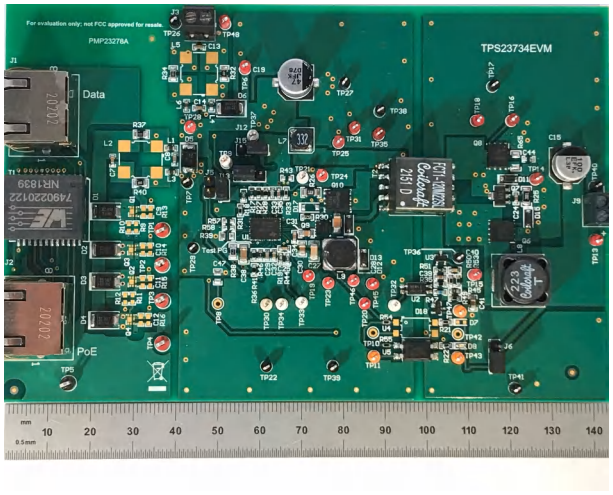
Test Report: PMP23278

Class 4 PoE PD Active Clamp Forward Converter (12 V, 2.1 A) Reference Design

Description

This reference design implements a Power over Ethernet (PoE) Power Device (PD) Active Clamp Forward converter with a 12-V, 2.1-A output.
A TPS23734 PD, pulse-width modulation (PWM) controller provides all the necessary functions to implement the PoE PD control and the PWM control for the Active Clamp Forward converter. This design uses secondary-side regulation (SSR), with an optocoupler feedback.



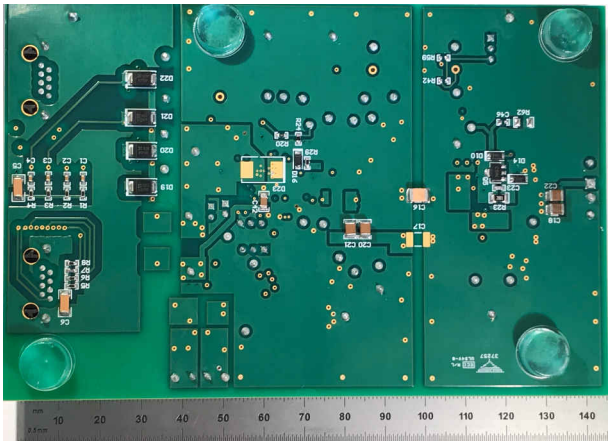
Top Photo

Feature

- Combined PD and PWM controller
- Secondary-side regulation (using optocoupler)
- Optional 48-V adapter input
- Frequency dithering for improved EMI

Applications

- IP network camera
- WLAN, Wi-Fi® access point
- Barcode reader



Bottom Photo

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1 Test Prerequisites

1.1 Voltage and Current Requirements

Table 1-1. Voltage and Current Requirements

Parameter	Specifications
Input voltage	37 V–57 V (48 V nominal)
Output voltage	12 V
Output current	2.1 A
Nominal Switching Frequency	250 kHz

1.2 Required Equipment

- Type 2 PoE Power Source Equipment (PSE)
- Isolated DC power source, 0 V–57 V, 1-A minimum
- 12-V, 5-A electronic load

1.3 Considerations

- All measurements were taken at approximately 25°C ambient
- All measurements taken with 48-V input and 2.1-A load, unless noted

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2 Testing and Results

2.1 Efficiency Graphs

Figure 2-1 shows the PMP23278 efficiency curve.

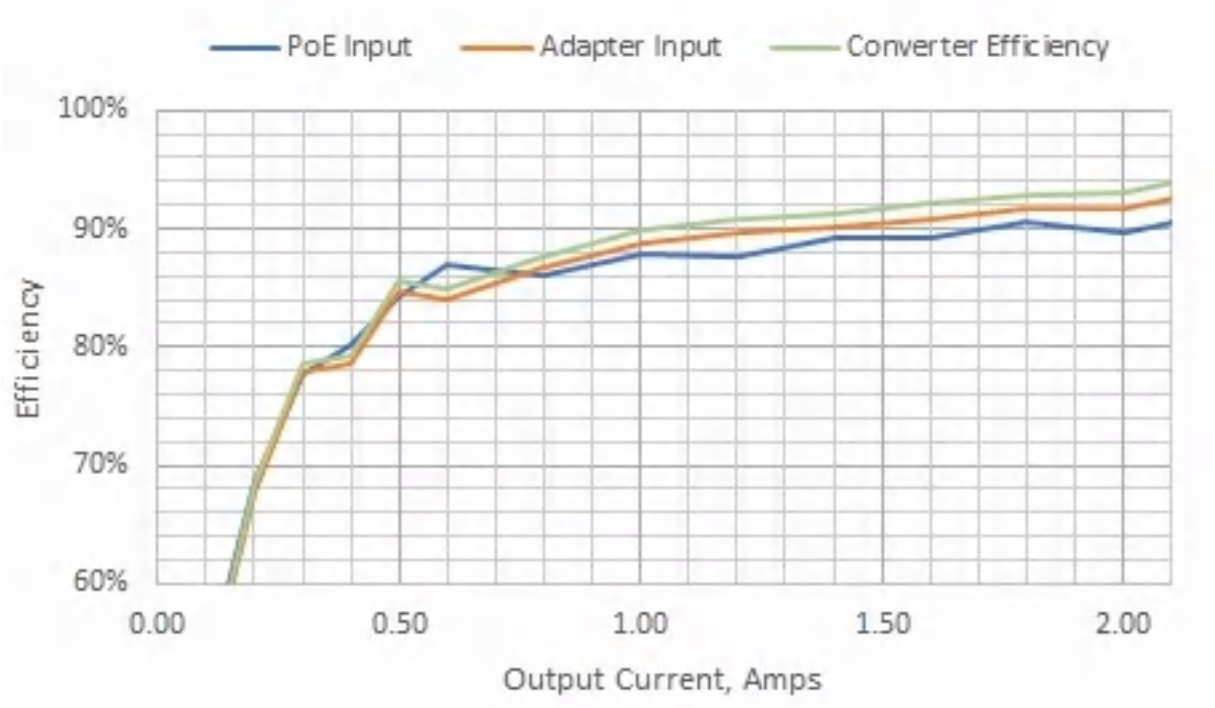

Figure 2-1. PMP23278 Rev. B Efficiency Graph, PoE Diode Bridge

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2.2 Efficiency Data

Efficiency data is shown in the following tables.

