Regulation

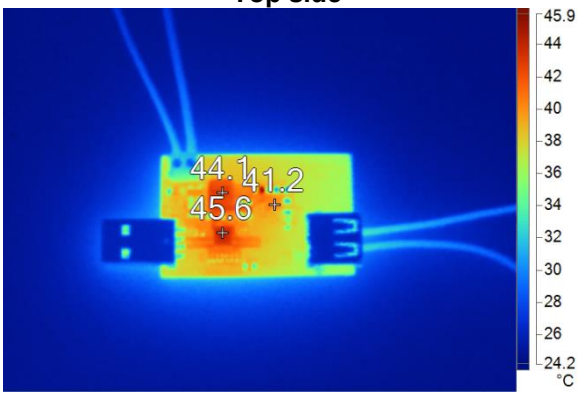


(A 2.74KΩ resistor on IMON pin for cable droop compensation.)

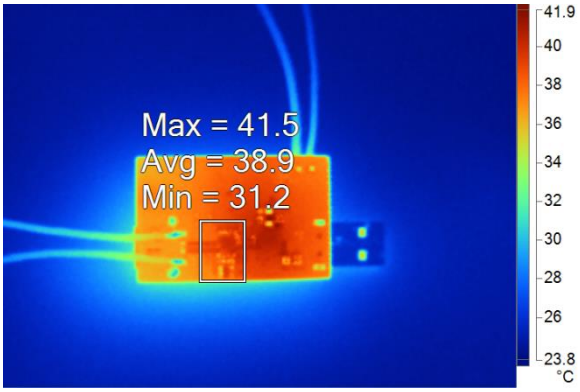
2.4 Thermal Images

Ta=25.1°C, 12V input, 2.4A output
(4-layer PCB, 2 oz copper on top and bottom layers, 1 oz copper on middle layers.)

Top side

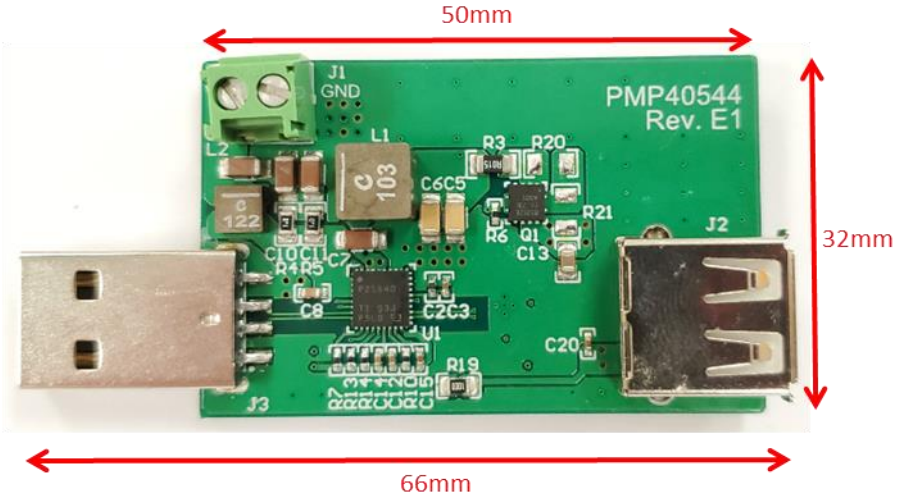


Bottom side



2.5 Dimensions

The dimension of this board is 66mm (length, including the plug)*32mm (width)*9mm (height).

