Test Report: PMP23123

Isolated Active Clamp Forward Converter (19-V, 4-A to 40-V, 2.5-A) Reference Design

Description

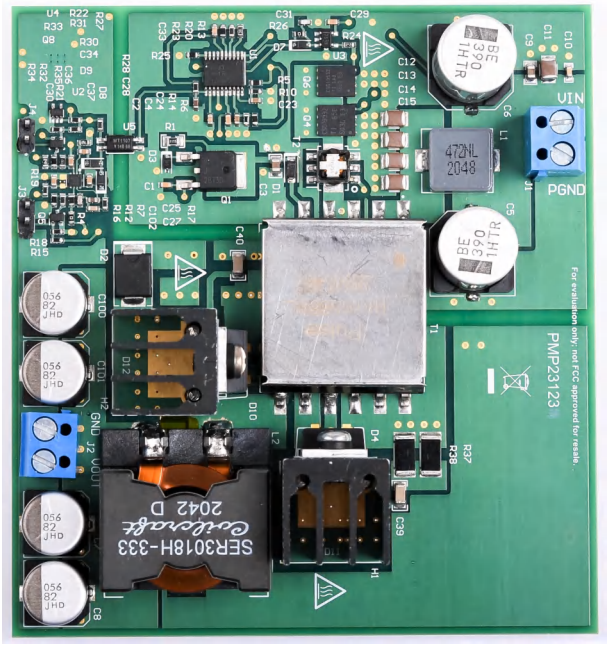
This reference design utilizes an active clamp-forward converter for an 18-V to 36-V DC input to isolated output adjustable from 40 V, 2.5 A to 19 V, 4 A. A UCC2897A PWM controller provides the control for the active clamp-forward converter.

Features

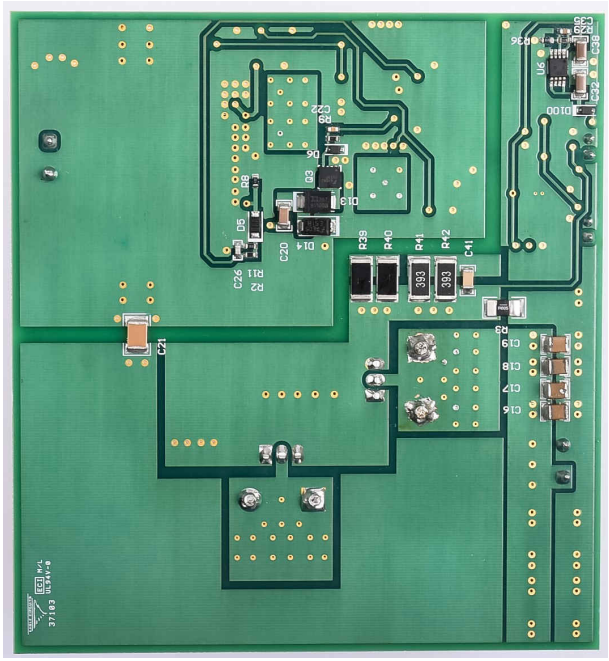
- Nominal 24-V DC input for industrial applications
- Adjustable output from 19 V to 40 V
- 88% efficiency at 19-V, 4-A; 91% efficiency at 40 V, 2.5 A

Applications

- Fire alarm control panel (FACP)
- Thermal imaging camera



Top Board Photo



Bottom Board Photo

1 Test Prerequisites

1.1 Voltage and Current Requirements

Table 1-1. Voltage and Current Requirements

Parameter	Specifications
Input voltage	18 V to 36 V DC
Output voltage	Adjustable, 19 V to 40 V ±3%
Output current	4 A maximum at 19-V output 2.5 A maximum at 40-V output
Output power	100-W continuous from 30-V to 40-V output; below 30-V output, derate linearly to 76 W at 19-V output
Switching frequency	200 kHz

1.2 Required Equipment

- Isolated DC power source, 0 V to 36 V , 10 A minimum
- 40-V, 4-A load

1.3 Considerations

WARNING

Board contains hot surfaces. Do not touch.

1.4 Dimensions

The board measures 94 mm × 102 mm.

2 Testing and Results

2.1 Efficiency Graphs

Figure 2-1 and Figure 2-2 show the PMP23123 efficiency graphs.

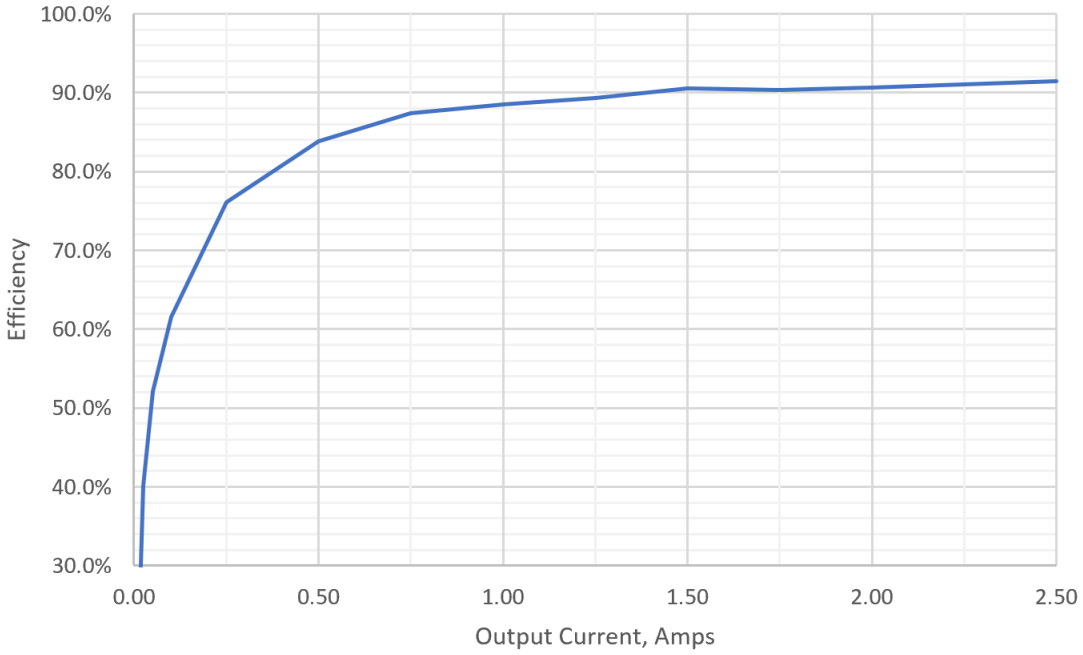


Figure 2-1. PMP23123 Rev. E Efficiency, 24-V Input, 40-V Output

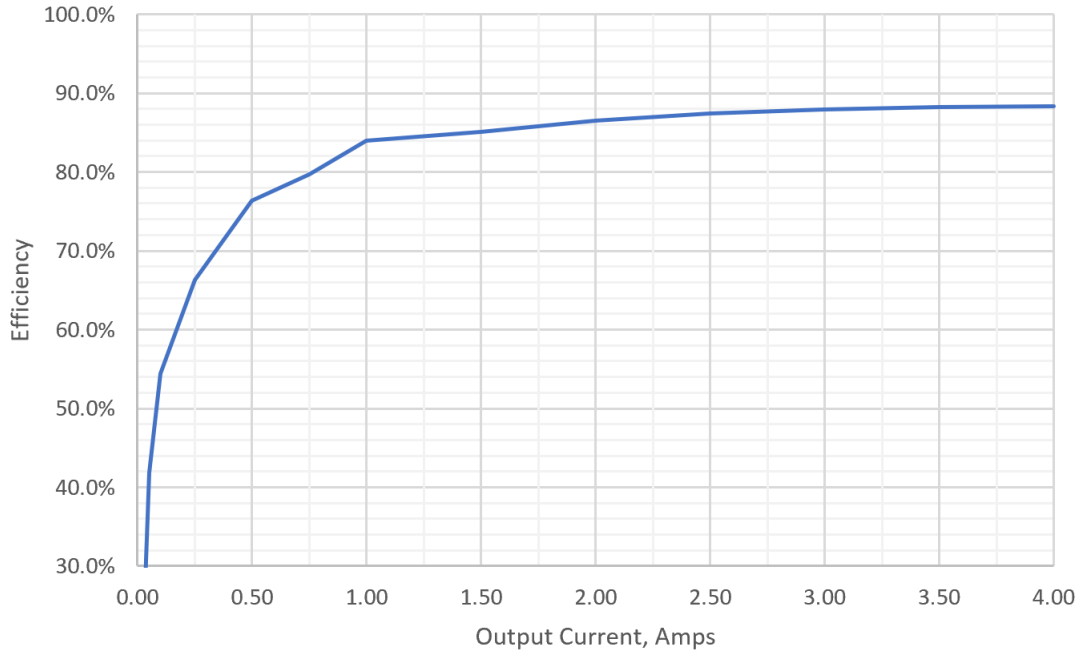


Figure 2-2. PMP23123 Rev. E Efficiency, 24-V Input, 19-V Output

2.2 Efficiency Data

Figure 2-3 and Figure 2-4 display the PMP23123 efficiency data.