I_{OUT} (J9)	V_{OUT} (J9)	I_{IN} (J2)	V_{IN}(J2)	Eff (J2)
0.00	12.08	0.025	48.00	0.0%
0.10	12.08	0.048	48.00	52.5%
0.20	12.08	0.073	48.00	68.6%
0.30	12.08	0.097	48.00	77.7%
0.40	12.08	0.126	48.01	80.2%
0.50	12.08	0.1499	48.00	84.2%
0.60	12.08	0.174	48.01	87.0%
0.80	12.08	0.234	48.02	86.0%
1.00	12.08	0.287	48.01	87.8%
1.20	12.08	0.344	48.00	87.7%
1.40	12.08	0.395	48.01	89.1%
1.60	12.08	0.451	48.00	89.3%
1.80	12.08	0.501	48.00	90.5%
2.00	12.08	0.561	48.01	89.7%
2.08	12.08	0.579	48.01	90.4%
2.20	12.08	0.606	48.01	91.4%

I_{OUT} (J9)	V_{OUT} (J9)	I_{IN} (J3)	V_{IN} (J3)	Eff (J3)	V_{IN} (VDD,PGND)	Eff (CONV)
0.00	12.08	0.0253	48.00	0.0%	47.60	0.0%
o.1o	12.08	0.049	48.00	51.0%	47.57	51.5%
0.20	12.08	0.074	48.00	67.8%	47.54	68.5%
0.30	12.08	0.097	48.00	77.8%	47.54	78.6%
0.40	12.08	0.128	48.01	78.5%	47.52	79.3%
0.50	12.08	0.149	48.00	84.6%	47.50	85.5%
0.60	12.08	0.180	48.00	84.0%	47.48	84.9%
0.80	12.08	0.232	48.00	86.7%	47.45	87.7%
1.00	12.08	0.284	48.00	88.7%	47.43	89.8%
1.20	12.08	0.337	48.00	89.6%	47.40	90.8%
1.40	12.08	0.391	48.00	90.1%	47.37	91.3%
1.60	12.08	0.443	48.00	90.8%	47.35	92.1%
1.80	12.08	0.494	48.00	91.6%	47.33	92.9%
2.00	12.08	0.549	48.00	91.8%	47.31	93.1%
2.11	12.08	0.574	48.00	92.6%	47.30	93.9%
2.20	12.08	0.602	48.00	92.0%	47.29	93.4%

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2.3 Thermal Images

Figure 2-2 and Figure 2-3 show the thermal images at full load and nominal line (48 V).

Measurements	
Sp1	38.6 °C
Sp2	31.2 °C
Sp3	35.4 °C
Sp4	30.6 °C
Sp5	30.4 °C
Sp6	39.8 °C
Sp7	30.7 °C
Sp8	32.2 °C
Sp9	38.3 °C
Parameters	
Emissivity	0.94
Refl. temp.	20 °C

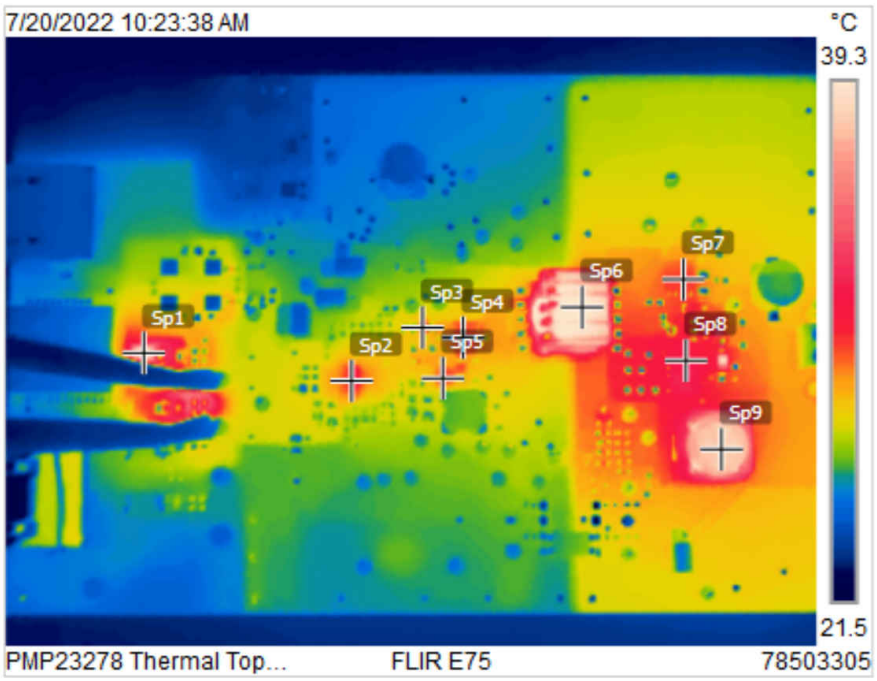

Figure 2-2. Top Thermal Image

Measurements	
Sp1	44.3 °C
Sp2	33.5 °C
Sp3	37.3 °C
Parameters	
Emissivity	0.94
Refl. temp.	20 °C

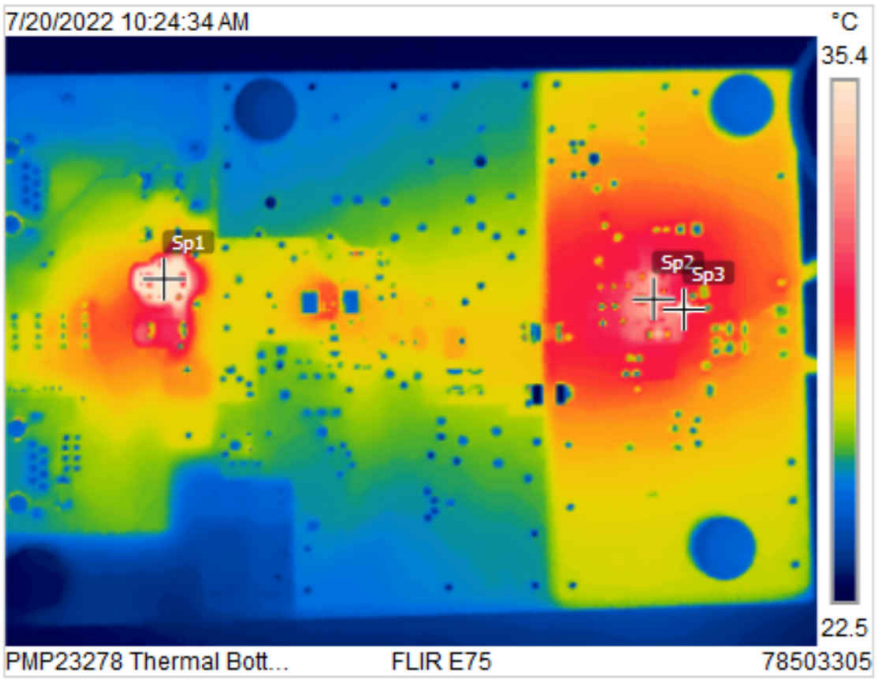

Figure 2-3. Bottom Thermal Image

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2.4 Bode Plots

Figure 2-4 shows the bode plot waveform.

