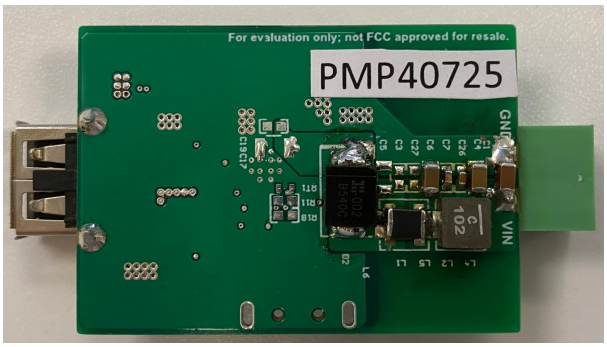
Test Report: PMP40725

CISPR 25 Class5 400-kHz 12-W Automotive USB Type-A Charger Reference Design

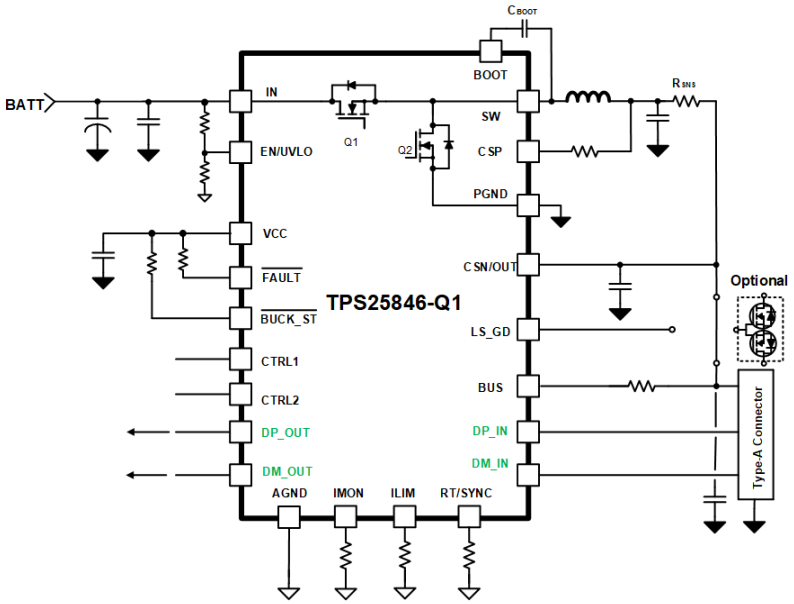
Description

This reference design is an EMI-optimized design for automotive USB Type-A charger with single 12-W output. The TPS25846-Q1 is used as 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 Conducted Electromagnetic Interference (EMI) standards. This reference design has already been tested to CISPR 25 Class 5 conducted EMI standards, which accelerates design time.

Top



Bottom



Block Diagram

1 Test Prerequisites

1.1 Design Requirements

Table 1-1. Design Requirements

Parameter	Specifications
Input Voltage	6-16 V_{DC}
Output Voltage	5.1 V_{DC}
Maximum Output Current	2.4 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 63101 module
- Oscilloscope: Tektronix DPO3054
- Electrical Thermography: Fluke TiS65

1.3 Dimensions

The dimension of this board is 50 mm (length) × 35 mm (width) × 10 mm (height, ignore the J1 component in the following image).

