Test Report: PMP40980

Multiple Output Isolated SiC Driver Bias Supply Reference Design for Onboard Charger Applications

Description

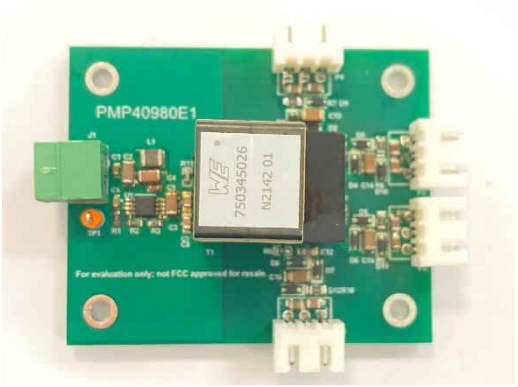
This reference design is an open-loop LLC converter, which provides four 18 V and 2.5 V outputs, up to 2.4 W for onboard charger applications. The UCC25800-Q1 device is used here as the controller. The LLC topology allows the transformer to have significant leakage inductance, but a much smaller primary-secondary capacitance, which significantly reduces common-mode current injection through the bias transformer.

Features

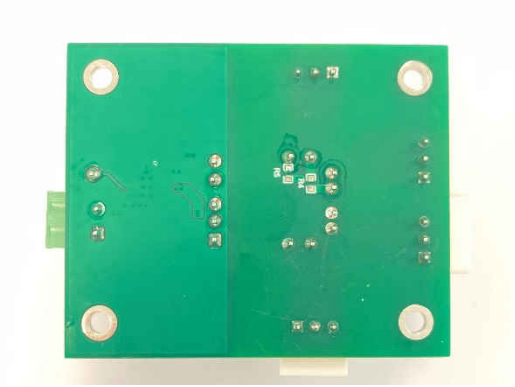
- Small size, open-loop LLC
- Reinforced insulation
- Compact PCB size (55 mm × 45 mm)

Applications

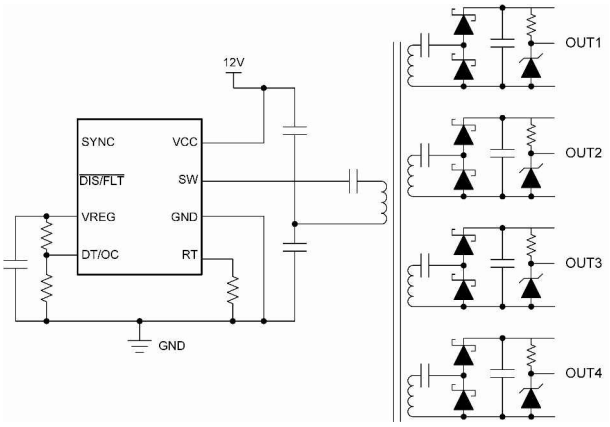
- On-board (OBC) and wireless charger
- IGBT and SiC gate transformer driver bias supply



Top of Board



Bottom of Board



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 range	12 V
Output voltage and current	4 × (18 V and –2.5 V, 30 mA), 2.4 W maximum
Nominal switching frequency	400 kHz
Isolation	Yes, 3000 V_{AC}, 1 min
Topology	Open-loop LLC

1.2 Required Equipment

- Multimeter (voltage): Fluke 287C
- Multimeter (current): Fluke 287C
- DC Source: Chroma 62012P-100-50
- E-Load: Chroma 63110 module
- Oscilloscope: Tektronix DPO3054
- Electrical Thermography: Fluke TiS65

1.3 Dimensions

The board dimensions are 55 mm (length) × 45 mm (width) × 25 mm (height).

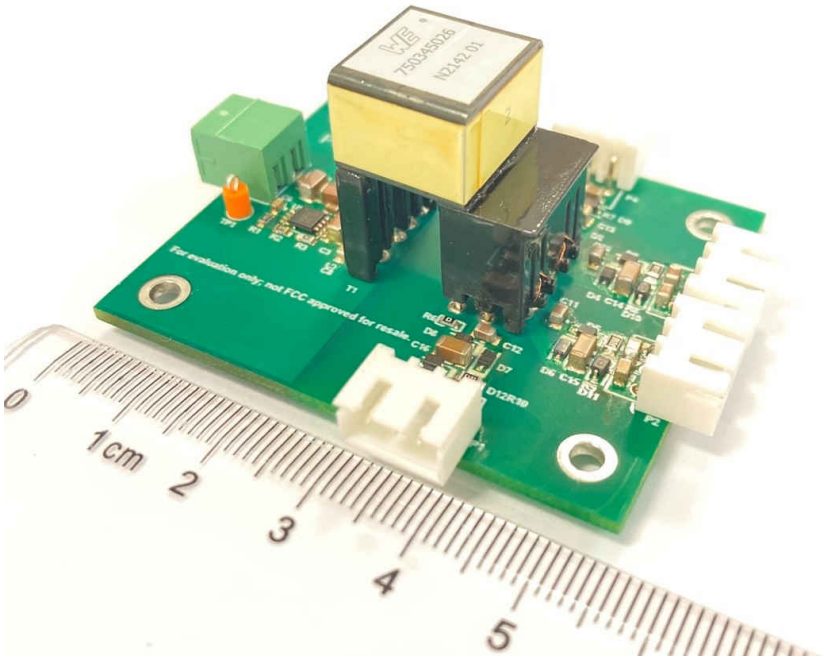

Figure 1-1. Dimensions

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2 Testing and Results

2.1 Efficiency Graphs

Efficiency is shown in the following figure.