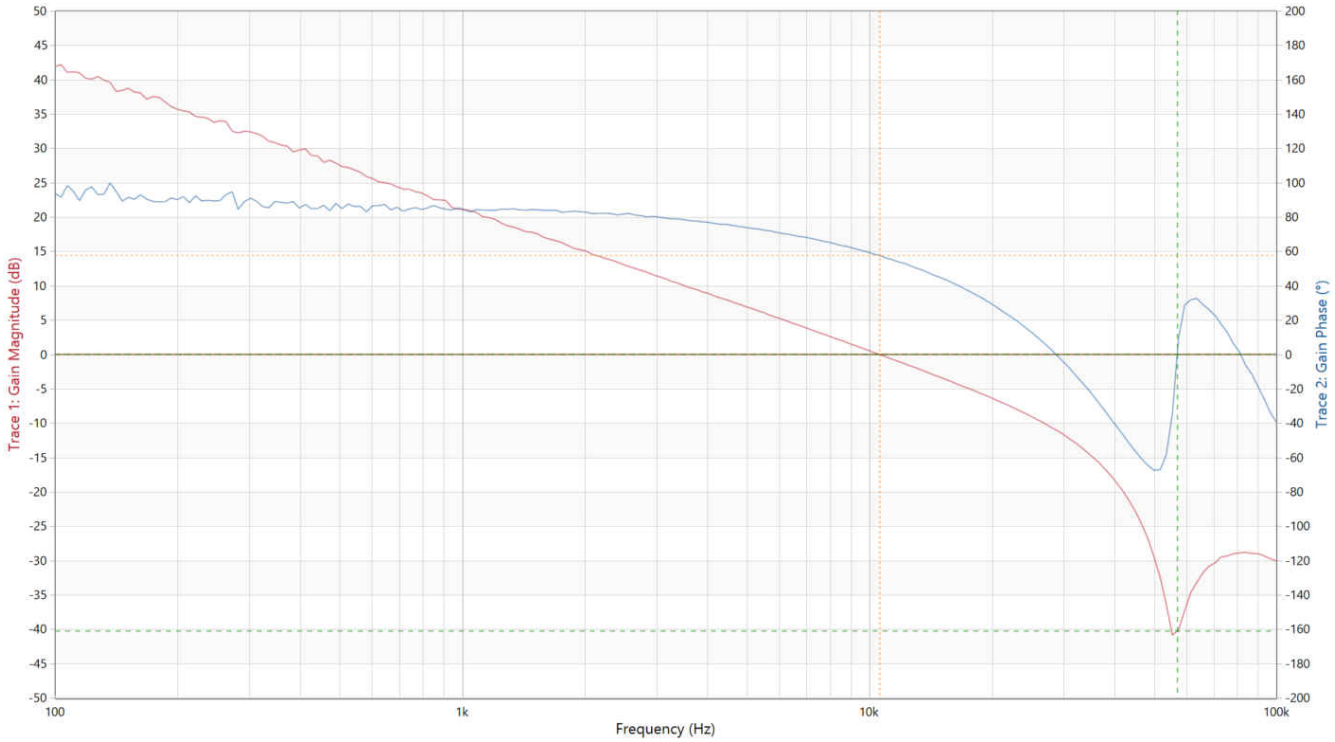

Figure 2-4. Bandwidth = 10.6 kHz, Phase Margin = 57.6 degrees, Gain Margin = 40.3 dB

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3 Waveforms

3.1 Switching

Switching behavior is shown in the following figures.

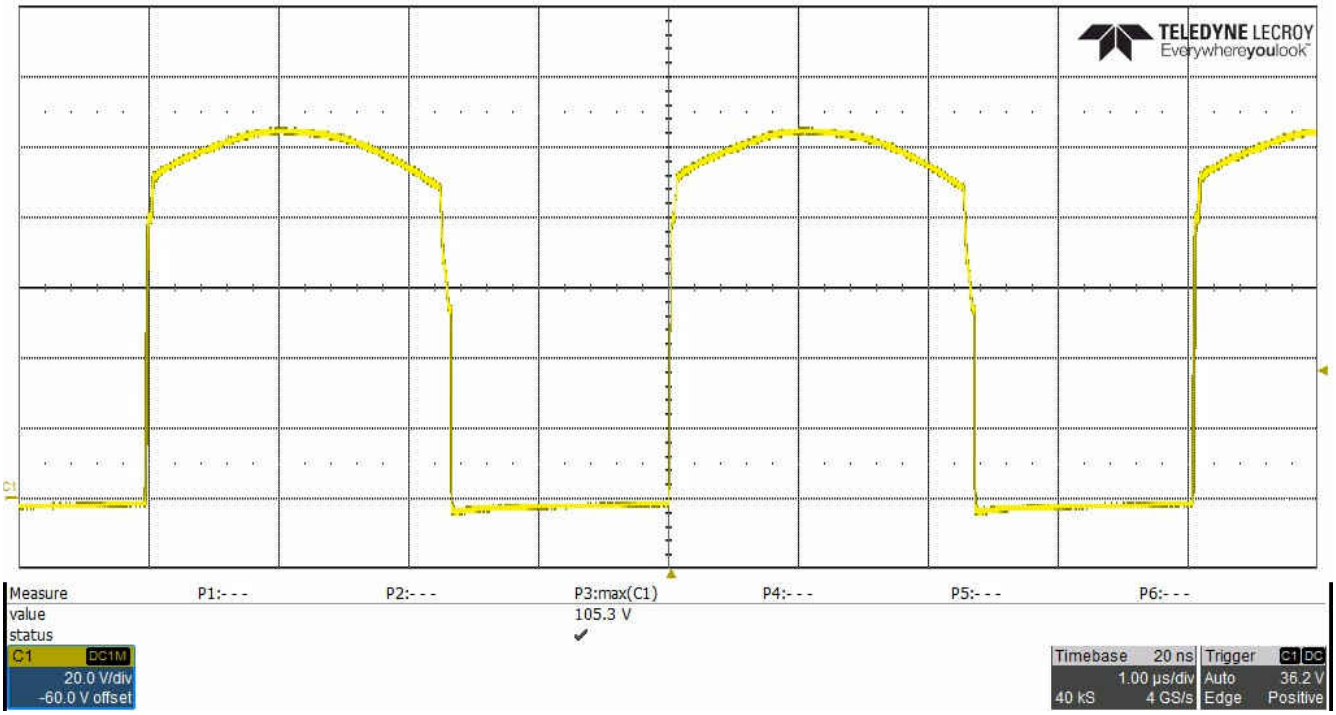

Figure 3-1. Voltage Drain-to-Source, Q10, 57-V Input, 2.1-A Load, 20 V/div, 1 µs/div, Measured 105.3 Vpeak