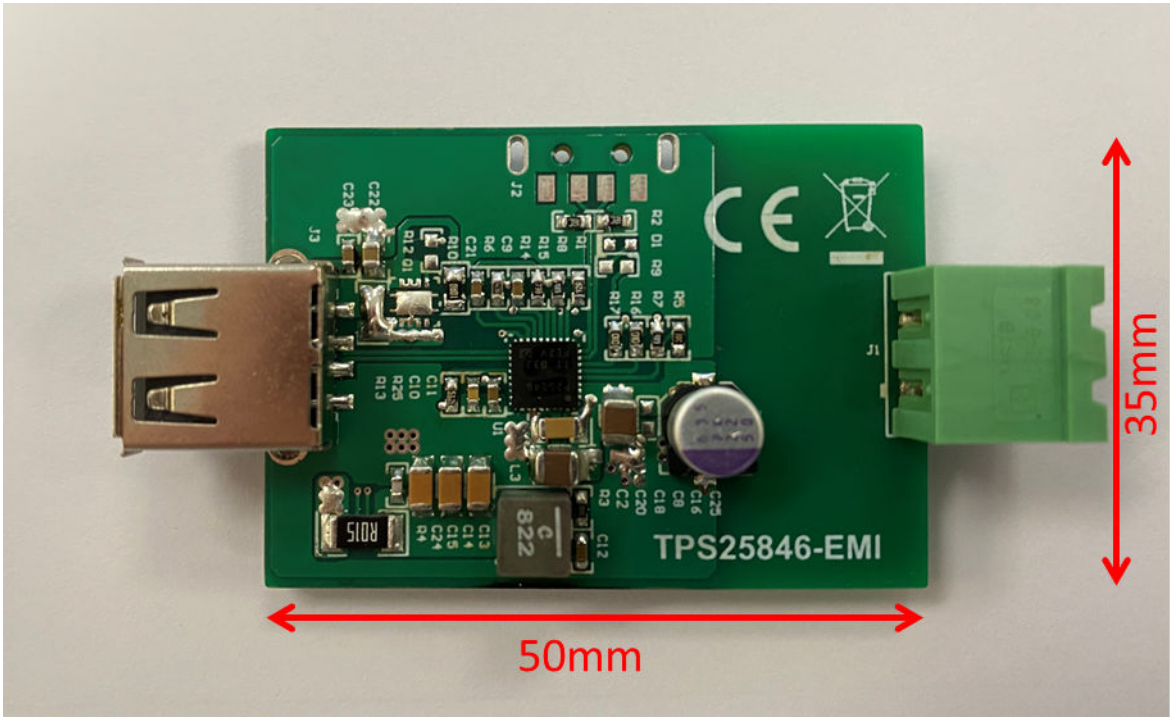


Figure 1-1. Dimensions

2 Testing and Results

2.1 Efficiency Graphs

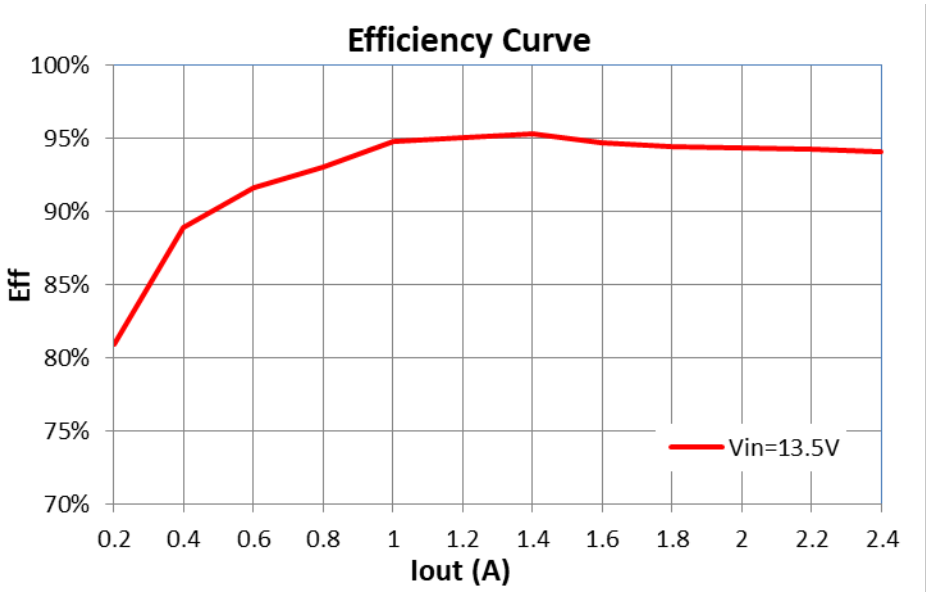


Figure 2-1. Efficiency Graph

2.2 Efficiency Data

Table 2-1. Efficiency Data

V_{IN}(V)	I_{IN}(A)	V_{OUT}(V)	I_{OUT}(A)	Efficiency(%)
13.248	0.018	5.097	0	0.00%
13.196	0.096	5.126	0.2	80.93%
13.172	0.176	5.155	0.4	88.95%
13.155	0.258	5.183	0.6	91.63%
13.140	0.341	5.212	0.8	93.06%
13.128	0.421	5.240	1.0	94.81%
13.116	0.507	5.269	1.2	95.08%
13.106	0.593	5.290	1.4	95.29%
13.096	0.689	5.340	1.6	94.69%
13.086	0.780	5.355	1.8	94.43%
13.076	0.872	5.380	2.0	94.37%