Iout (A)	Vout (V)	Pout (W)	Iin (A)	Vin (V)	Pin (W)	Ploss (W)	Eff
0.00	40.042	0.0	0.043	24.00	1.0	1.0	0.0%
0.025	40.046	1.0	0.104	24.00	2.5	1.5	40.1%
0.05	40.049	2.0	0.160	24.00	3.8	1.8	52.1%
0.10	40.045	4.0	0.271	24.00	6.5	2.5	61.6%
0.25	40.045	10.0	0.548	24.01	13.2	3.1	76.1%
0.50	40.042	20.0	0.995	24.01	23.9	3.9	83.8%
0.75	40.040	30.0	1.430	24.02	34.3	4.3	87.4%
1.00	40.039	40.0	1.883	24.02	45.2	5.2	88.5%
1.25	40.035	50.0	2.333	24.00	56.0	5.9	89.4%
1.50	40.037	60.1	2.762	24.01	66.3	6.3	90.6%
1.75	40.027	70.0	3.228	24.01	77.5	7.5	90.4%
2.00	40.012	80.0	3.675	24.01	88.2	8.2	90.7%
2.25	39.997	90.0	4.110	24.04	98.8	8.8	91.1%
2.50	39.986	100.0	4.550	24.03	109.3	9.4	91.4%

Figure 2-3. Efficiency Data, 24-V Input, 40-V Output

Iout (A)	Vout (V)	Pout (W)	Iin (A)	Vin (V)	Pin (W)	Ploss (W)	Eff
0.00	19.098	0.0	0.028	24.01	0.7	0.7	0.0%
0.05	19.097	1.0	0.095	24.02	2.3	1.3	41.8%
0.10	19.097	1.9	0.146	24.02	3.5	1.6	54.5%
0.25	19.096	4.8	0.300	24.01	7.2	2.4	66.3%
0.50	19.096	9.5	0.521	24.00	12.5	3.0	76.4%
0.75	19.093	14.3	0.749	24.00	18.0	3.7	79.7%
1.00	19.096	19.1	0.947	24.01	22.7	3.6	84.0%
1.50	19.085	28.6	1.400	24.02	33.6	5.0	85.1%
2.00	19.087	38.2	1.838	24.00	44.1	5.9	86.5%
2.50	19.088	47.7	2.273	24.02	54.6	6.9	87.4%
3.00	19.083	57.2	2.711	24.02	65.1	7.9	87.9%
3.50	19.082	66.8	3.153	24.02	75.7	8.9	88.2%
4.00	19.084	76.3	3.601	24.00	86.4	10.1	88.3%

Figure 2-4. Efficiency Data, 24-V Input, 19-V Output

2.3 Thermal Images

Figure 2-5 through Figure 2-10 show the PMP23123 thermal images.

Measurements	
Sp1	69.0 °C
Sp2	66.8 °C
Sp3	67.5 °C
Sp4	58.5 °C
Sp5	58.2 °C
Sp6	63.0 °C
Sp7	56.3 °C
Sp8	48.0 °C