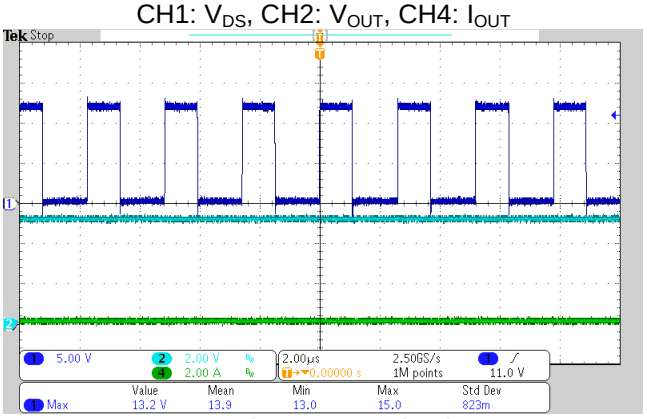


3 Waveforms

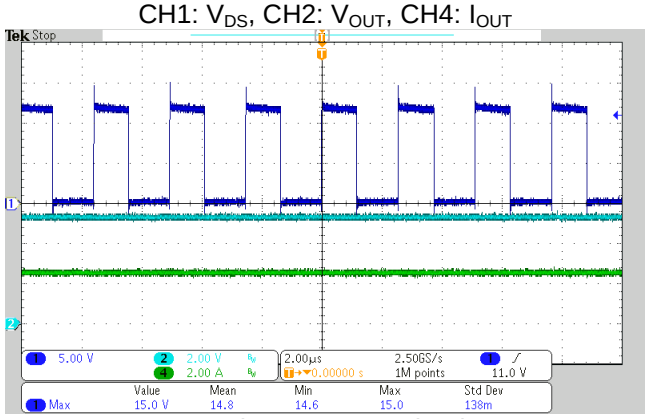
3.1 Switching

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

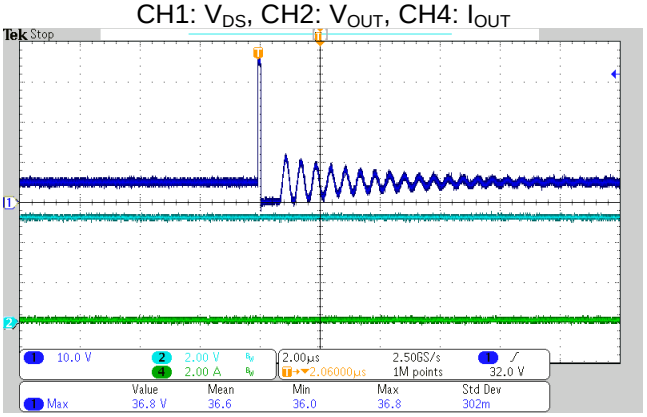
12V input, 5V no-load
CH1: V_{DS}, CH2: V_{OUT}, CH4: I_{OUT}



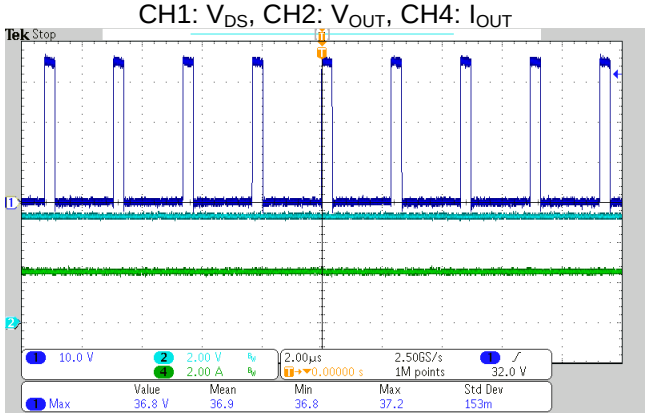
12V input, 5V 2.4A load
CH1: V_{DS}, CH2: V_{OUT}, CH4: I_{OUT}