13.066	0.967	5.416	2.2	94.30%
13.057	1.063	5.444	2.4	94.14%

2.3 Load Regulation

V_{IMON} is shorted to GND for cable droop compensation.

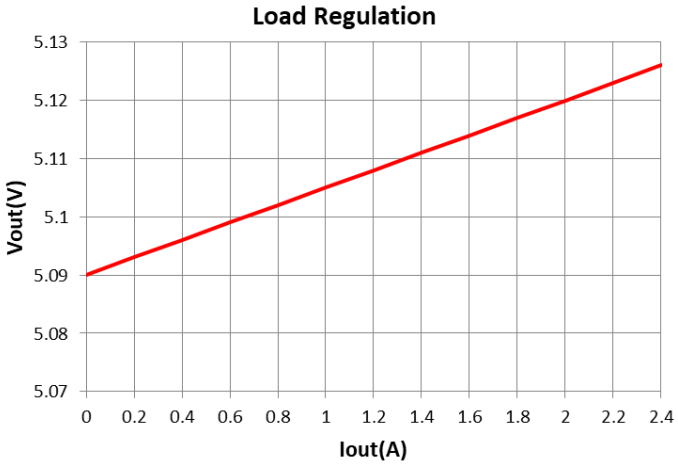


Figure 2-2. Load Regulation

2.4 Thermal Images

Ta = 25°C, 13.5-V Input, V_{OUT} = 5.1 V, I_{OUT} = 2.4-A Output (4-layer PCB, 2-oz copper)

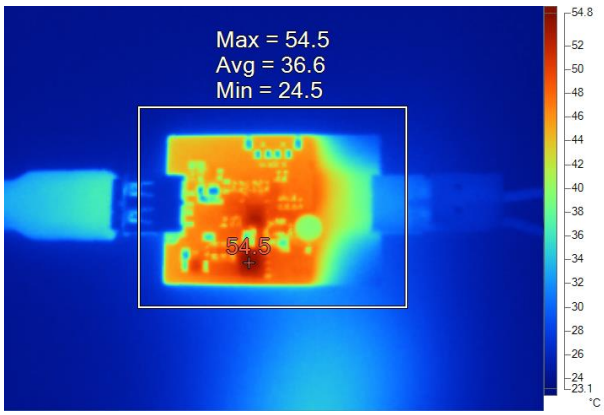


Figure 2-3. Top Side

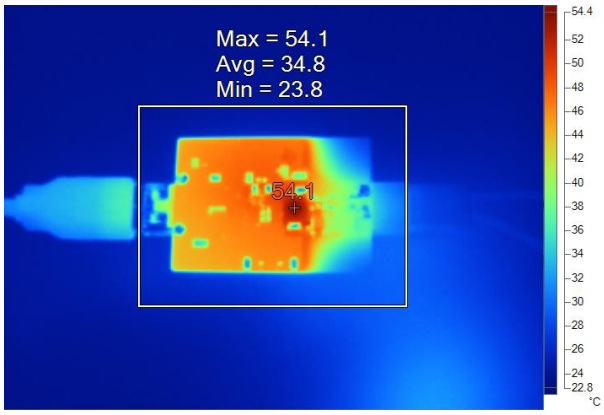


Figure 2-4. Bottom Side

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 or shielding. The waveforms of EMI test results are shown in following pictures.