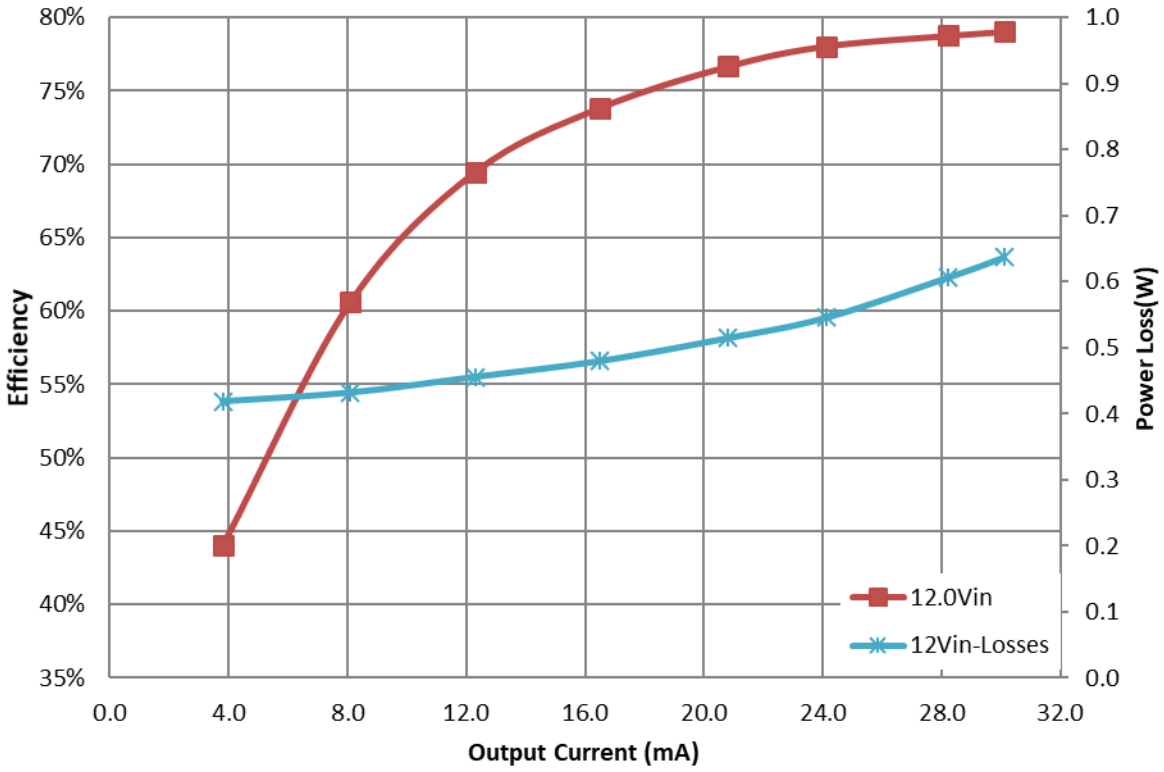

Figure 2-1. Efficiency Graph

2.2 Efficiency Data

Efficiency data is shown in the following table.

V_{IN}/V	I_{IN}/A	V_{OUT1}/V	I_{OUT1}/A	V_{OUT2}/V	I_{OUT2}/A	V_{OUT3}/V	I_{OUT3}/A	V_{OUT4}/V	I_{OUT4}/A	P_{IN}/W	P_{OUT}/W	P_{Loss}/W	Eff/%
12.036	0.0621	21.492	0.0038	21.505	0.0043	21.52	0.0035	21.521	0.0037	0.7474	0.3291	0.4183	44.03
12.033	0.0911	21.277	0.0081	21.297	0.0076	21.31	0.0077	21.314	0.0078	1.0962	0.6645	0.4317	60.62
12.028	0.1241	21.015	0.0123	21.029	0.0128	21.05	0.012	21.059	0.0122	1.4927	1.0372	0.4555	69.48
12.024	0.1525	20.737	0.0165	20.761	0.0162	20.783	0.0162	20.793	0.0163	1.8337	1.3541	0.4796	73.85
12.018	0.1834	20.496	0.0208	20.519	0.0205	20.549	0.0205	20.562	0.0205	2.2041	1.6897	0.5144	76.66
12.015	0.2067	20.32	0.0241	20.344	0.0238	20.377	0.0236	20.396	0.0237	2.4835	1.9382	0.5453	78.04
12.009	0.2376	20.072	0.0282	20.098	0.028	20.142	0.0278	20.159	0.0277	2.8533	2.2471	0.6062	78.75
12.01	0.2529	19.955	0.0301	19.982	0.0301	20.023	0.03	20.05	0.0298	3.0373	2.4003	0.637	79.03

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2.3 Load Regulation

Load regulation is shown in the following table.

V_{IN}(V)	I_{OUT}(mA)	V_{OUT1_18}(V)	$V_{OUT1\_2.5}$(V)	V_{OUT2_18}(V)	$V_{OUT2\_2.5}$(V)	V_{OUT3_18}(V)	$V_{OUT3\_2.5}$(V)	V_{OUT4_18}(V)	$V_{OUT4\_2.5}$(V)
12.036	4	19.451	2.0435	19.449	2.0529	19.445	2.0778	19.479	2.043
12.033	8	19.246	2.0337	19.255	2.0433	19.241	2.0692	19.279	2.0355
12.028	12	18.983	2.0346	18.983	2.0452	18.98	2.0707	19.025	2.0363
12.024	16	18.715	2.0263	18.728	2.0354	18.725	2.0605	18.764	2.0276
12.018	20	18.478	2.0222	18.492	2.0316	18.495	2.0567	18.541	2.0239
12.015	24	18.301	2.0195	18.316	2.0284	18.325	2.0539	18.375	2.0213
12.009	28	18.058	2.0152	18.075	2.0248	18.091	2.0505	18.146	2.0169
12.01	30	17.945	2.0137	17.963	2.0229	17.979	2.0482	18.038	2.0155

2.4 Voltage Regulation

The following figure shows the total rectified secondary output voltage of the converter with a 12-V_{DC} input voltage.