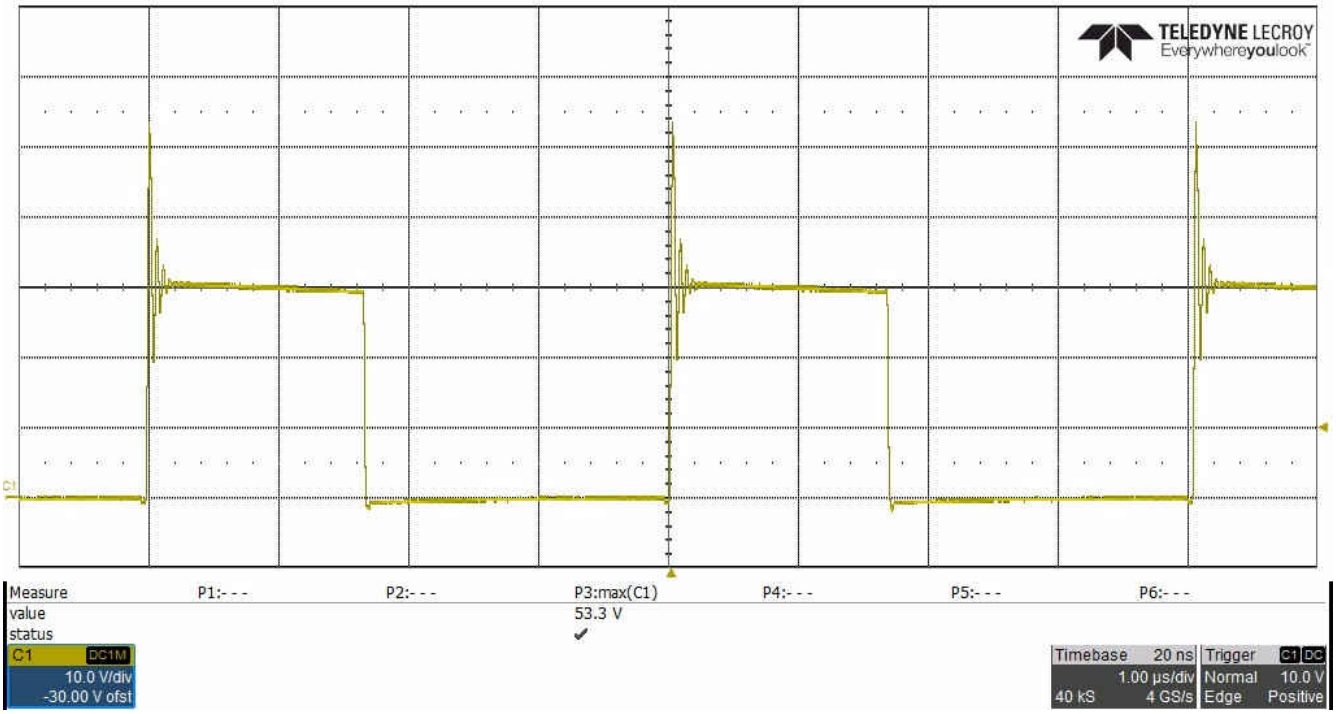

Figure 3-2. Voltage Drain-to-Source, Q6, 57-V Input, 2.1-A Load, 10 V/div, 1 µs/div, Measured 53.3 Vpeak

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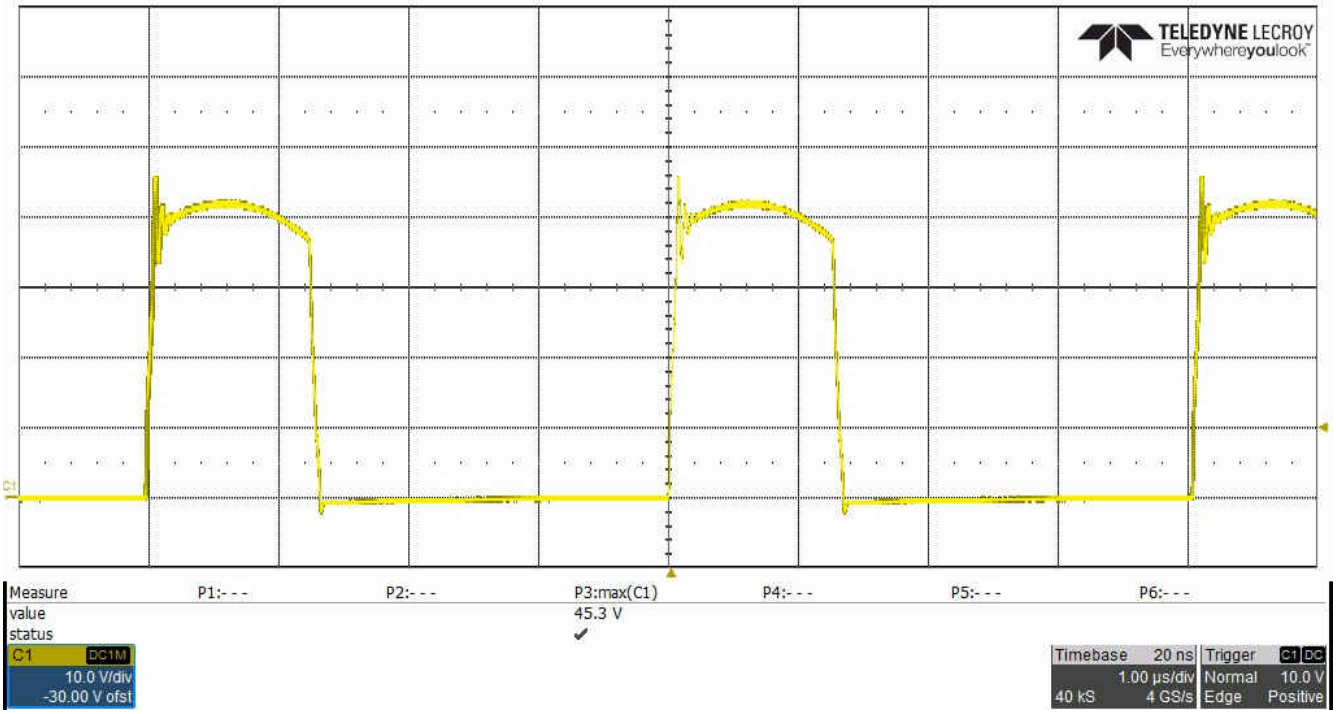

Figure 3-3. Voltage Drain-to-Source, Q8, 37-V Input, 2.1-A Load, 10 V/div, 1 µs/div, Measured 45.3 Vpeak

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3.2 Voltage Ripple

Ripple measurements taken with a 48-V input, 2.1-A load, and 20-MHz Bandwidth Limit (BWL).