Parameters	
Emissivity	0.94
Refl. temp.	20 °C

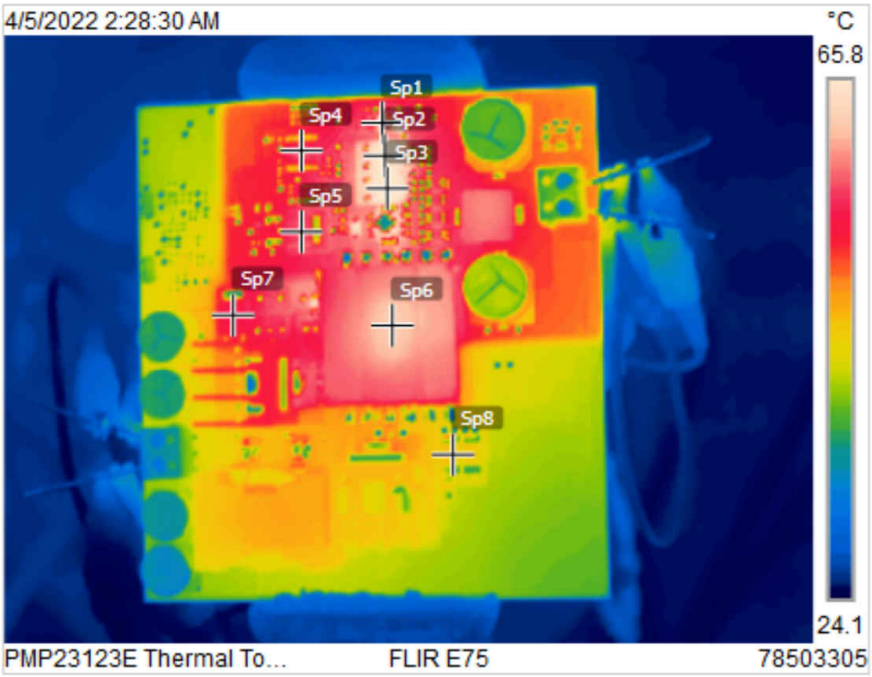


Figure 2-5. Top View, 24-V Input, 40-V, 2.5-A Output

Measurements	
Sp1	55.7 °C
Sp2	60.9 °C
Sp3	53.0 °C
Sp4	49.2 °C

Parameters	
Emissivity	0.94
Refl. temp.	20 °C

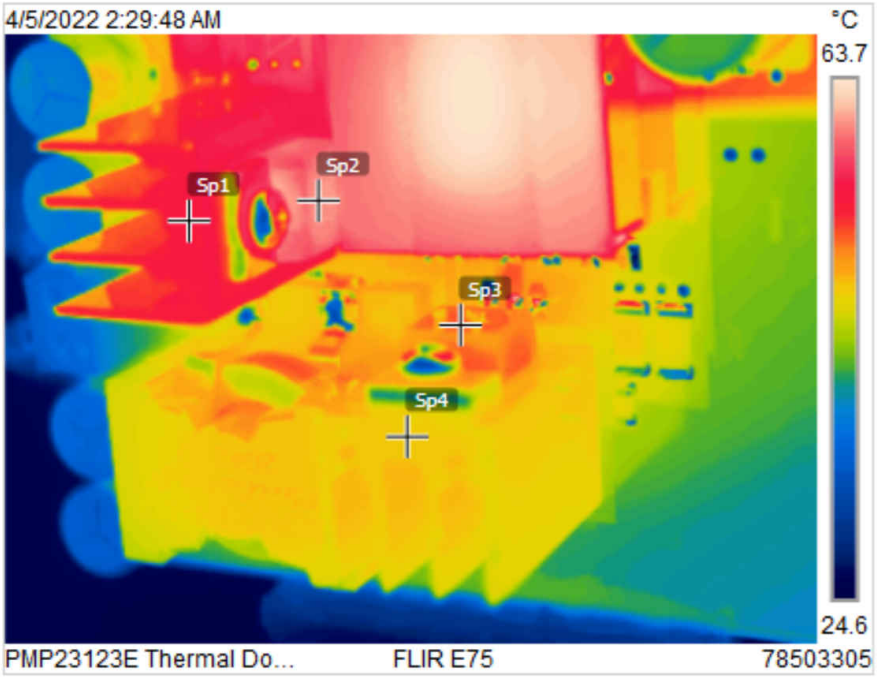


Figure 2-6. Diodes, 24-V Input, 40-V, 2.5-A Output

Measurements	
Sp1	70.8 °C
Sp2	61.0 °C
Sp3	69.1 °C
Sp4	72.2 °C

Parameters	
Emissivity	0.94
Refl. temp.	20 °C

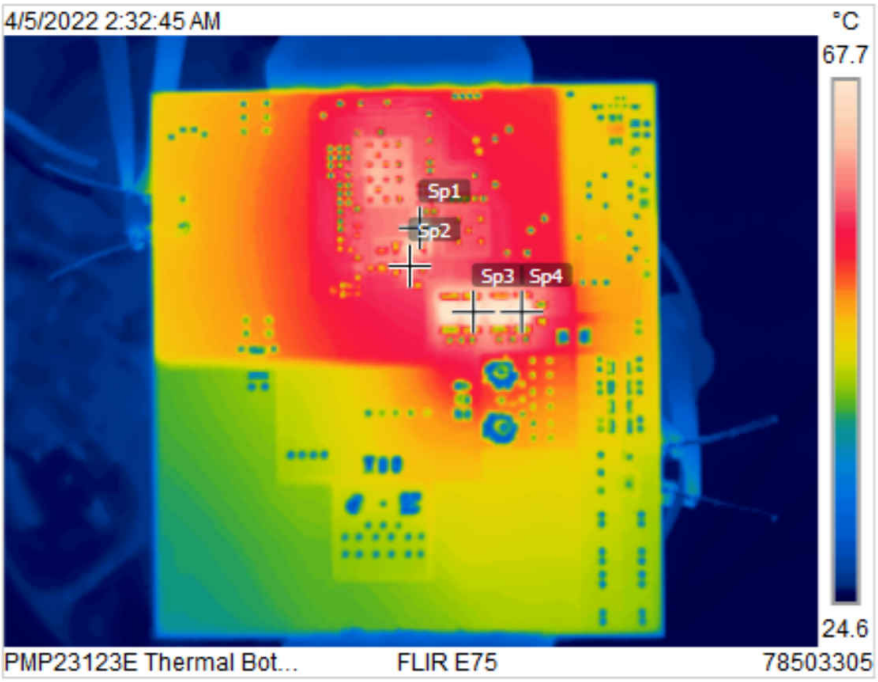


Figure 2-7. Bottom View, 24-V Input, 40-V, 2.5-A Output

Measurements	
Sp1	68.7 °C
Sp2	65.7 °C
Sp3	67.0 °C
Sp4	59.5 °C
Sp5	59.3 °C
Sp6	69.4 °C
Sp7	67.3 °C
Sp8	50.7 °C

Parameters	
Emissivity	0.94
Refl. temp.	20 °C

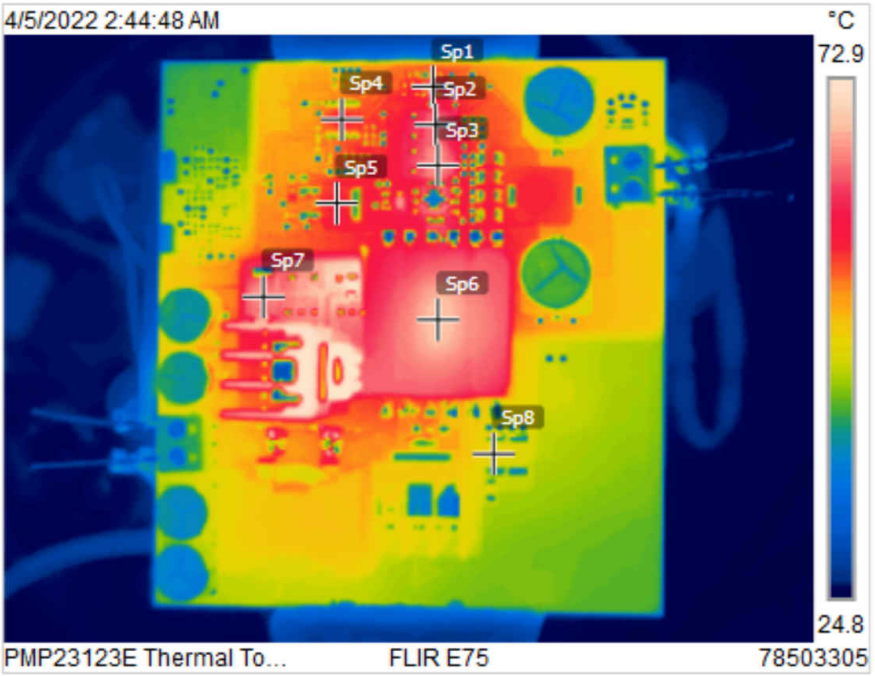


Figure 2-8. Top View, 24-V Input, 19-V, 4-A Output

Measurements	
Sp1	73.6 °C
Sp2	81.5 °C
Sp3	56.5 °C
Sp4	52.3 °C

Parameters	
Emissivity	0.94
Refl. temp.	20 °C

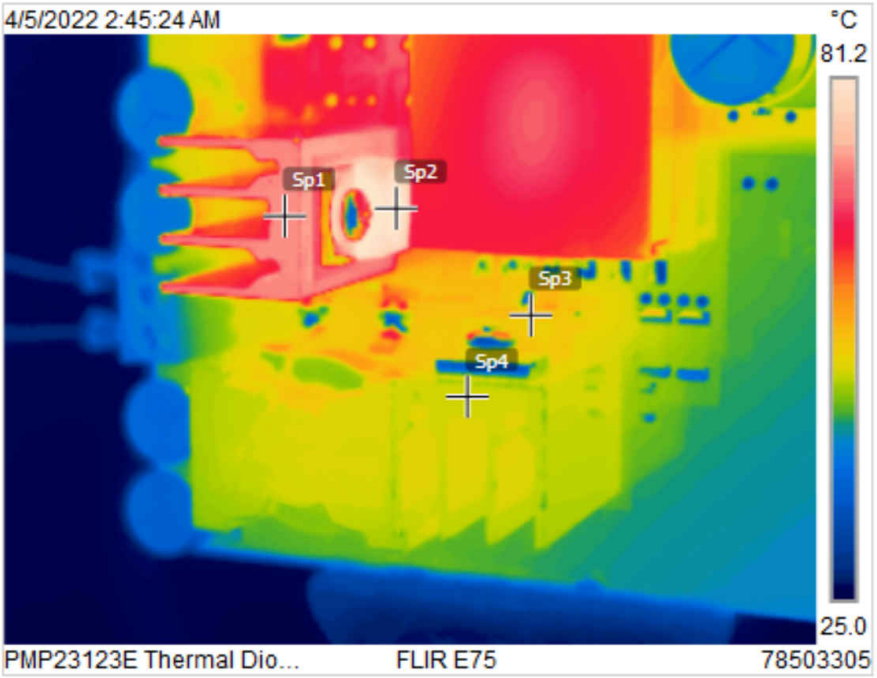


Figure 2-9. Diodes, 24-V Input, 19-V, 4-A Output

Measurements	
Sp1	63.2 °C
Sp2	64.0 °C
Sp3	84.4 °C
Sp4	85.9 °C

Parameters	
Emissivity	0.94
Refl. temp.	20 °C

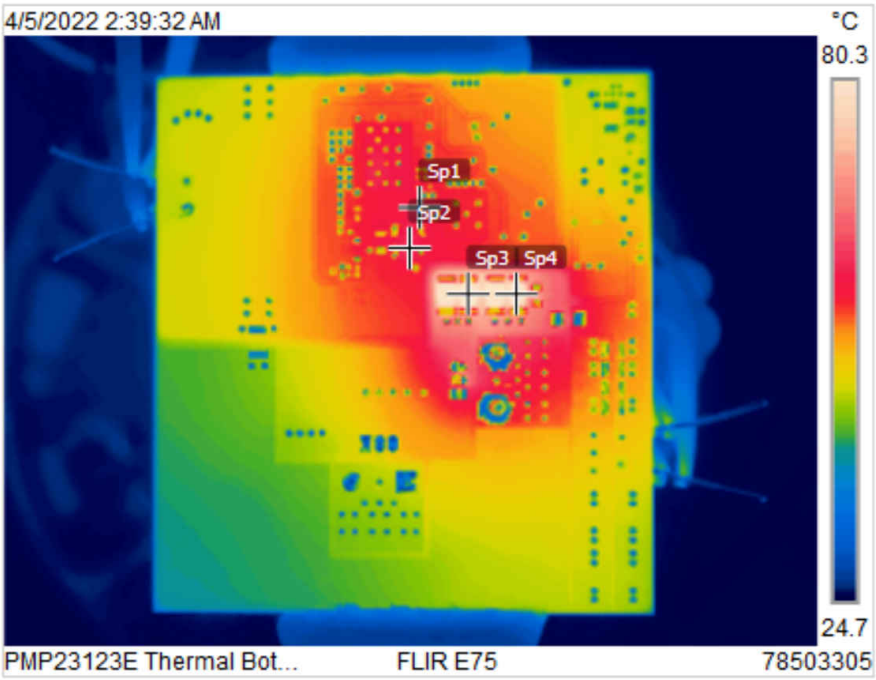


Figure 2-10. Bottom View, 24-V Input, 19-V, 4-A Output

2.4 Bode Plots

Figure 2-11 through Figure 2-16 illustrate the PMP23123 bode plots.