36V input, 5V no-load
CH1: V_{DS}, CH2: V_{OUT}, CH4: I_{OUT}



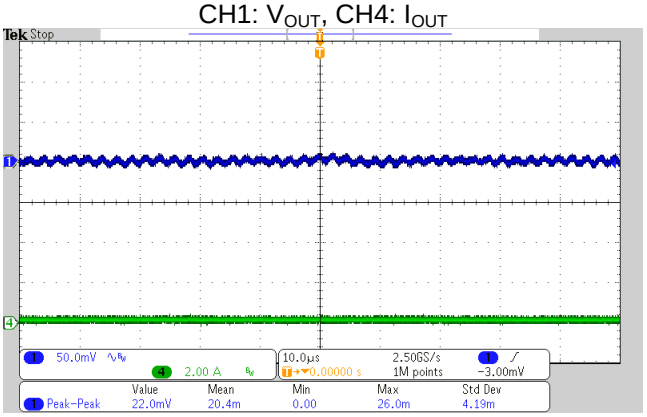
36V input, 5V 2.4A load
CH1: V_{DS}, CH2: V_{OUT}, CH4: I_{OUT}



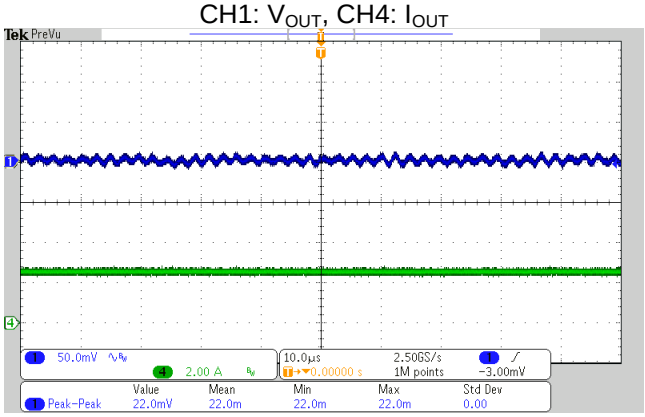
3.2 Output Voltage Ripple

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

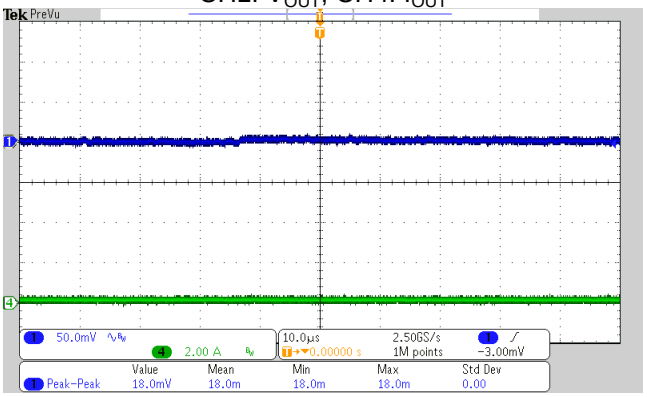
12V input, 5V no-load
CH1: V_{OUT}, CH4: I_{OUT}



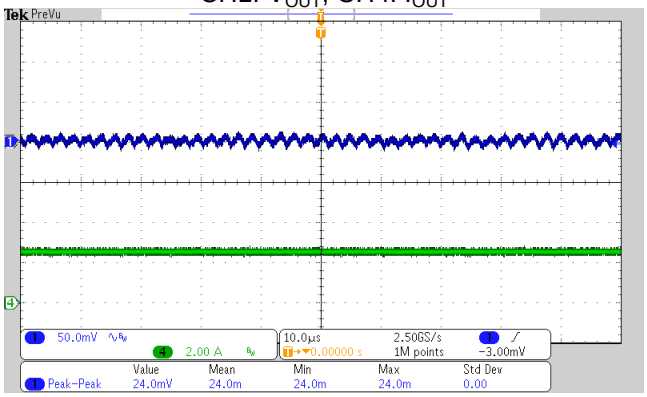
12V input, 5V 2.4A load
CH1: V_{OUT}, CH4: I_{OUT}