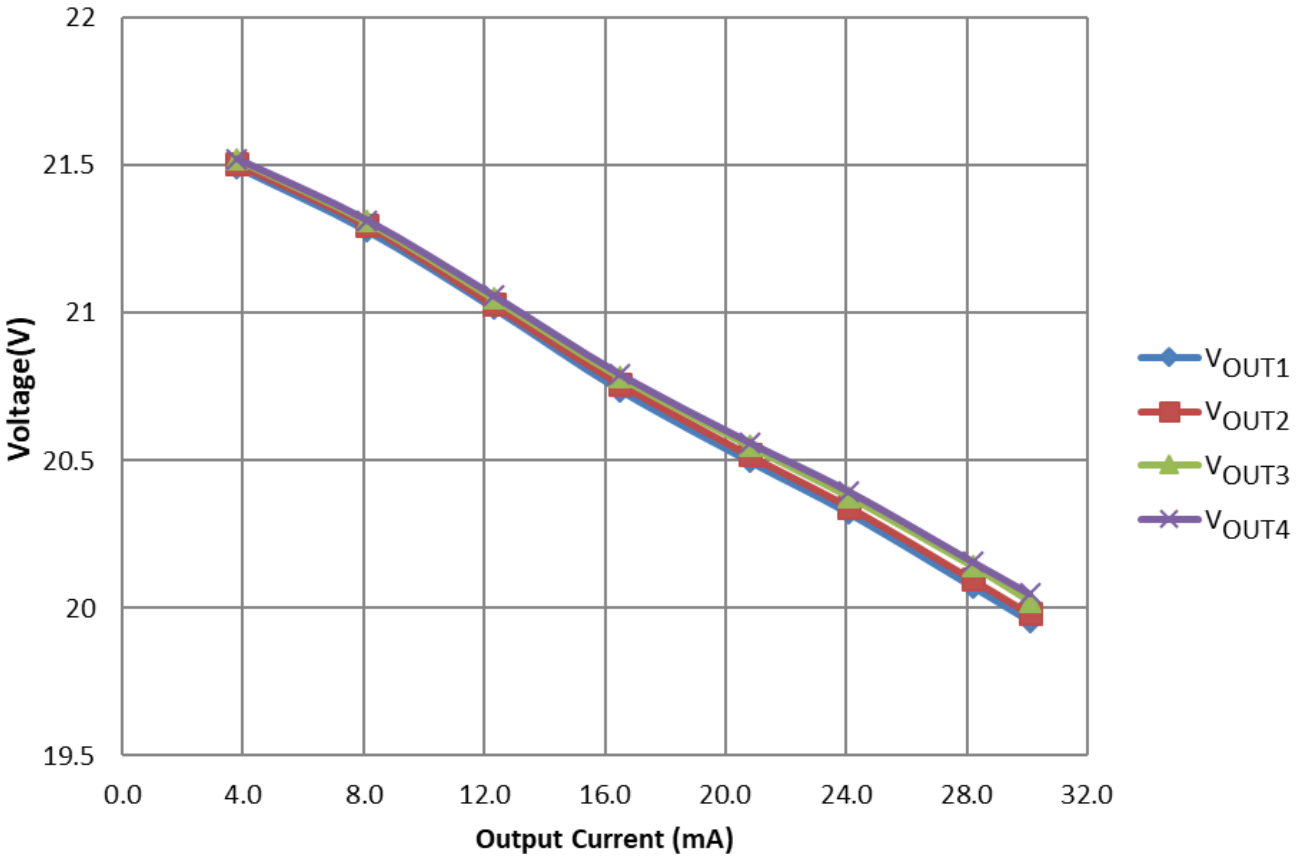

Figure 2-2. Voltage Regulation

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2.5 Thermal Images

The thermal image is shown in the following figure.