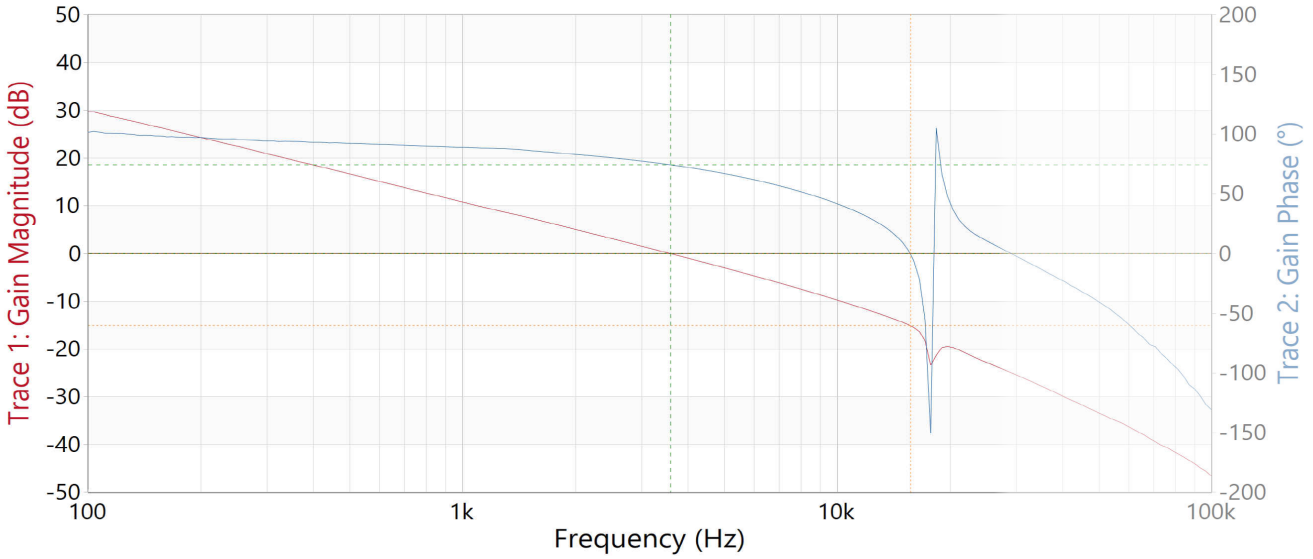


Figure 2-11. 18-V Input, 40-V, 2.5-A Output; Bandwidth = 5.1 kHz, Phase Margin = 64.8 Degrees, Gain Margin = 15.0 dB

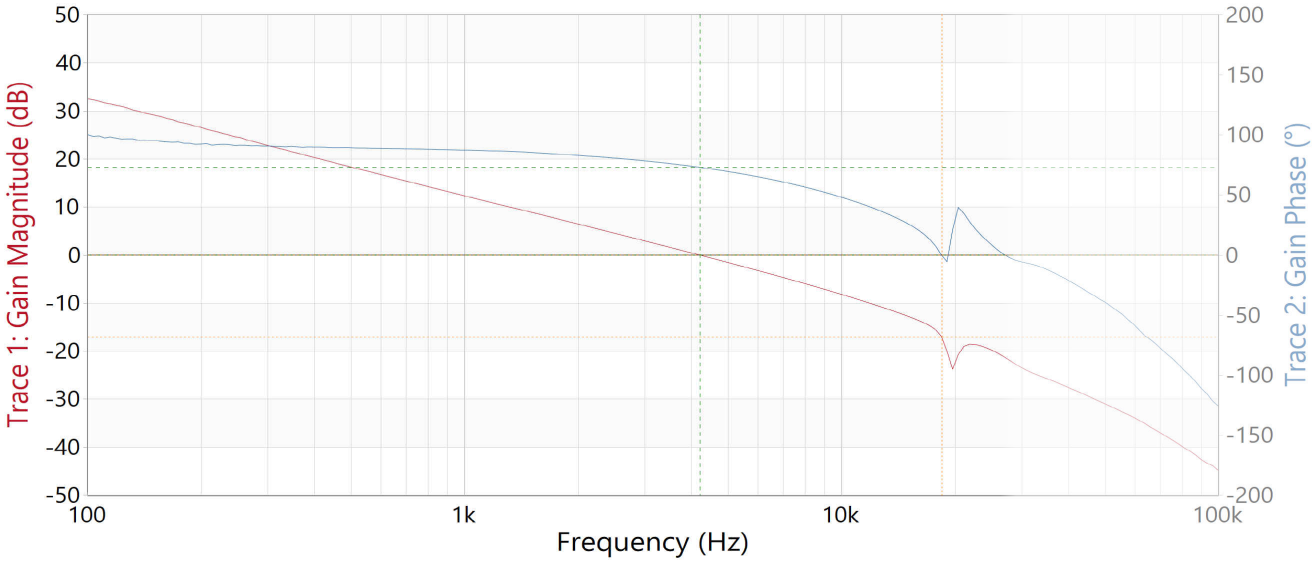


Figure 2-12. 24-V Input, 40-V, 2.5-A Output; Bandwidth = 4.2 kHz, Phase Margin = 73.1 Degrees, Gain Margin = 17.0 dB

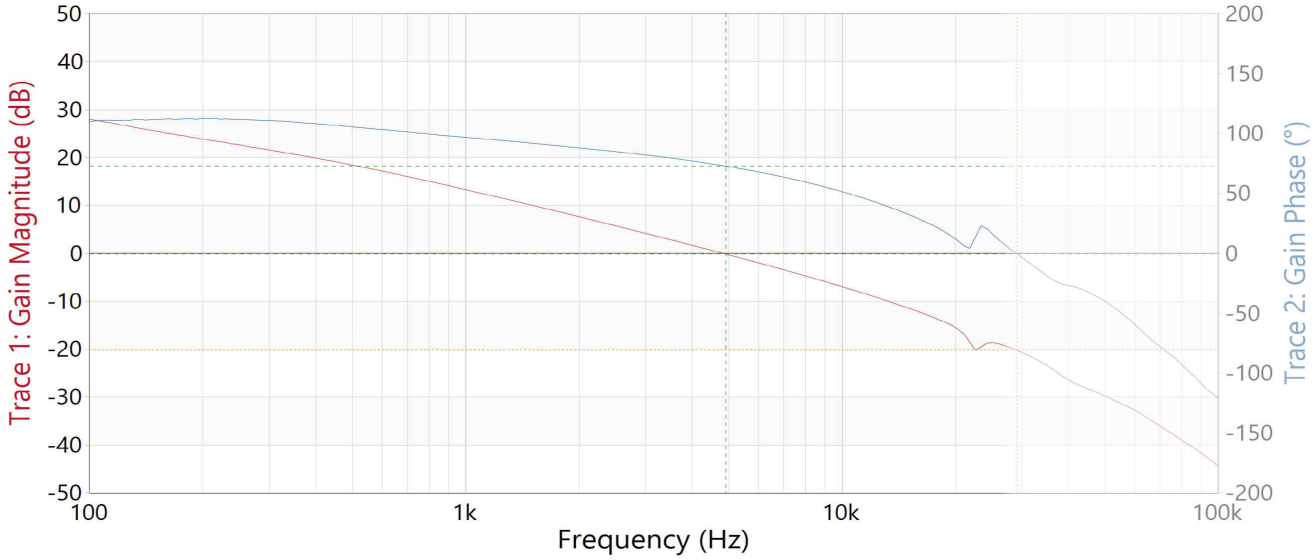


Figure 2-13. 36-V Input, 40-V, 2.5-A Output; Bandwidth = 4.9 kHz, Phase Margin = 72.9 Degrees, Gain Margin = 20.2 dB