EMI Performance From 150 kHz to 108 MHz: V_{IN} = 13.5 V, V_{BUS} =5.1 V, I_{BUS} = 2.4 A Output

(Green: Peak Detection Result; Purple: Average Detection Result; Red: CISPR 25 Class 5 Peak Limits; Blue: CISPR 25 Class 5 Average Limits)

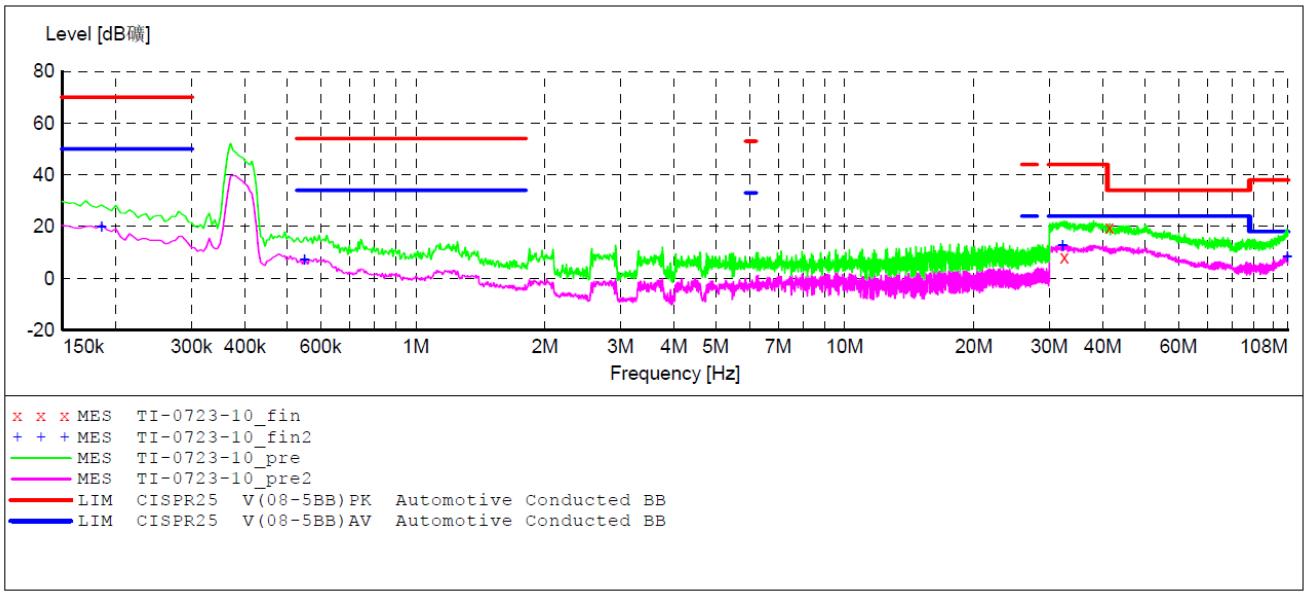


Figure 2-5. Conducted Emissions

3 Waveforms

3.1 Switching

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

13.5-V input, 5.1-V output; CH1: V_{BUS}, CH2: V_{SW}, CH3: I_{BUS}

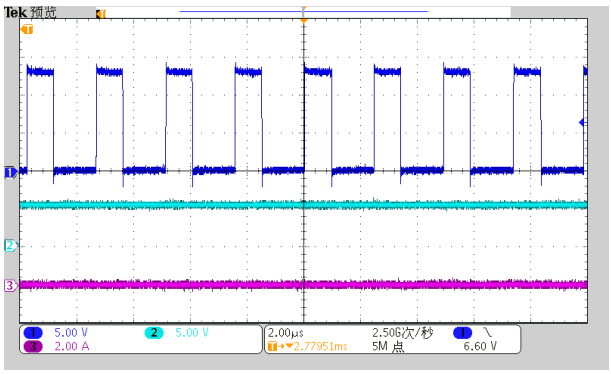


Figure 3-1. No-Load

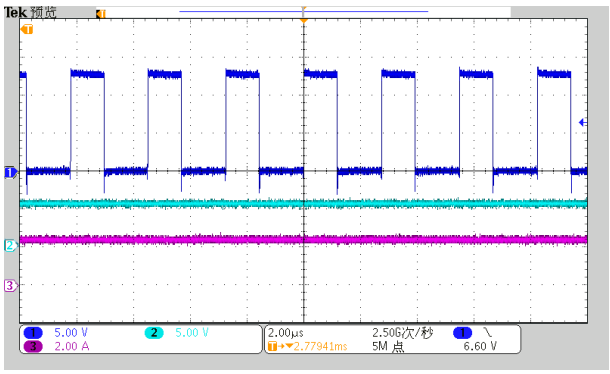


Figure 3-2. 2.4-A Output

3.2 Output Voltage Ripple