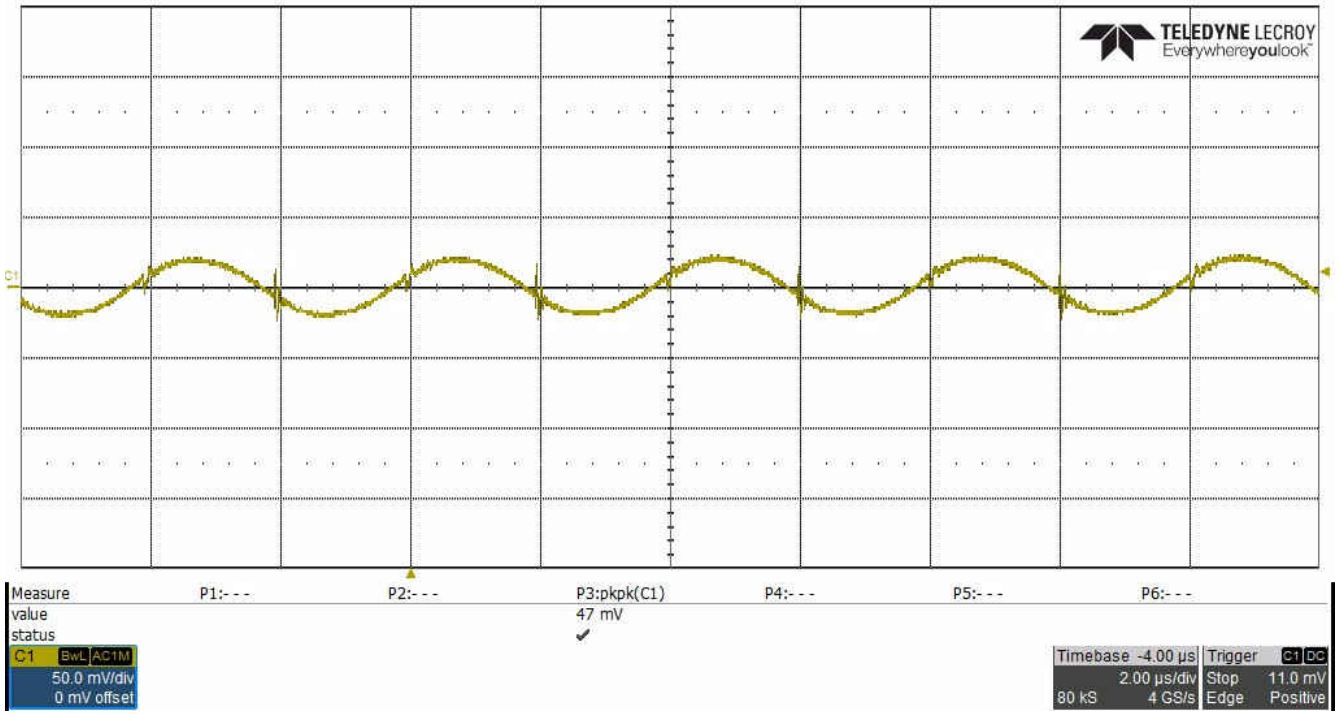

Figure 3-4. Output Ripple (J9), 50 mV/div, 2 µs/div, Measured 47 mVpp

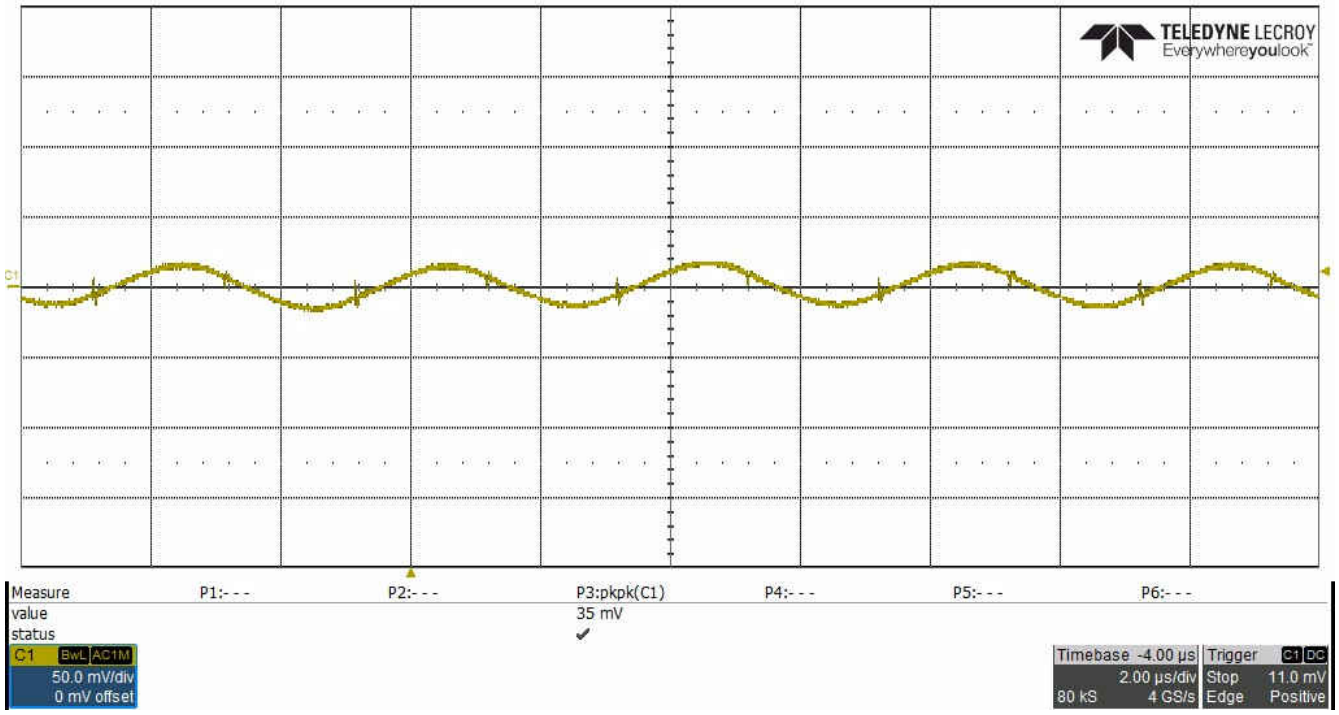

Figure 3-5. Input Ripple (C42), 50 mV/div, 2 µs/div, Measured 35 mVpp

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3.3 Load Transients

Load transient response is shown in the following figures.

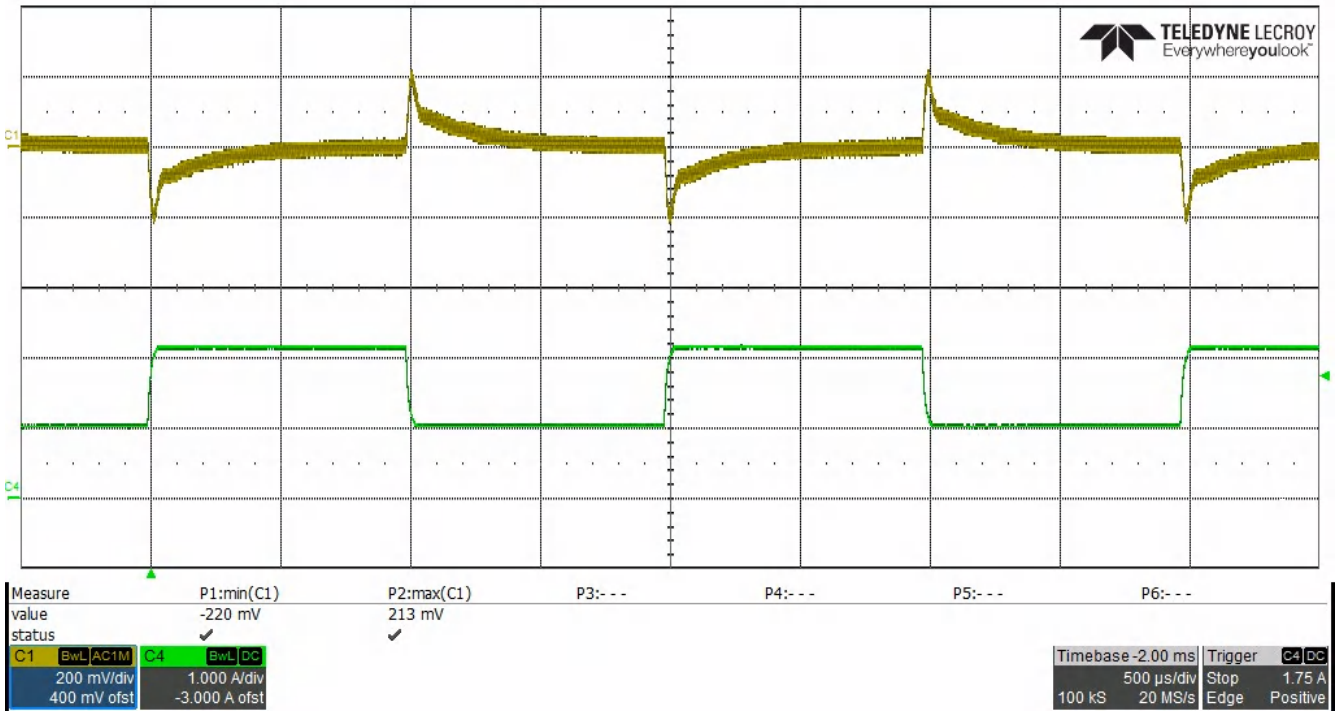

Figure 3-6. Output Load Step Response, 1.00-A to 2.10-A Load Step, 200 mV/div, 1 A/div, 500 µs/div, Slew Rate = 250 mA/µs, Measured –220 mV to +213 mV