36V input, 5V no-load
CH1: V_{OUT}, CH4: I_{OUT}



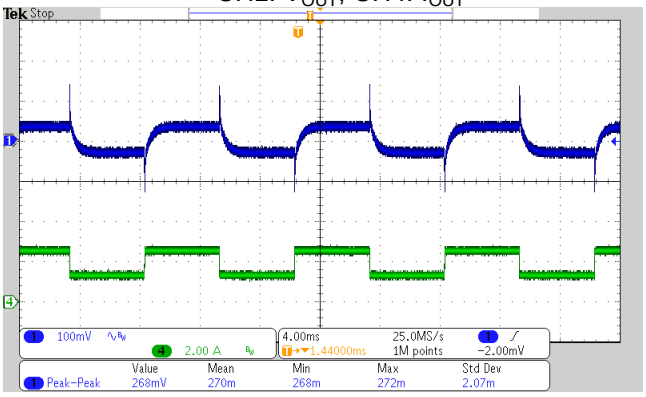
36V input, 5V 2.4A load
CH1: V_{OUT}, CH4: I_{OUT}



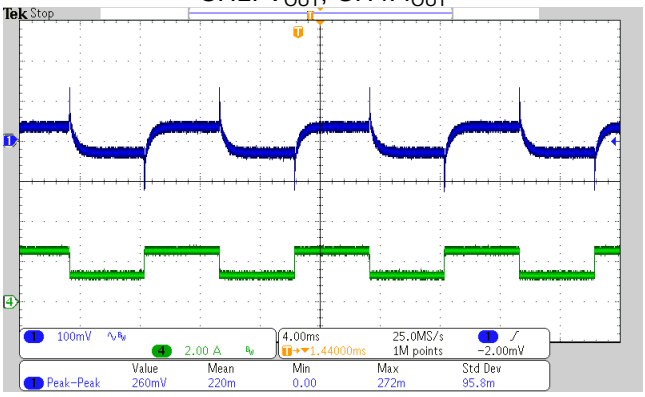
3.3 Load Transient

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

12V input, 1.2A->2.4A
CH1: V_{OUT}, CH4: I_{OUT}



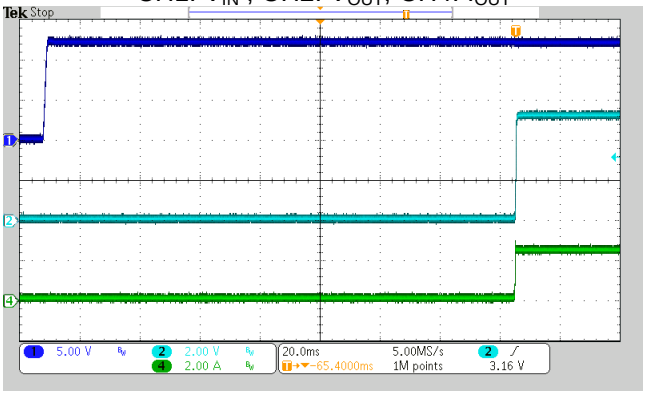
36V input, 1.2A->2.4A
CH1: V_{OUT}, CH4: I_{OUT}