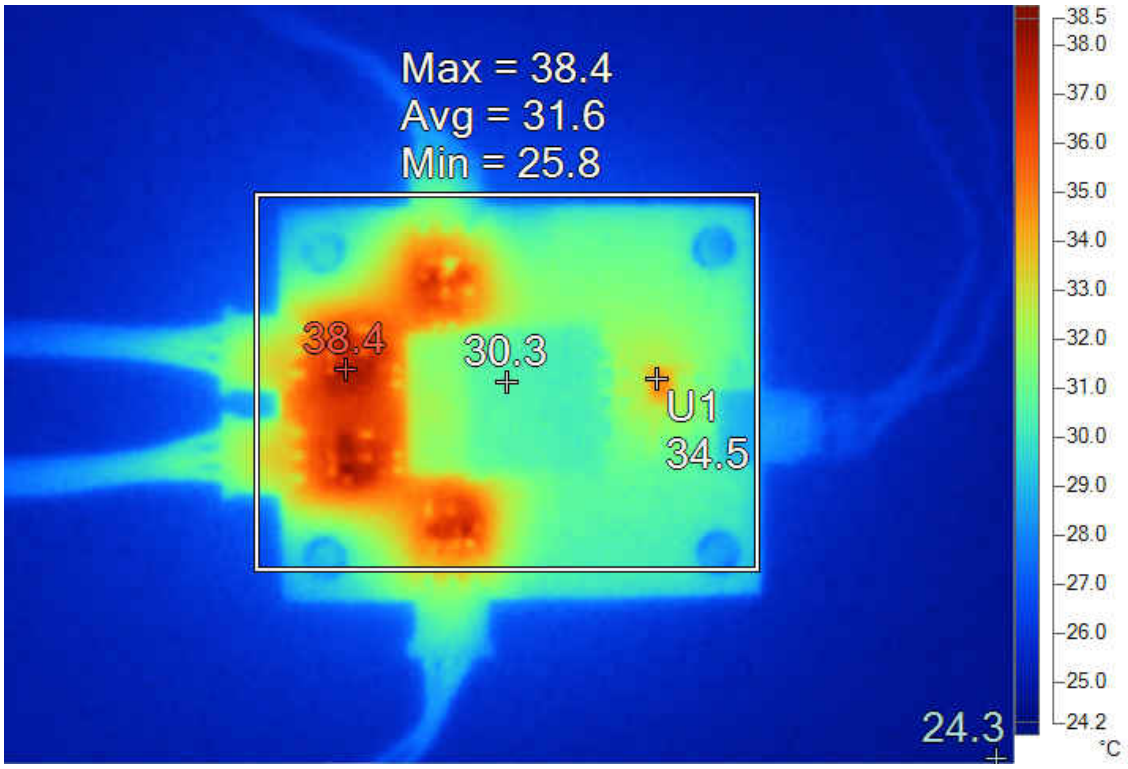

Figure 2-3. Thermal Image

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3 Waveforms

3.1 Switching

Switching behavior is shown in the following figures.