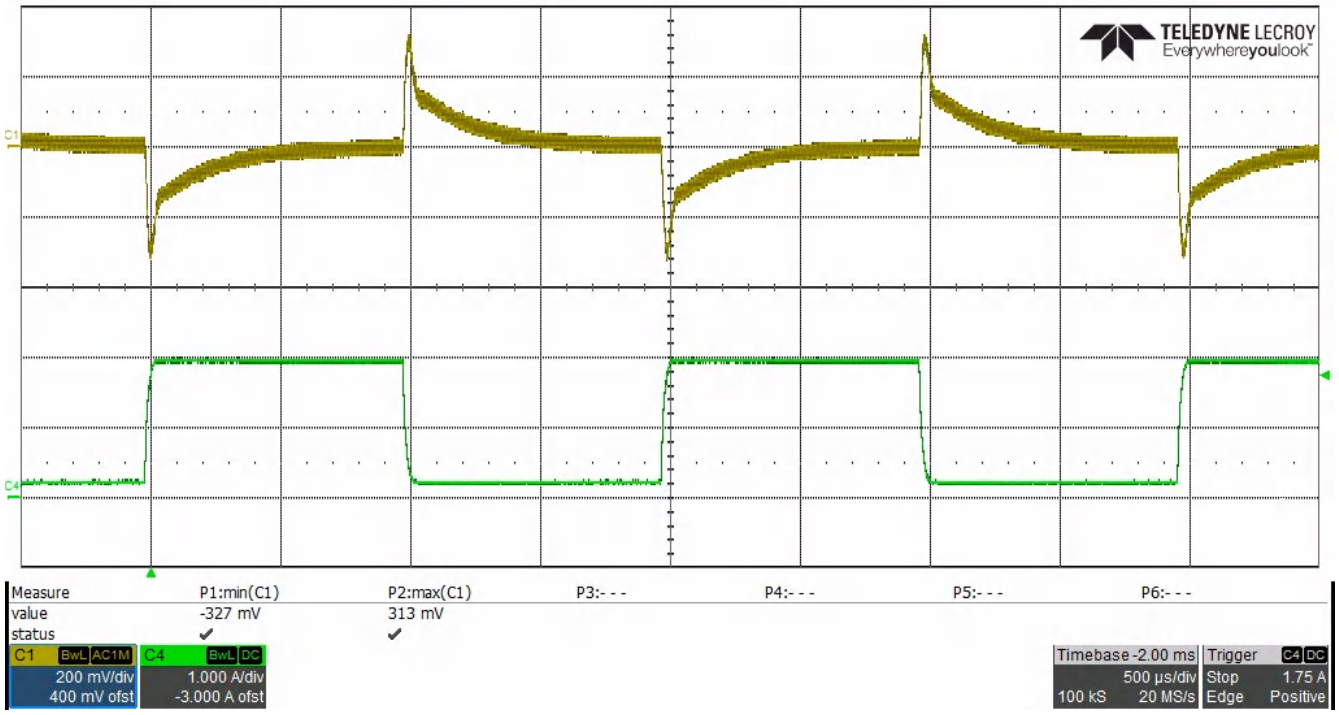

Figure 3-7. Output Load Step Response, 200-mA to 1.90-A Load Step, 200 mV/div, 1 A/div, 500 µs/div, Slew Rate = 250 mA/µs, Measured –327 mV to +313 mV

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3.4 Short-Circuit Protection

Short at output connector J9. Input power during short circuit is 48.01 V, 150 mA, and 7.20 W.