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

13.5-V input, 5.1-V output; CH1: V_{BUS_AC}, CH3: I_{BUS}

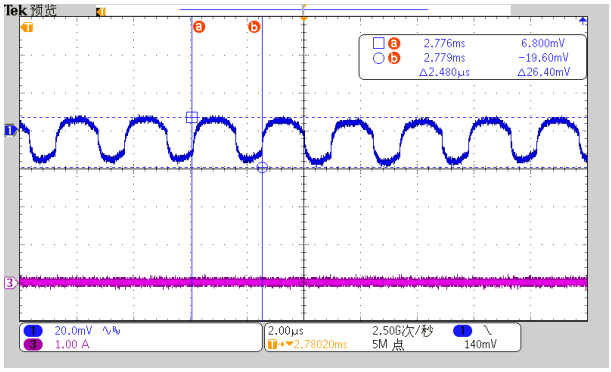


Figure 3-3. No-Load

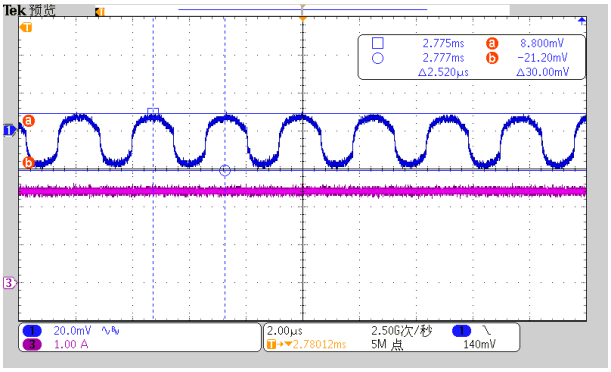


Figure 3-4. 2.4-A Output

3.3 Power on and off

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

13.5-V input, 5.1-V output; CH1: V_{IN} , CH2: V_{BUS} , CH3: I_{BUS}

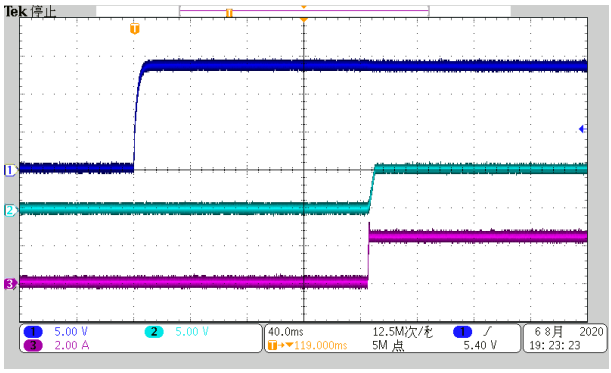


Figure 3-5. Power on

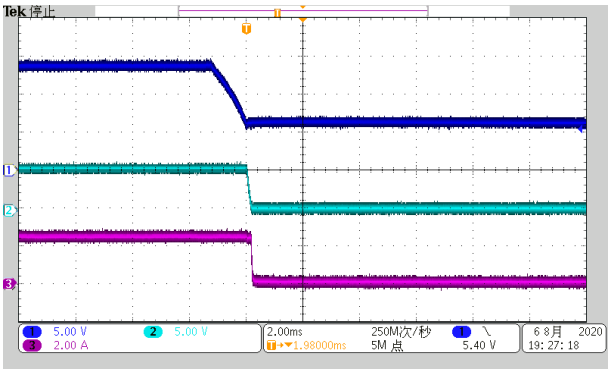


Figure 3-6. Power off

3.4 Load Transients

The waveforms of output AC ripples at load transient are shown in following pictures. The slew rate is set to 1.6 A/µs for the test.