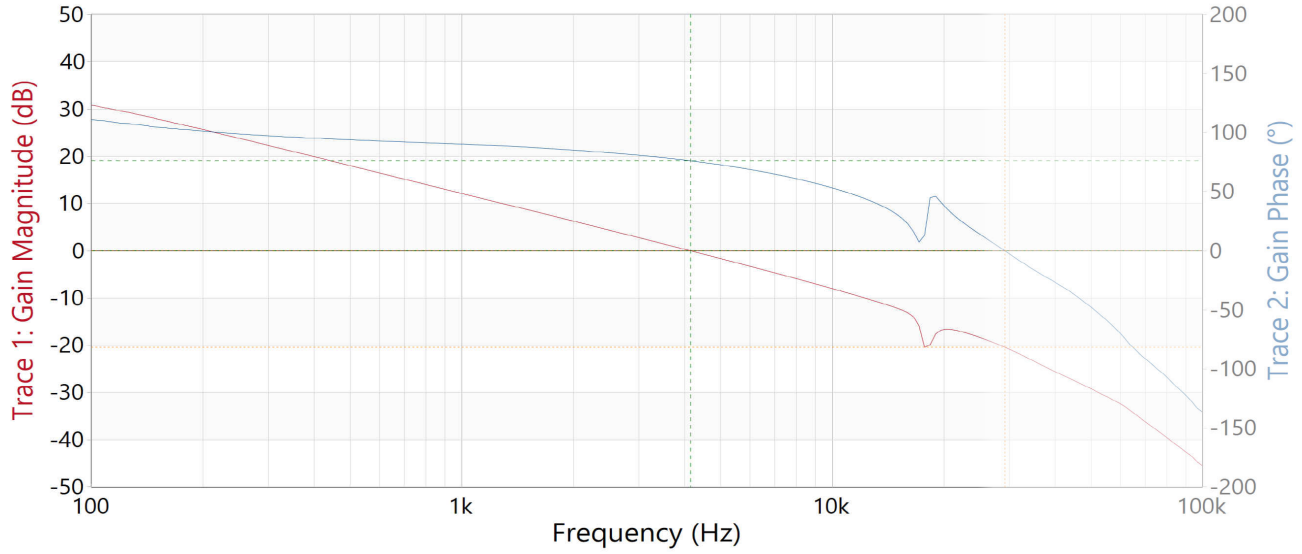


Figure 2-14. 18-V Input, 19-V, 4-A Output; Bandwidth = 4.1 kHz, Phase Margin = 76.2 Degrees, Gain Margin = 20.4 dB

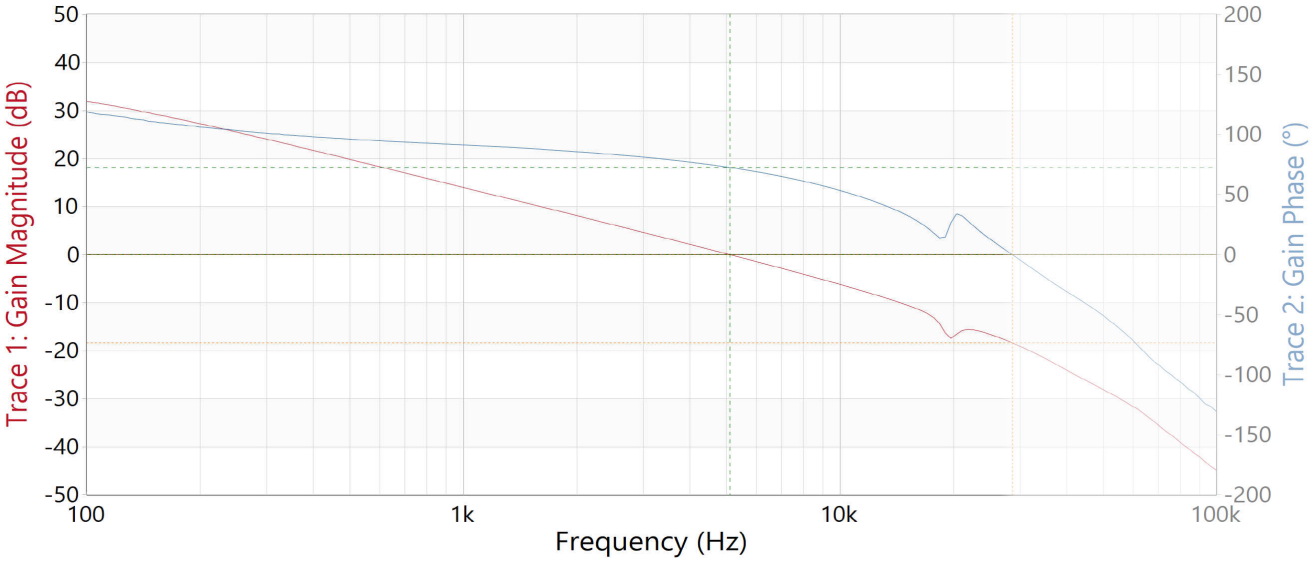


Figure 2-15. 24-V Input, 19-V, 4-A Output; Bandwidth = 5.1 kHz, Phase Margin = 72.6 Degrees, Gain Margin = 18.3 dB

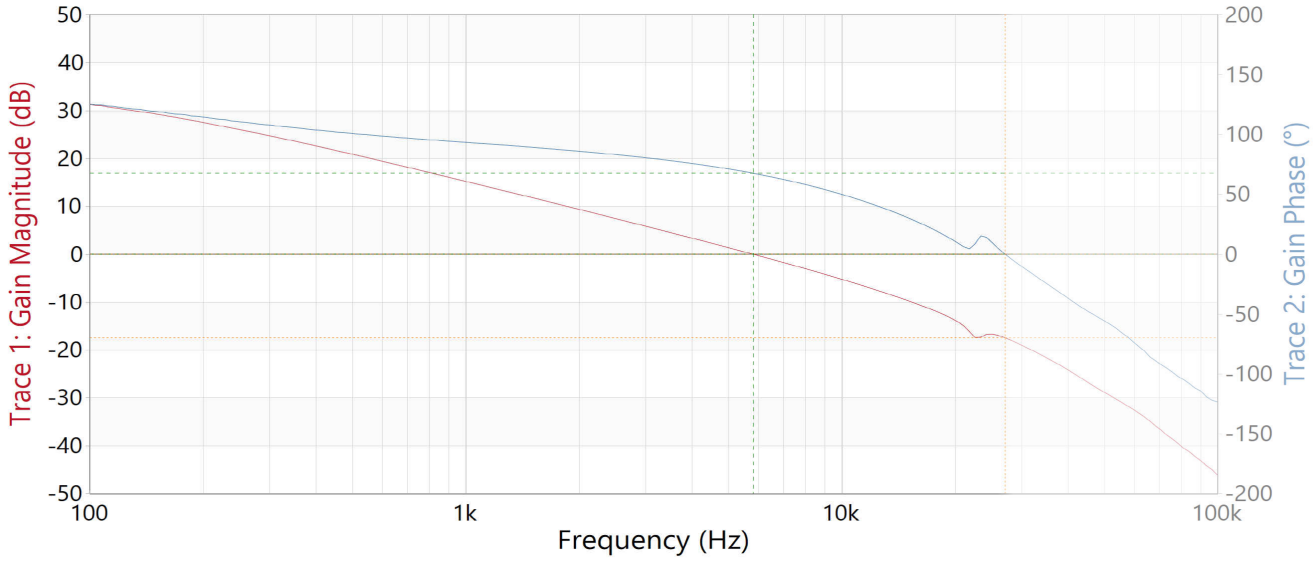


Figure 2-16. 36-V Input, 19-V, 4-A Output; Bandwidth = 5.8 kHz, Phase Margin = 67.6 Degrees, Gain Margin = 17.4 dB

3 Waveforms

3.1 Switching

The PMP23123 waveforms are illustrated in the following images.

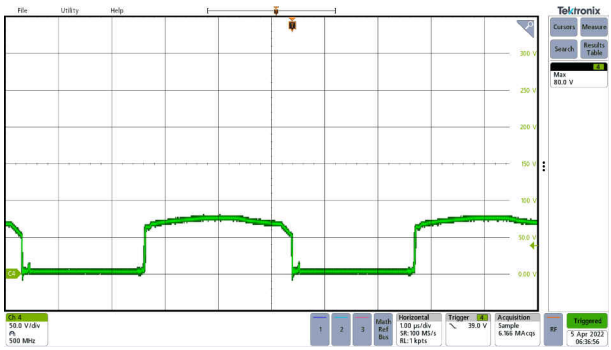


Figure 3-1. Voltage Anode To Cathode, D4, 24-V Input, 40-V, 2.5-A Output, 50 V/div, 1 µs/div, Measured 80-V Peak

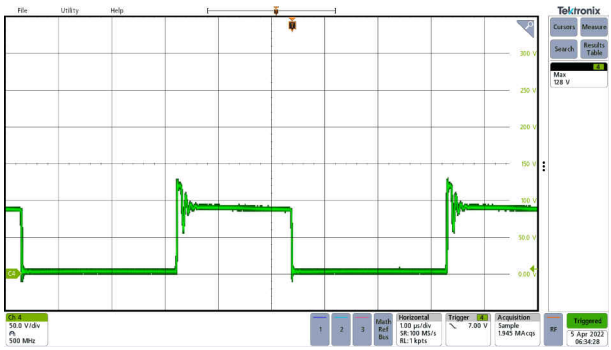


Figure 3-2. Voltage Anode to Cathode, D10, 24-V Input, 40-V, 2.5-A Output, 50 V/div, 1 µs/div, Measured 128-V Peak