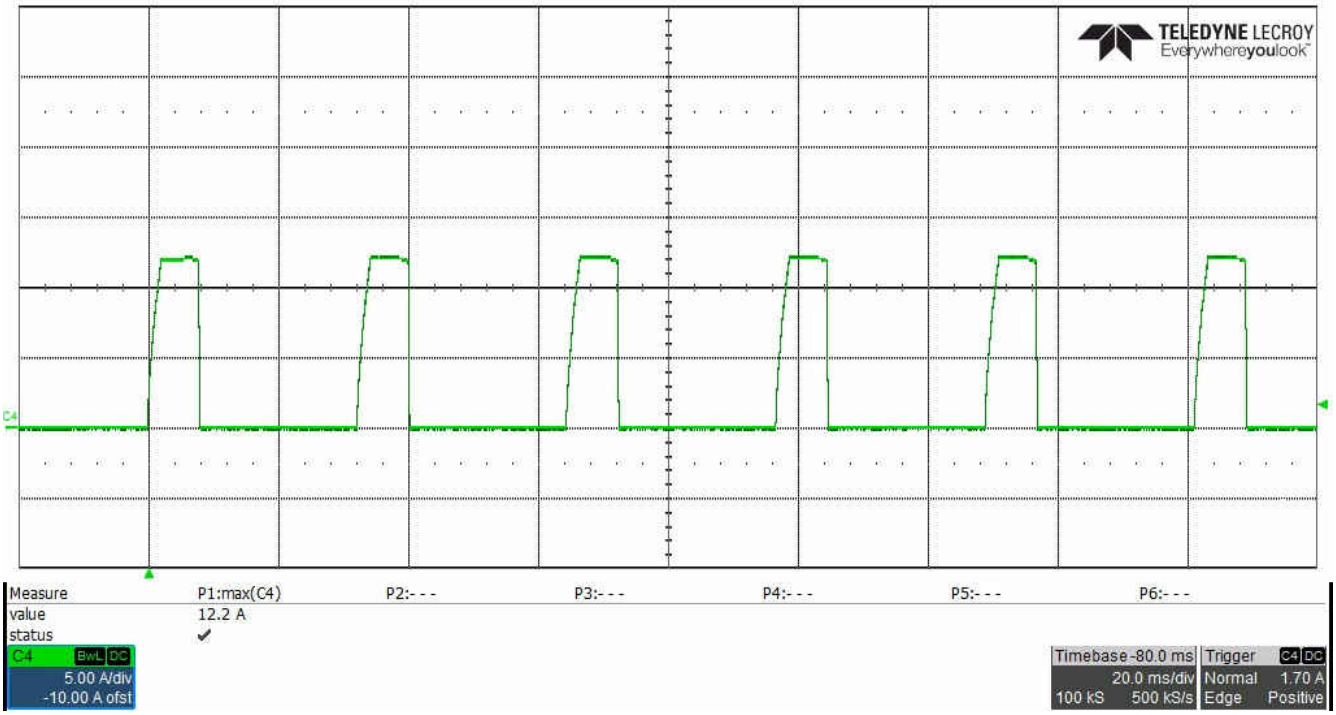

Figure 3-8. Output Current, 5 A/div, 20 ms/div, Measured 12. 2 Apeak

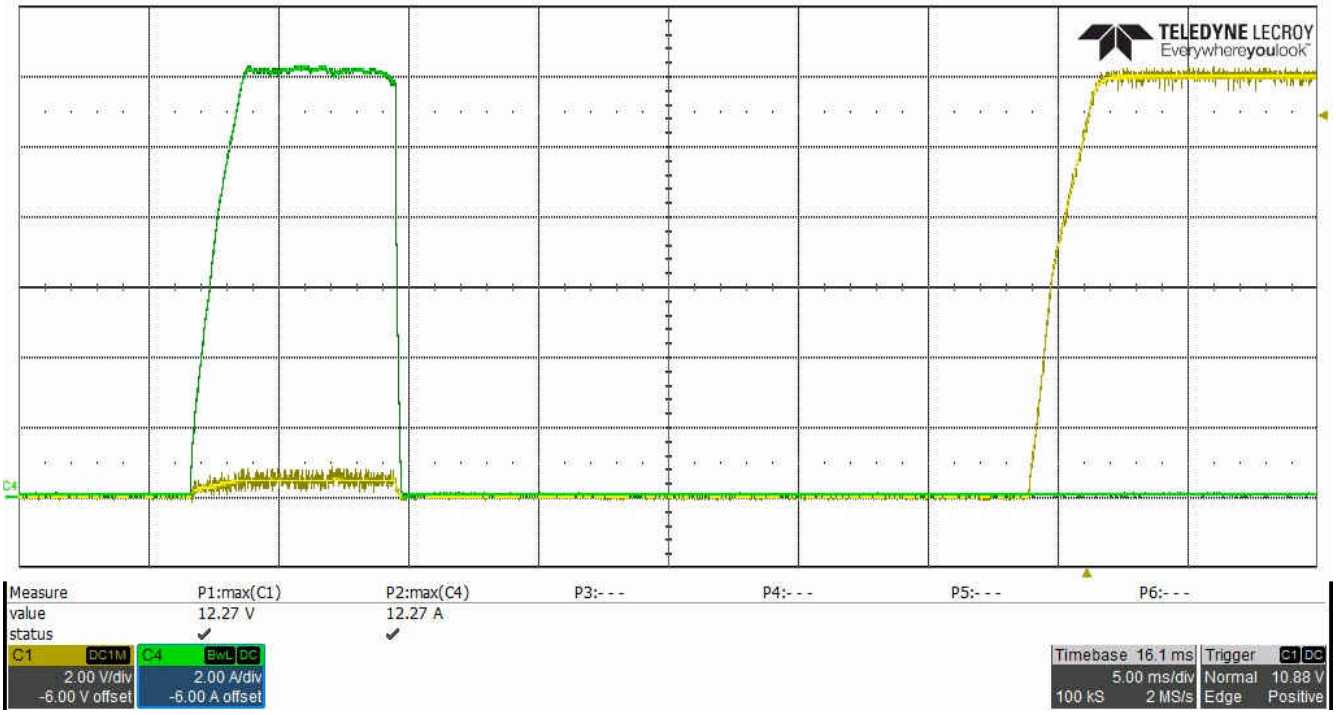

Figure 3-9. Output Voltage Recovery From Short Circuit, 2 V/div, 2 A/div, 5 ms/div

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Figure 3-10 and Figure 3-11 show thermal plots during short circuit.

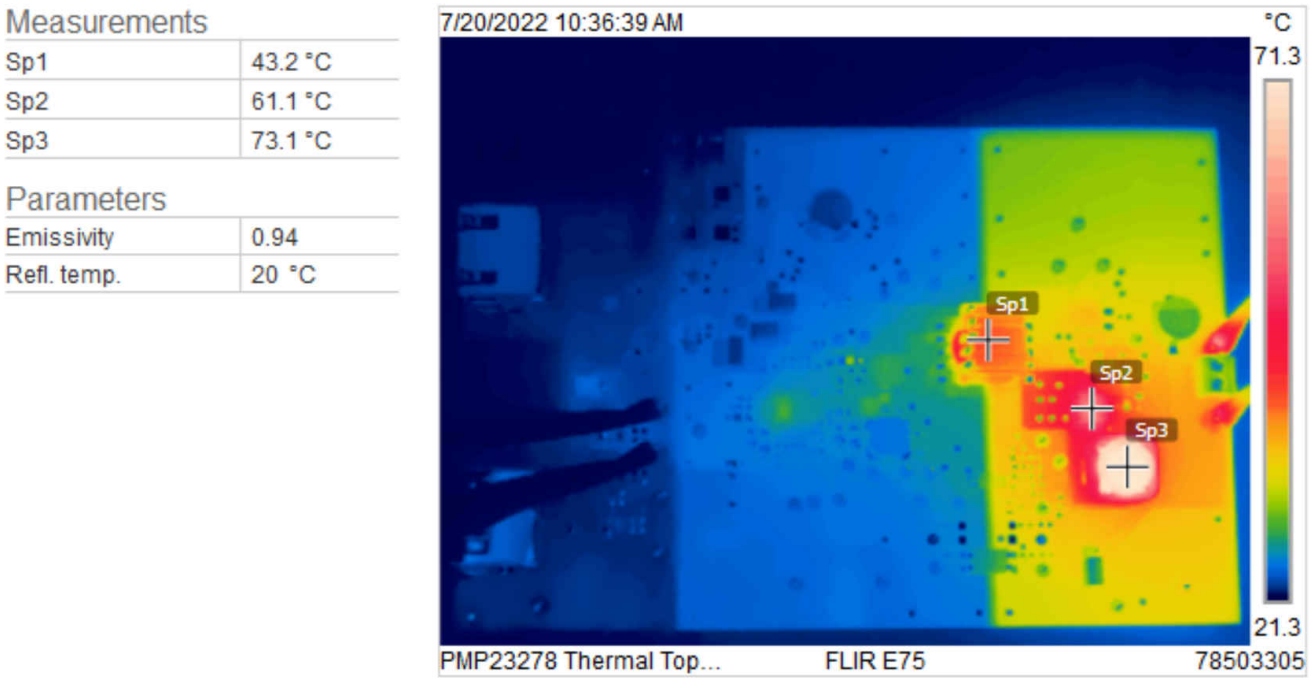

Figure 3-10. Thermal Plot During Short Circuit, Top

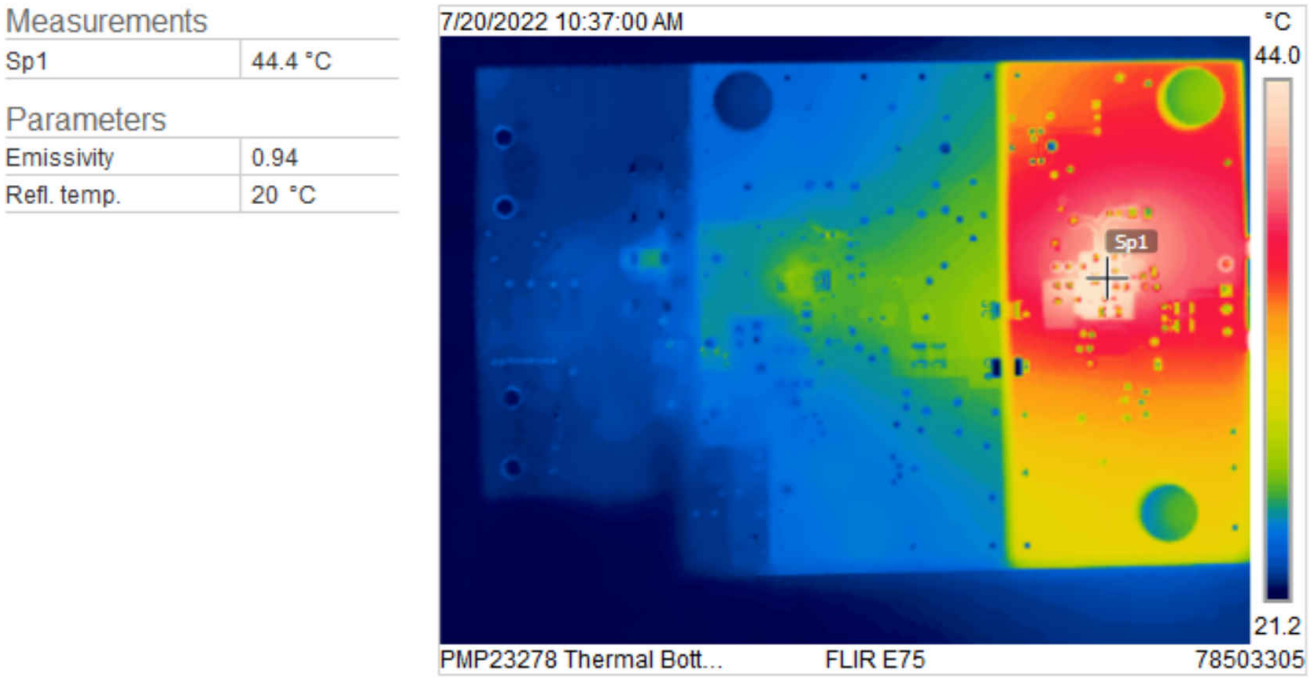

Figure 3-11. Thermal Plot During Short Circuit, Bottom

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3.5 Start-Up Sequence

Start-up behavior is shown in the following figures.