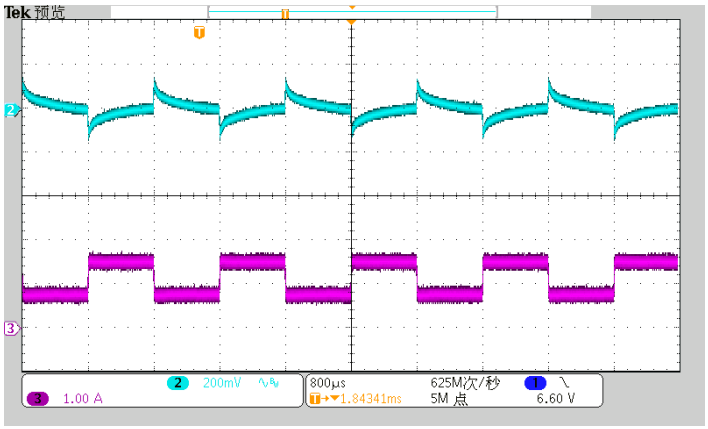


Figure 3-7. 13.5-V Input, 0.75-A to 1.5-A Output; CH2: V_{BUS_AC}, CH3: I_{BUS}

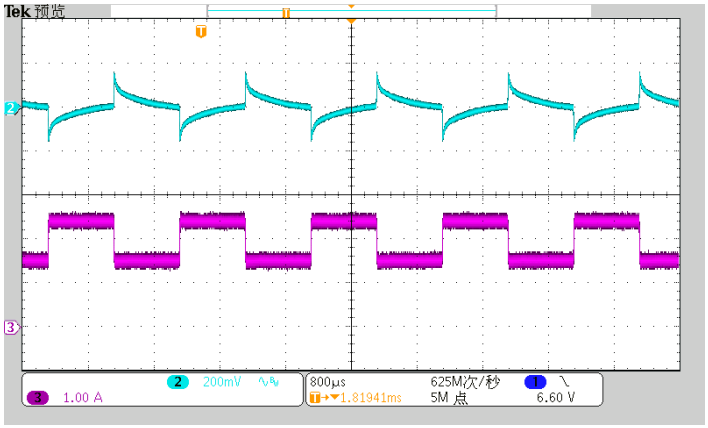


Figure 3-8. 13.5-V Input, 1.5-A to 2.4-A Output; CH2: V_{BUS_AC}, CH3: I_{BUS}

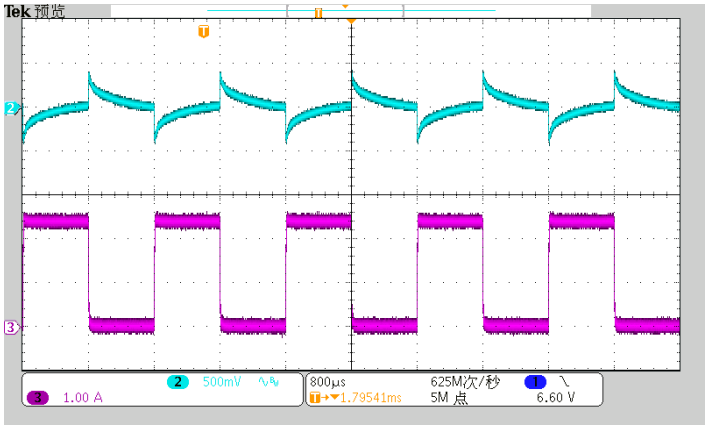


Figure 3-9. 13.5-V Input, 0-A to 2.4-A Output;CH2: V_{BUS_AC}, CH3: I_{BUS}

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