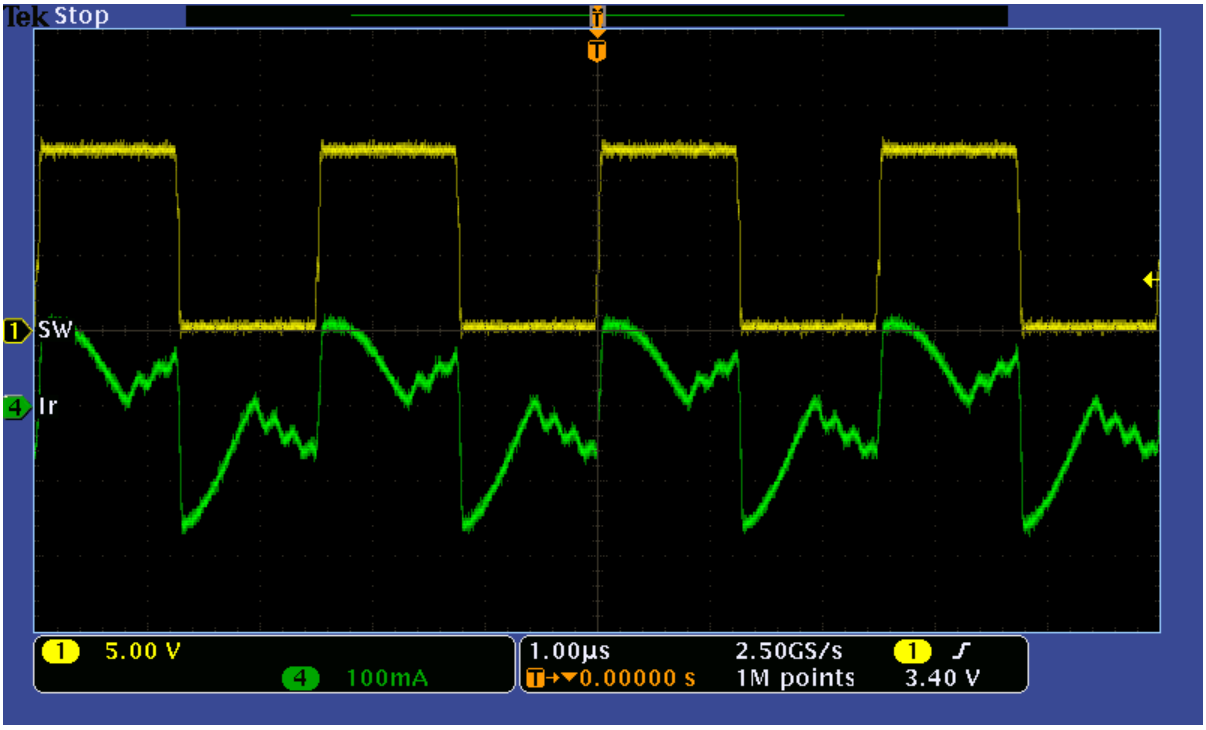

Figure 3-1. Switching , No Load

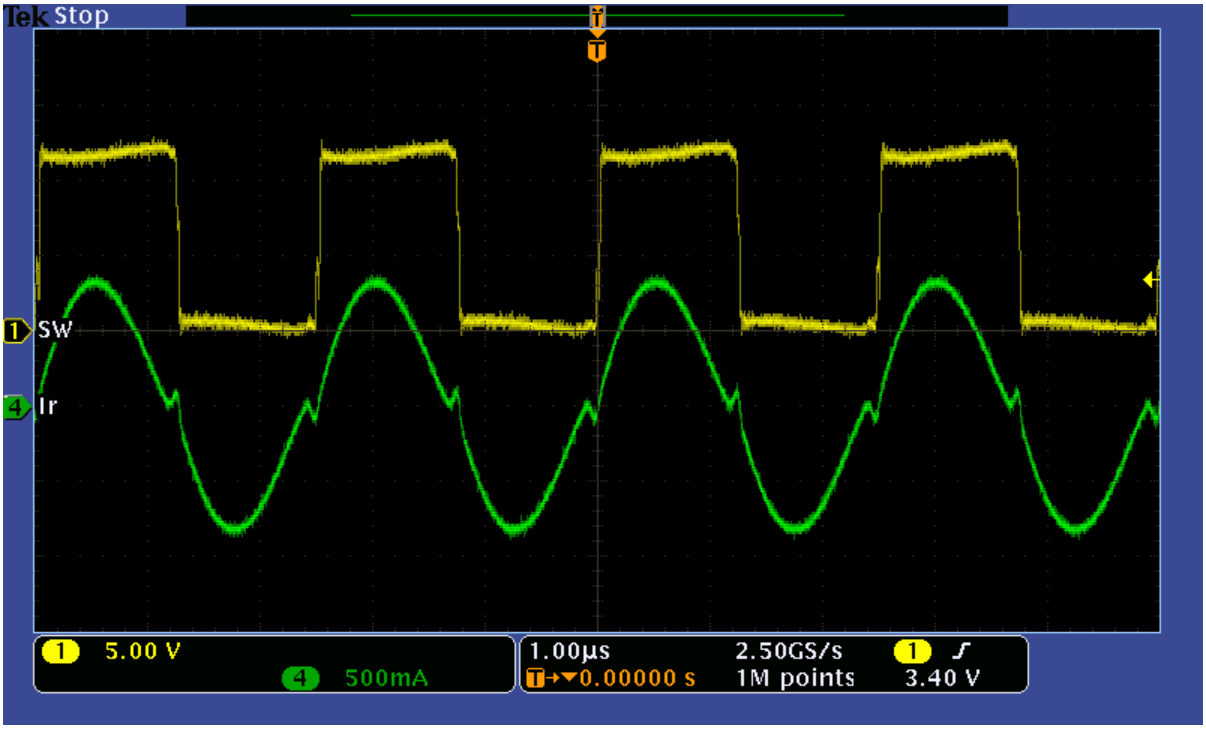

Figure 3-2. Switching , Full Load

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3.2 Output Voltage Ripple

Output voltage ripple is shown in the following figures.