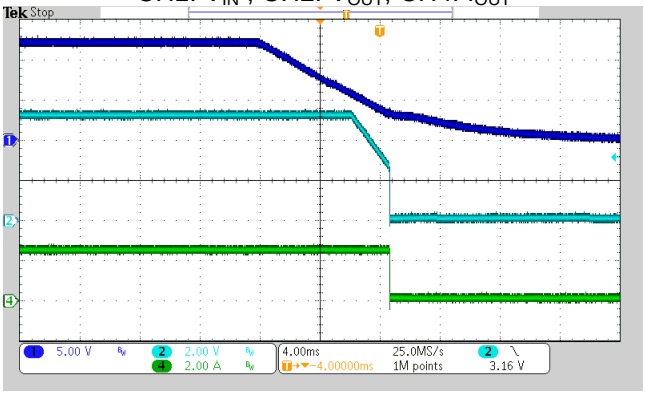
3.4 Power on/off

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

Power on
CH1: V_{IN} , CH2: V_{OUT}, CH4: I_{OUT}



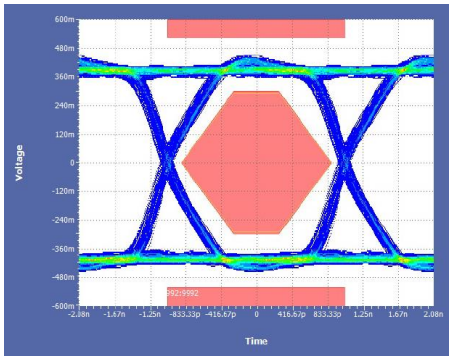
Power off
CH1: V_{IN} , CH2: V_{OUT}, CH4: I_{OUT}



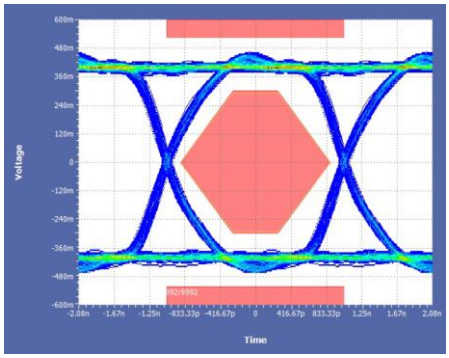
3.5 Eye Compliance Test

The eye diagrams on source, TPS25840Q1EVM-079 and PMP40544 board are shown as below. The eye diagram test is passed on PMP40544 with a cable as long as 3 meters.

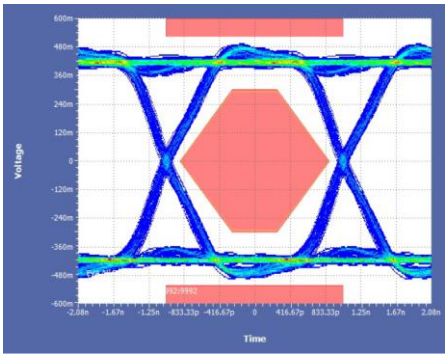
Measured source with 0-m cable



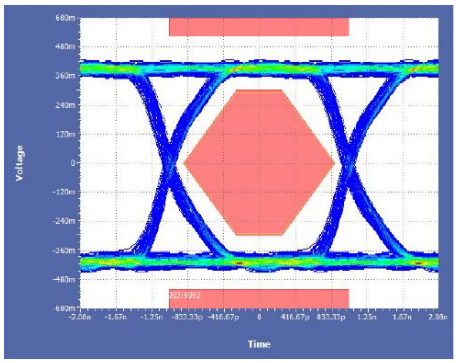
Measured on TPS25840Q1EVM-079 with 0-m cable