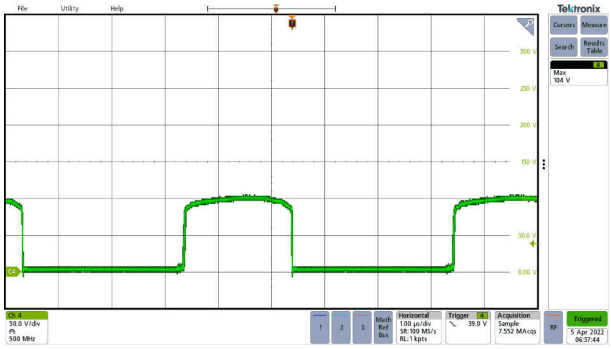


Figure 3-3. Voltage Anode to Cathode, D4, 18-V Input, 40-V, 2.5-A Output, 50 V/div, 1 µs/div, Measured 104-V Peak

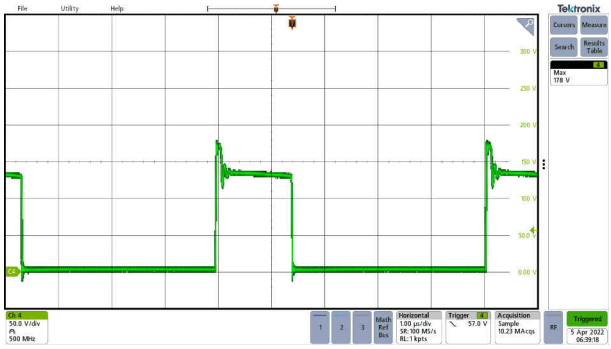


Figure 3-4. Voltage Anode to Cathode, D10, 36-V Input, 40-V, 2.5-A Output, 50 V/div, 1 µs/div, Measured 178-V Peak

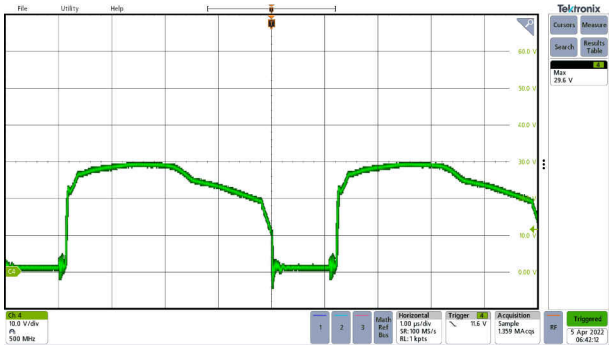


Figure 3-5. Voltage Anode to Cathode, D4, 24-V Input, 19-V, 4-A Output, 10 V/div, 1 µs/div, Measured 29.6-V Peak

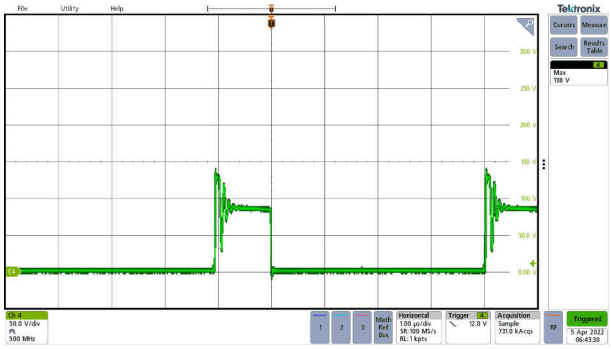


Figure 3-6. Voltage Anode to Cathode, D10, 24-V Input, 19-V, 4-A Output, 50 V/div, 1 µs/div, Measured 138-V Peak

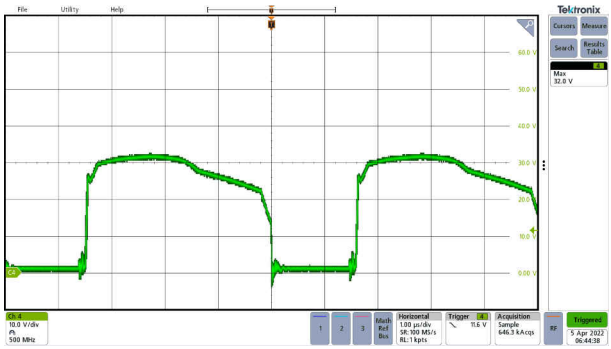


Figure 3-7. Voltage Anode to Cathode, D4, 18-V Input, 19-V, 4-A Output, 10 V/div, 1 µs/div, Measured 32.8-V Peak

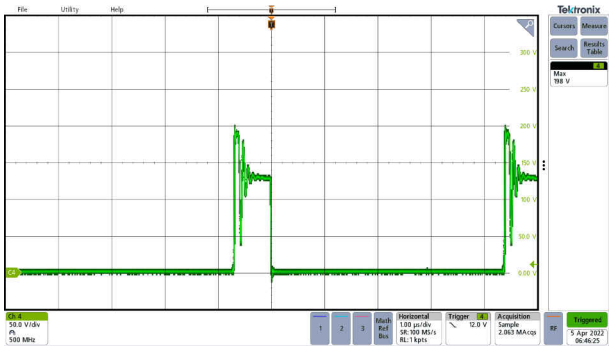


Figure 3-8. Voltage Anode to Cathode, D10, 36-V Input, 19-V, 4-A Output, 50 V/div, 1 µs/div, Measured 198-V Peak

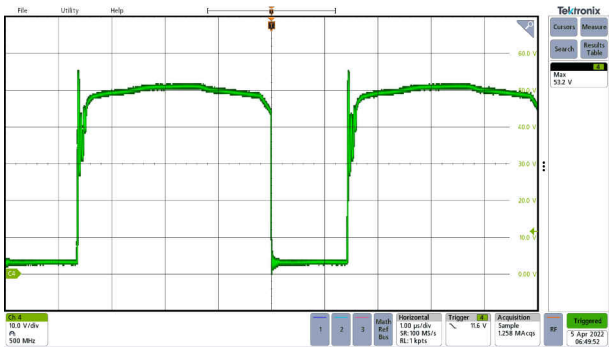


Figure 3-9. Voltage Drain to Source, Q4 and Q6, 36-V Input, 40-V, 2.5-A Output, 10 V/div, 1 µs/div, Measured 53.2-V Peak

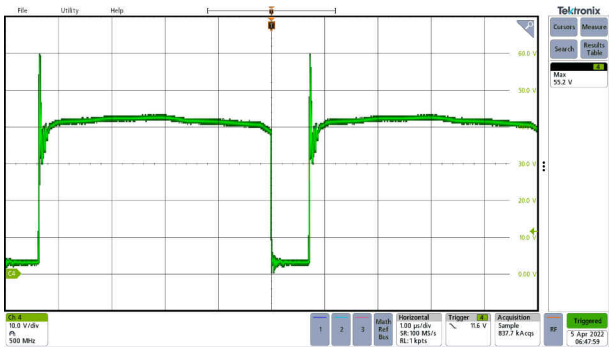


Figure 3-10. Voltage Drain to Source, Q4 and Q6, 36-V Input, 19-V, 4-A Output, 10 V/div, 1 µs/div, Measured 55.2-V Peak

3.2 Voltage Ripple

The following images illustrate the PMP23123 voltage ripple waveforms.