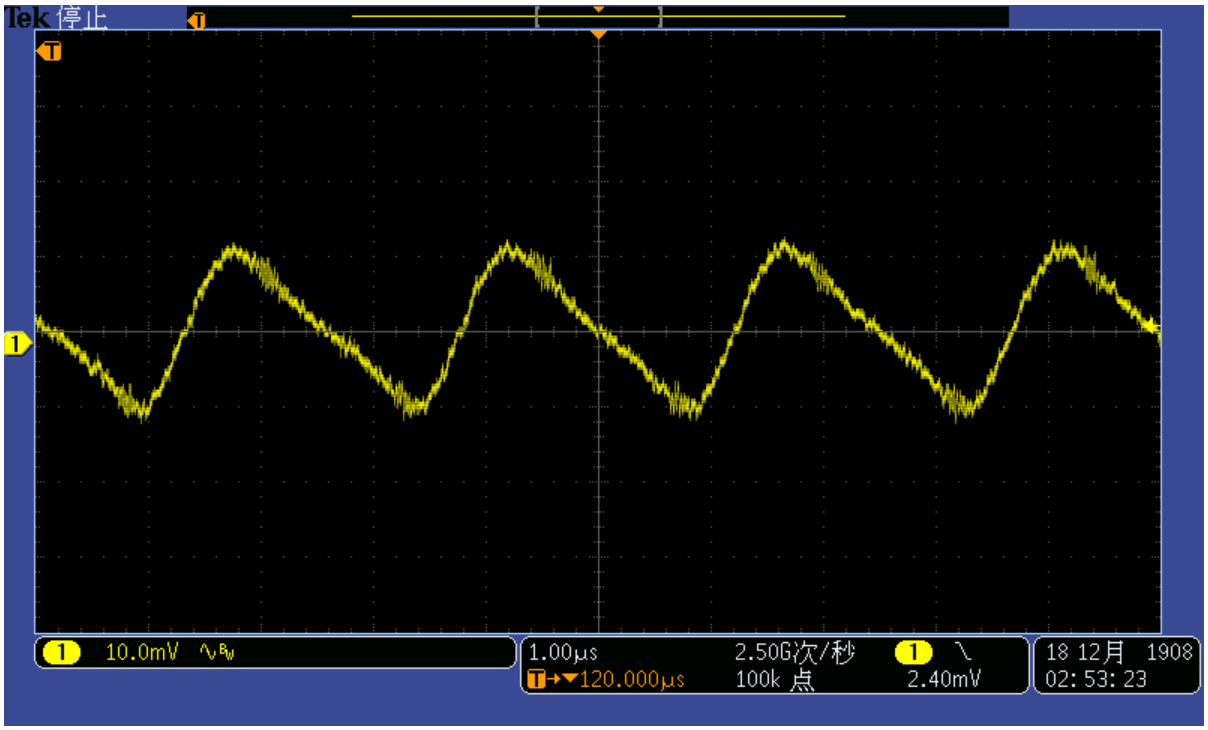

Figure 3-3. Output Voltage Ripple (18 V Channel), V_{IN} = 12 V

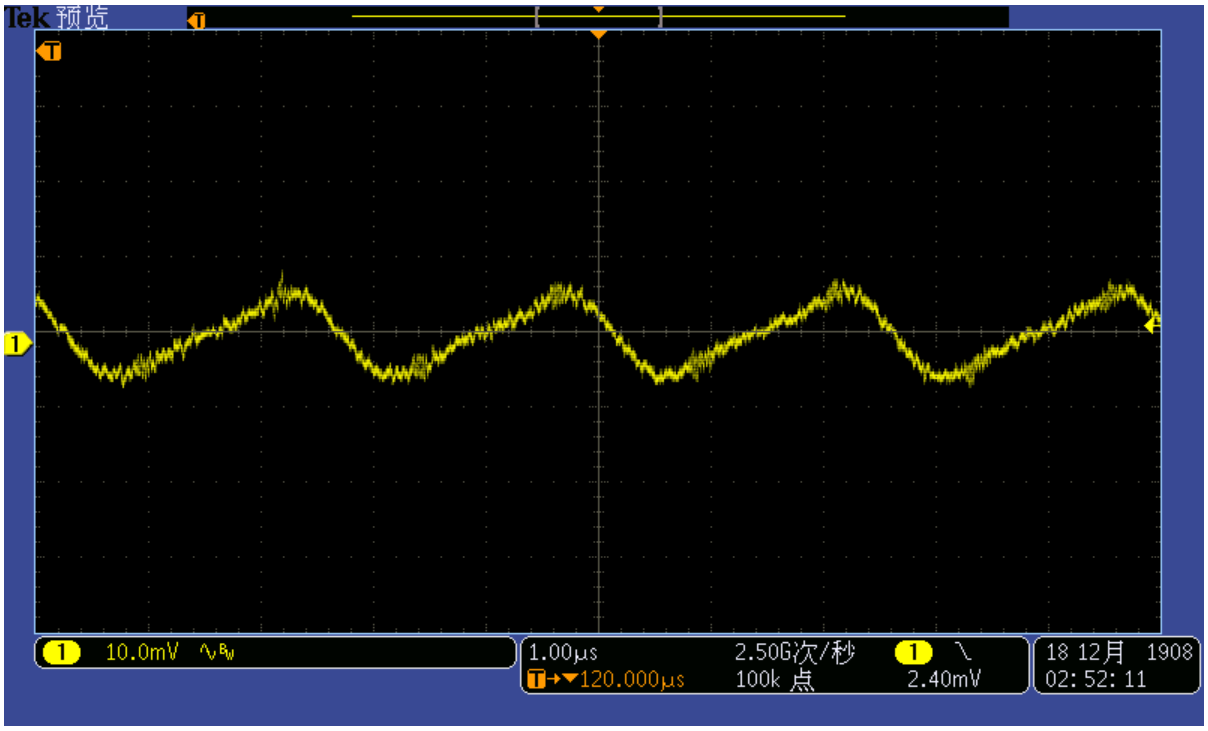

Figure 3-4. Output Voltage Ripple (–2.5 V Channel), V_{IN} = 12 V

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3.3 Short-Circuit Protection

Short-circuit protection is shown in the following figures.