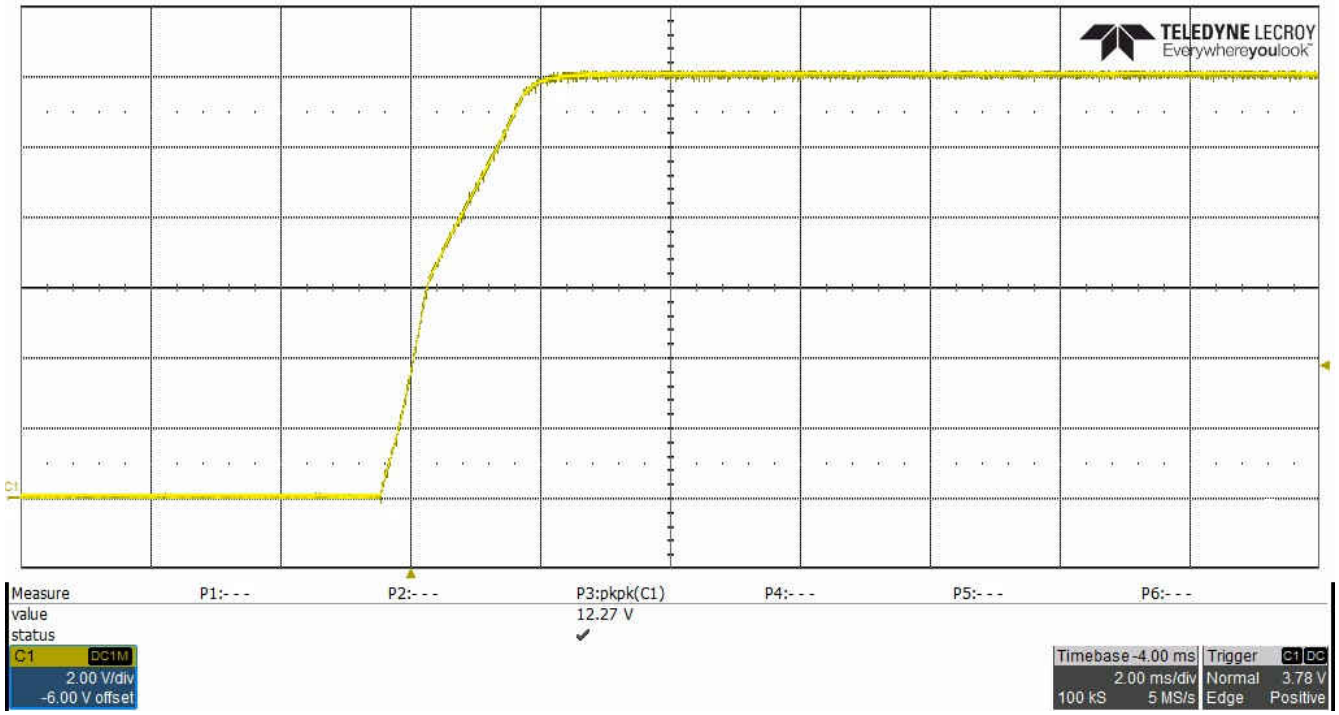

Figure 3-12. 0-A Load, 2 ms/div, 2 V/div

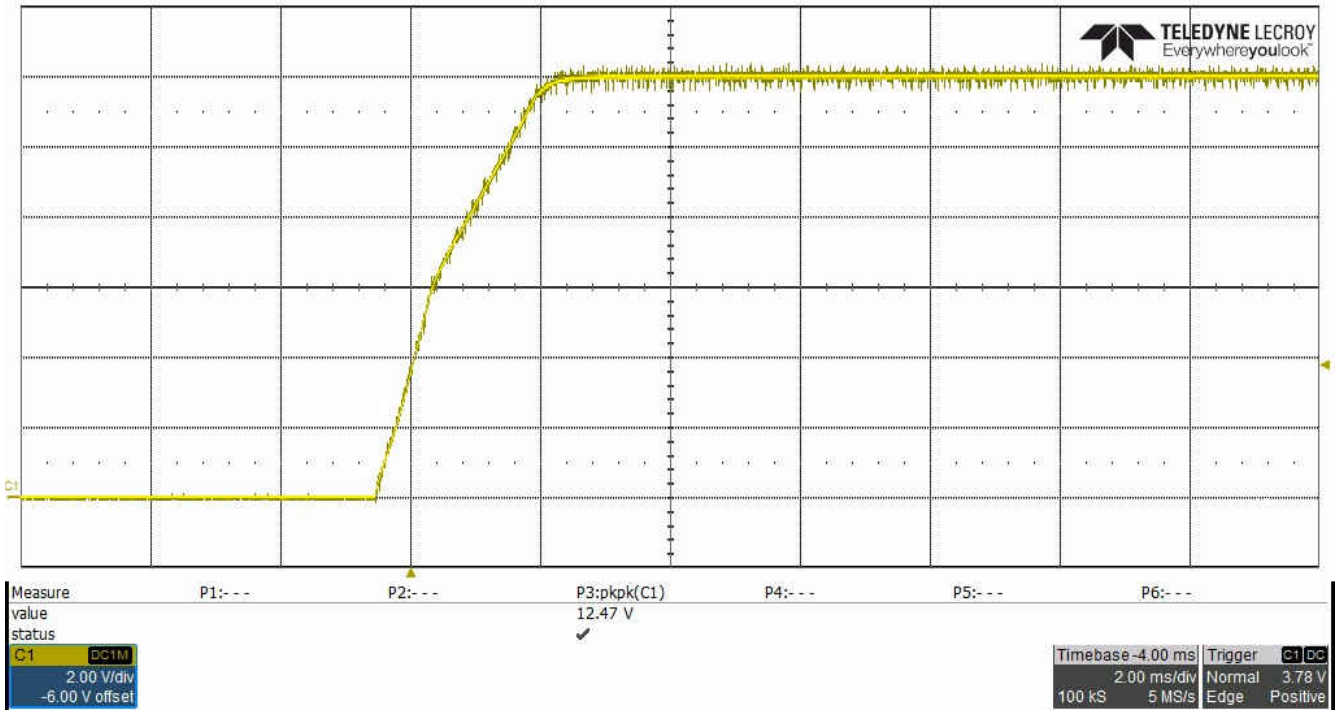

Figure 3-13. 2.1-A Load, 2 ms/div, 2 V/div

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