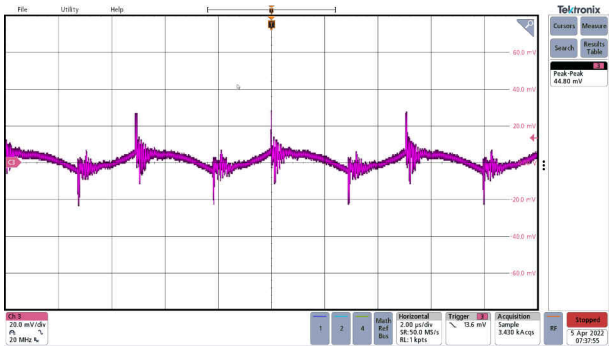


Figure 3-11. Output Voltage Ripple at J2, 24-V Input, 40-V, 2.5-A Output; Measured 44.8-mV Peak-to-Peak

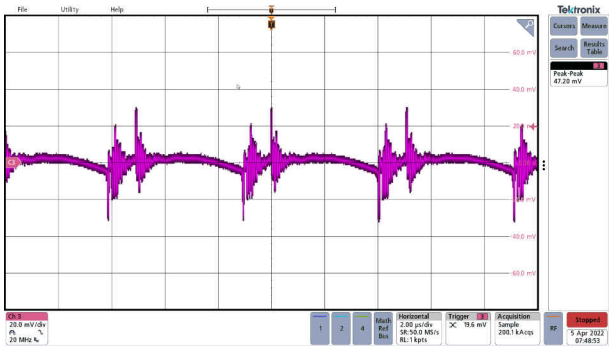


Figure 3-12. Output Voltage Ripple at J2, 24-V Input, 19-V, 4-A Output; Measured 47.2-mV Peak-to-Peak

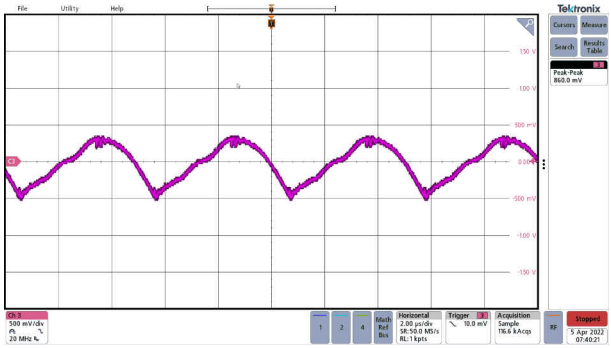


Figure 3-13. Input Voltage Ripple at C12, 24-V Input, 40-V, 2.5-A Output; Measured 860-mV Peak-to-Peak

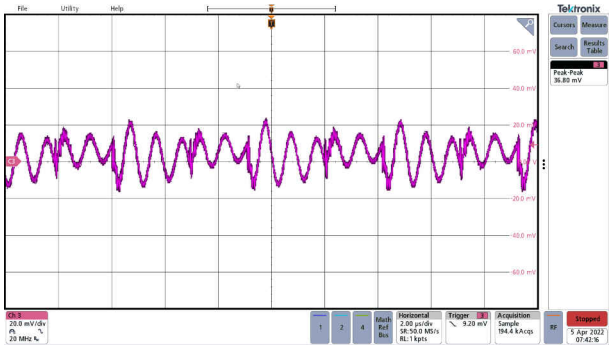


Figure 3-14. Input Voltage Ripple at J1, 24-V Input, 40-V, 2.5-A Output; Measured 36.8-mV Peak-to-Peak

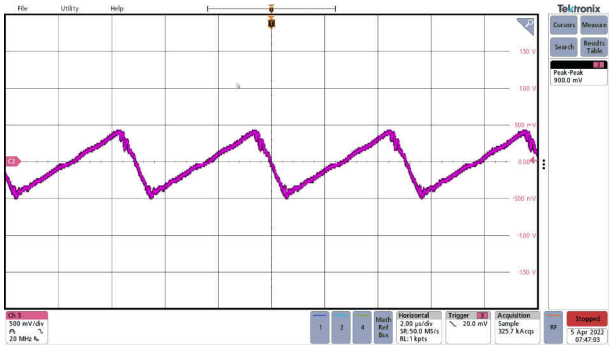


Figure 3-15. Input Voltage Ripple at C12, 24-V Input, 19-V, 4-A Output; Measured 900-mV Peak-to-Peak

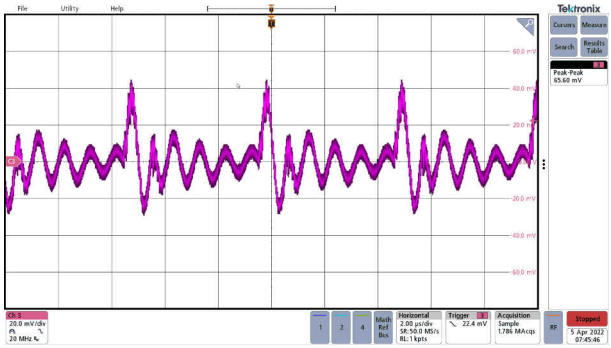


Figure 3-16. Input Voltage Ripple at J1, 24-V Input, 19-V, 4-A Output; Measured 65.6-mV Peak-to-Peak

3.3 Load Transients

Figure 3-17 through Figure 3-19 show the output voltage response, at 40-V output, 0-A to 2.5-A load step.

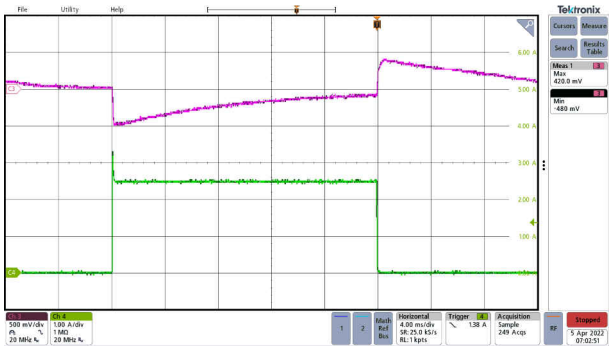


Figure 3-17. 18-V Input, 5 ms/div
CH2: Output Voltage, 500 mV/div
CH4: Output Current, 1 A/div, Measured +420 mV and –480 mV

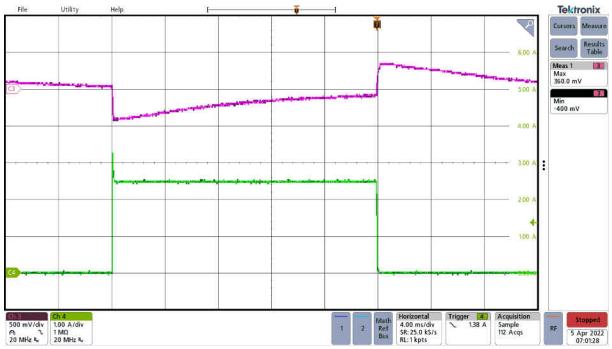


Figure 3-18. 24-V Input, 5 ms/div
CH2: Output Voltage, 500 mV/div
CH4: Output Current, 1 A/div, Measured +360 mV and –400 mV

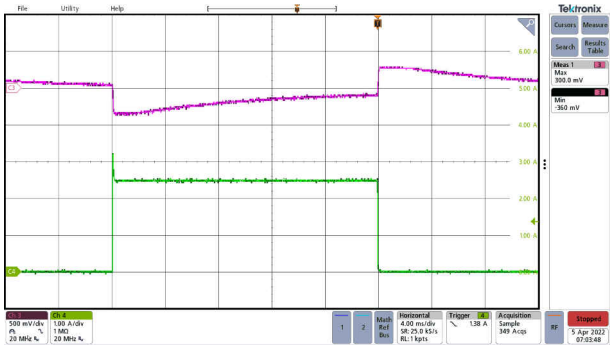


Figure 3-19. 36-V Input, 5 ms/div
CH2: Output Voltage, 500 mV/div
CH4: Output Current, 1 A/div, Measured +3000 mV and –360 mV

Figure 3-20 through Figure 3-22- show the output voltage response, at 19-V output, 0-A to 4-A load step.

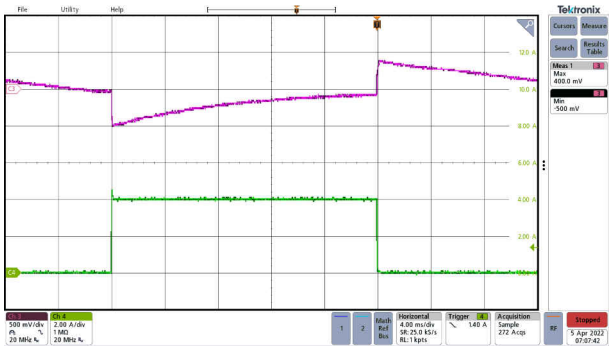


Figure 3-20. 18-V Input, 5 ms/div
CH2: Output Voltage, 500 mV/div
CH4: Output Current, 2 A/div, Measured +400 mV and –500 mV

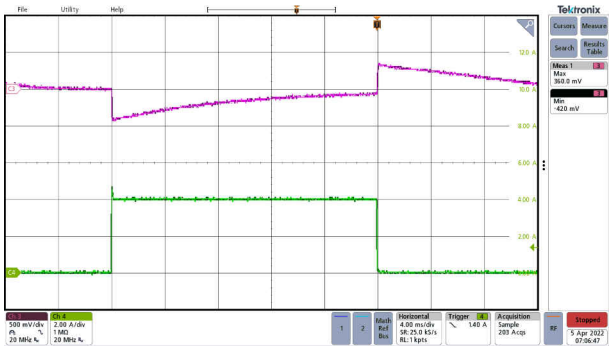


Figure 3-21. 24-V Input, 5 ms/div
CH2: Output Voltage, 500 mV/div
CH4: Output Current, 2 A/div, Measured +360 mV and –420 mV

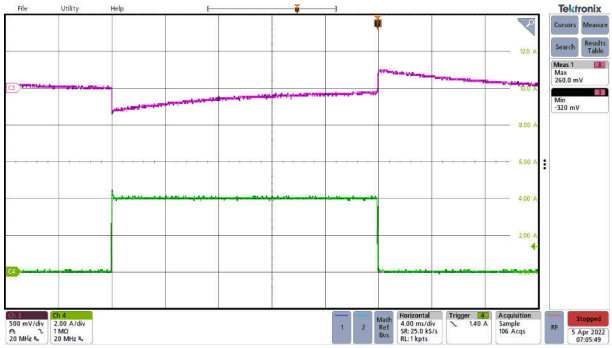


Figure 3-22. 36-V Input, 5 ms/div
CH2: Output Voltage, 500 mV/div
CH4: Output Current, 2 A/div, Measured +260 mV and –320 mV

3.4 Start-Up Sequence

Start-up behavior is shown in the following figures.