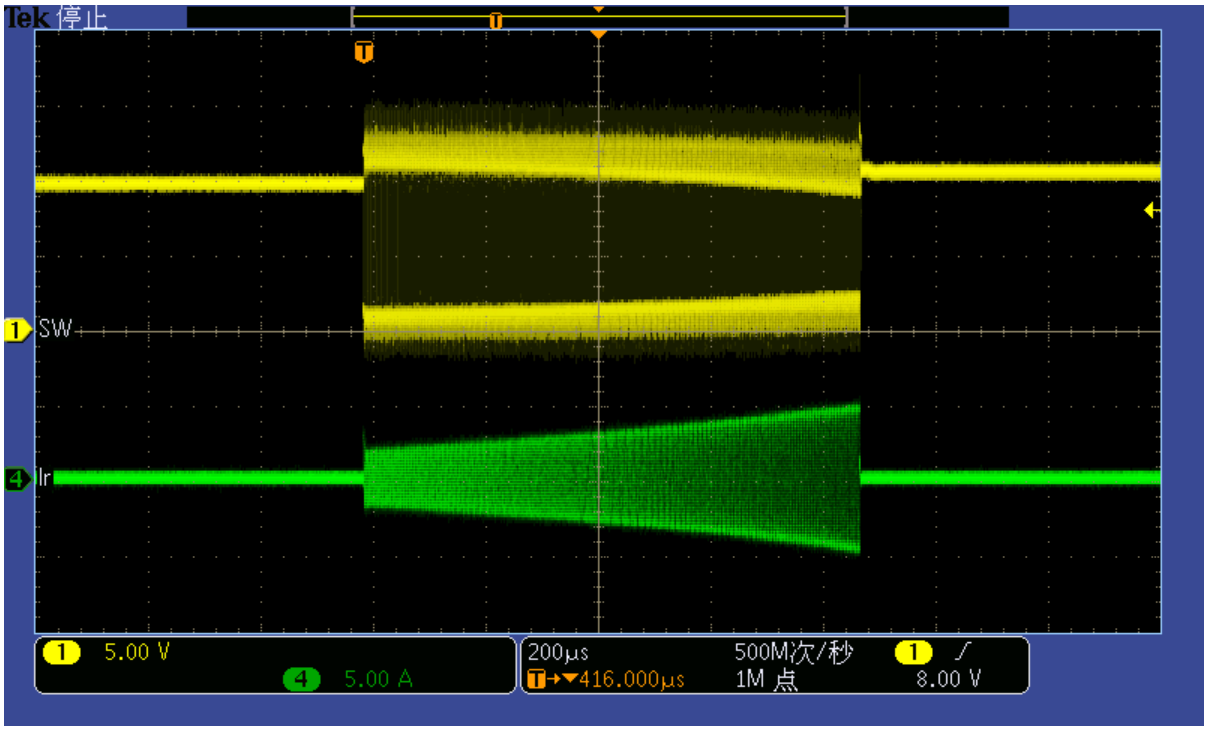

Figure 3-5. Short-Circuit Protection

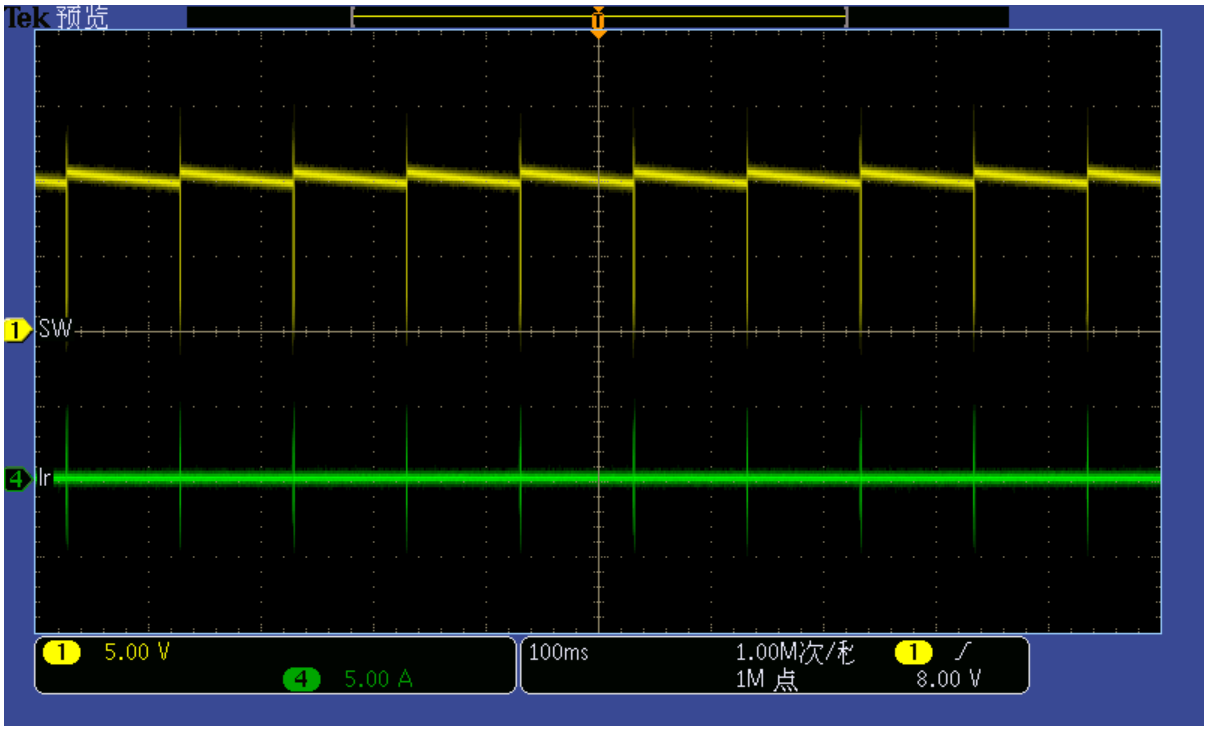

Figure 3-6. Short-Circuit Protection

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3.4 Load Transients

Load transient response is shown in the following figures. The slew rate is set to 0.16 A/µs. The figure shows the load transient of OUTPUT1 with the other outputs at full load and the input voltage at 12 V. The load current is sourced from the 18 V directly to the –2.5 V with no COM connection.

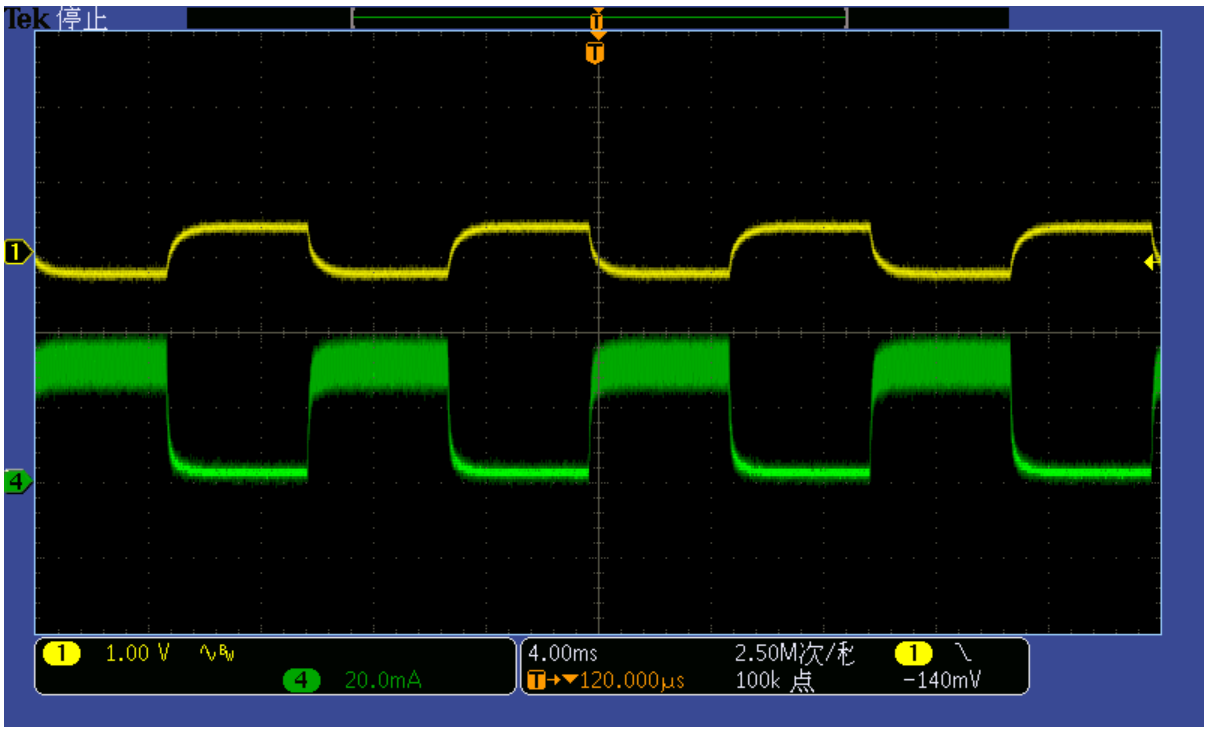

Figure 3-7. Load Transient From 30 mA to 0 mA

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3.5 Start-up Sequence

Start-up behavior is shown in the following figure.