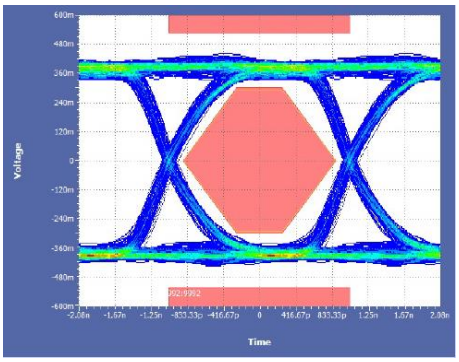
Measured on PMP40544 with 0-m cable



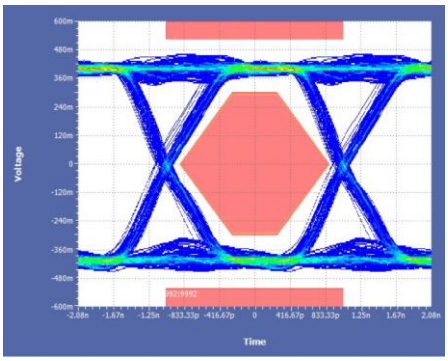
Measured source with 1-m cable



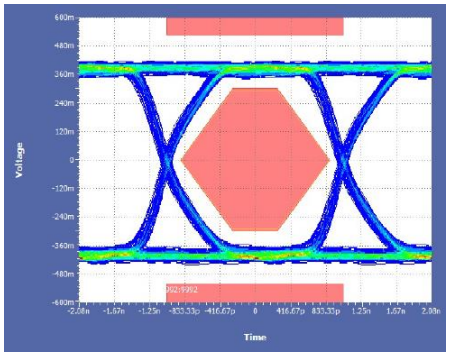
Measured on TPS25840Q1EVM-079 with 1-m cable



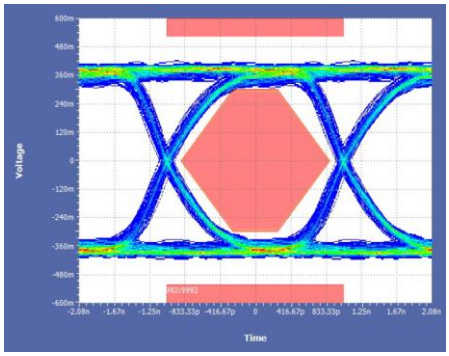
Measured on PMP40544 with 1-m cable



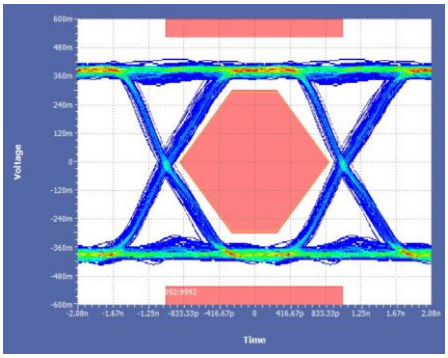
Measured source with 1.8-m cable



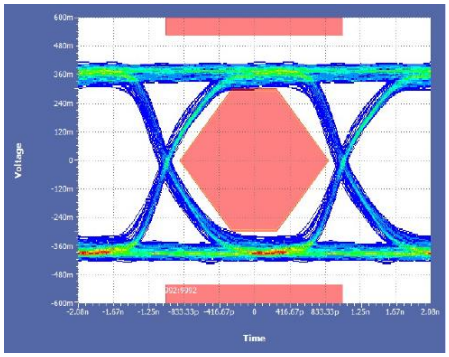
Measured on TPS25840Q1EVM-079 with 1.8-m cable



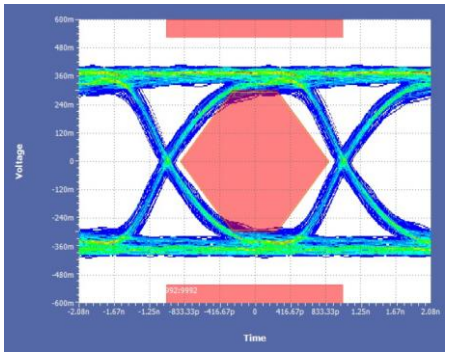
Measured on PMP40544 with 1.8-m cable



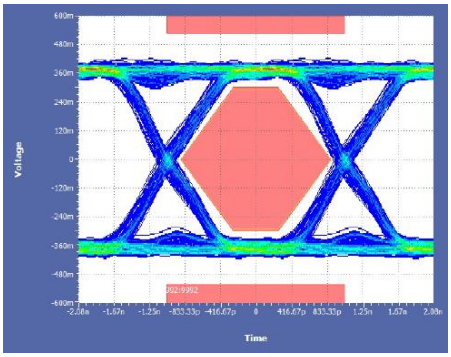
Measured source with 3-m cable



Measured on TPS25840Q1EVM-079 with 3-m cable



Measured on PMP40544 with 3-m cable



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