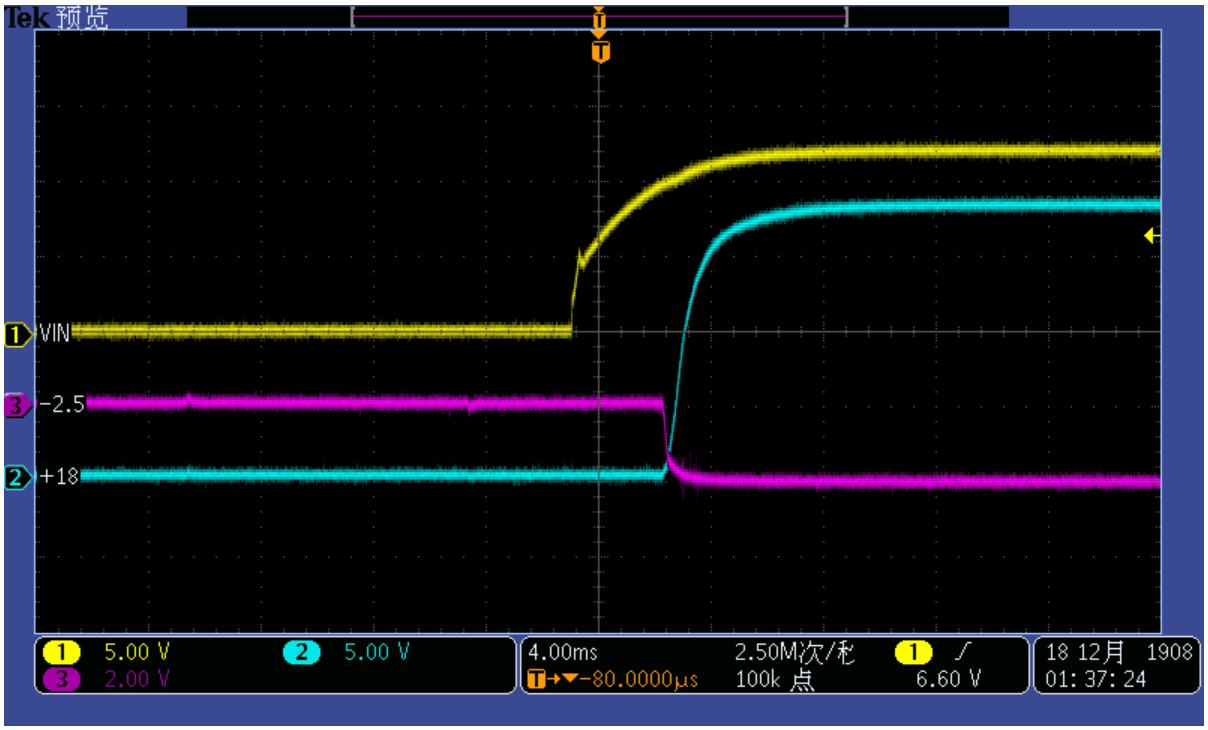

Figure 3-8. Start-up

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3.6 Undervoltage Protection

Undervoltage protection is shown in the following figure.

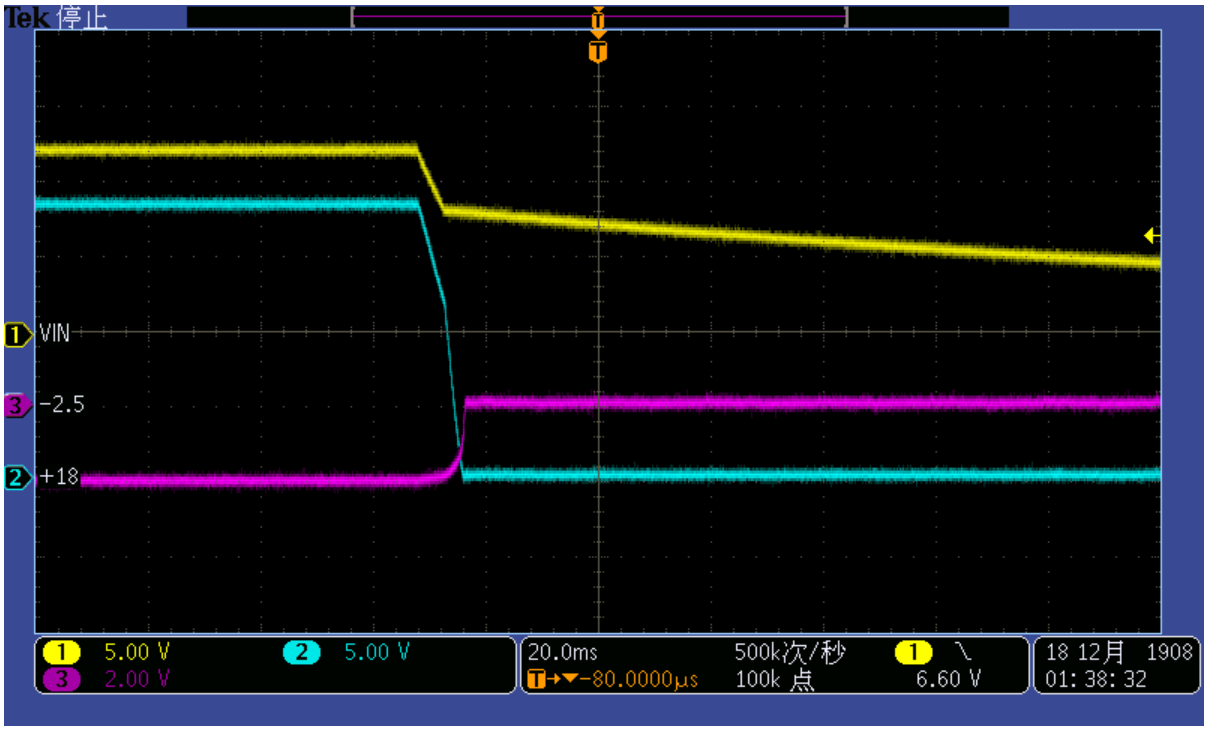

Figure 3-9. Undervoltage

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