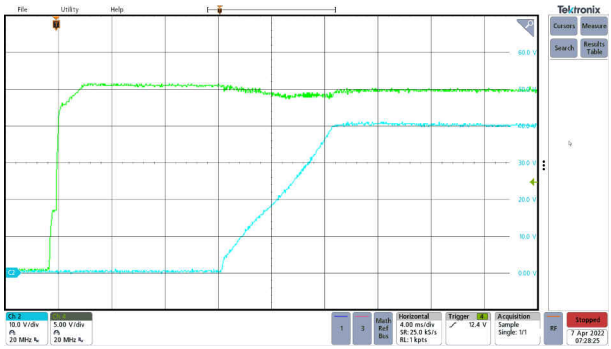


Figure 3-23. Start-up, 40-V, 0-A Output, 24-V Input, 5 ms/div, CH2: Output Voltage, 10 V/div, CH4: Input Voltage, 5 V/div

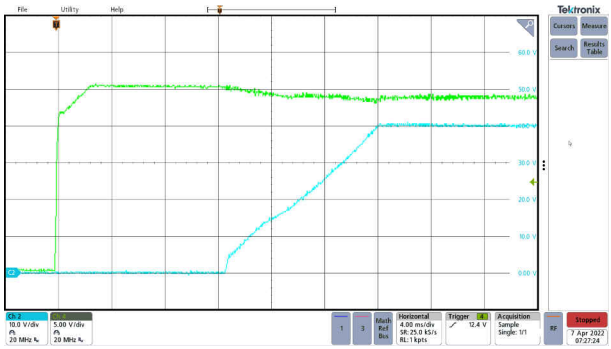


Figure 3-24. Start-up, 40-V, 2.5-A Output, 24-V Input, 5 ms/div, CH2: Output Voltage, 10 V/div, CH4: Input Voltage, 5 V/div

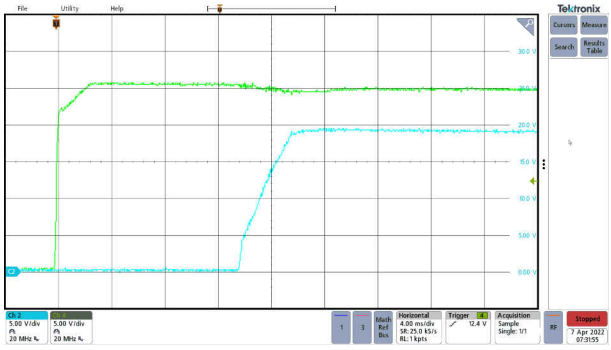


Figure 3-25. Start-up, 19-V, 0-A Output, 24-V Input, 5 ms/div, CH2: Output Voltage, 5 V/div, CH4: Input Voltage, 5 V/div

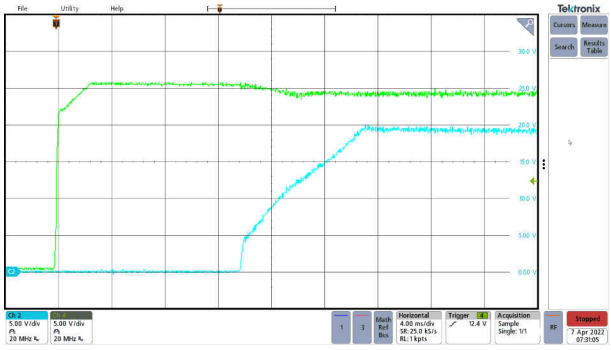


Figure 3-26. Start-up, 19-V, 4-A Output, 24-V Input, 5 ms/div, CH2: Output Voltage, 5 V/div, CH4: Input Voltage, 5 V/div

3.5 Output Voltage Step

The following images illustrate the PMP23123 output voltage step waveforms.

Tie J3 pin 1 and J4 pin 1 together. Short and open the J3 and J4 pin, 1. 24-V input. A 2.5-A load is at both the 19-V and 40-V output.

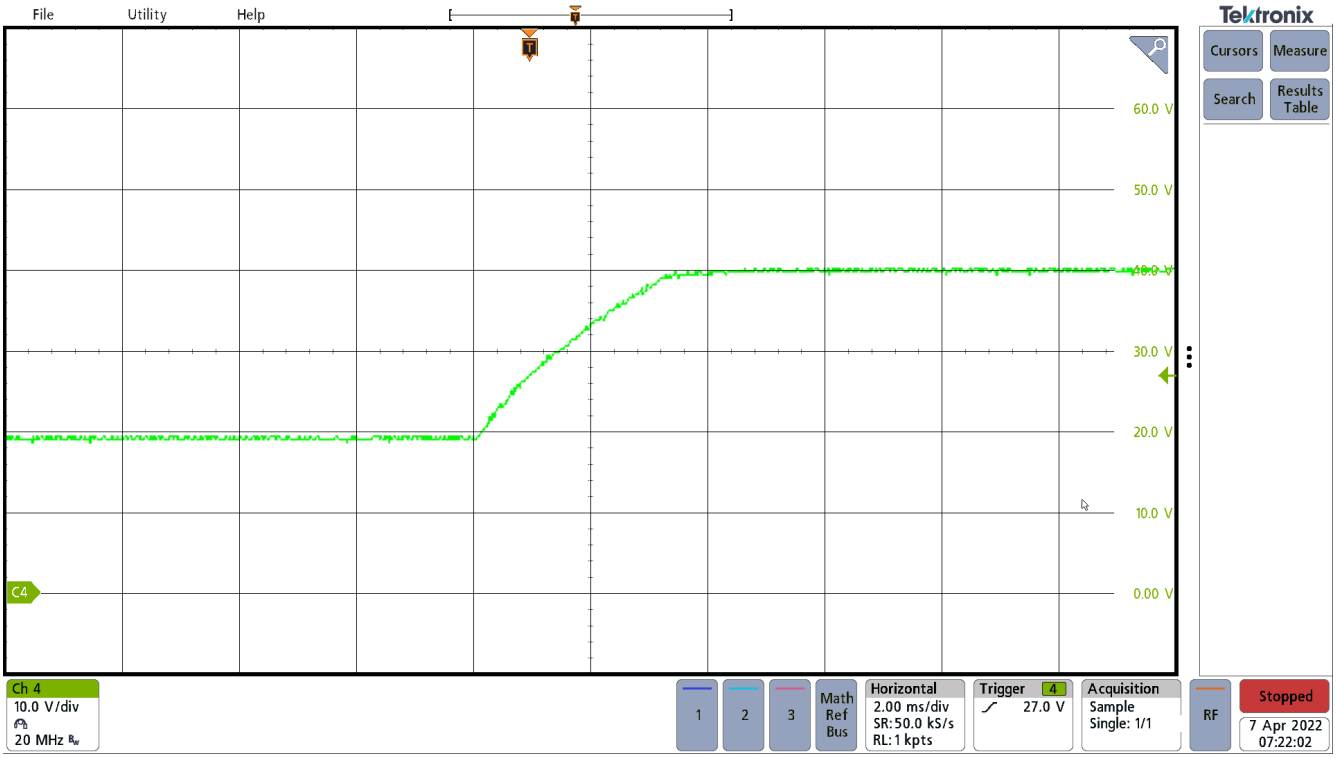


Figure 3-27. 19-V to 40-V Output Voltage Transition, 10 V/div, 2 ms/div

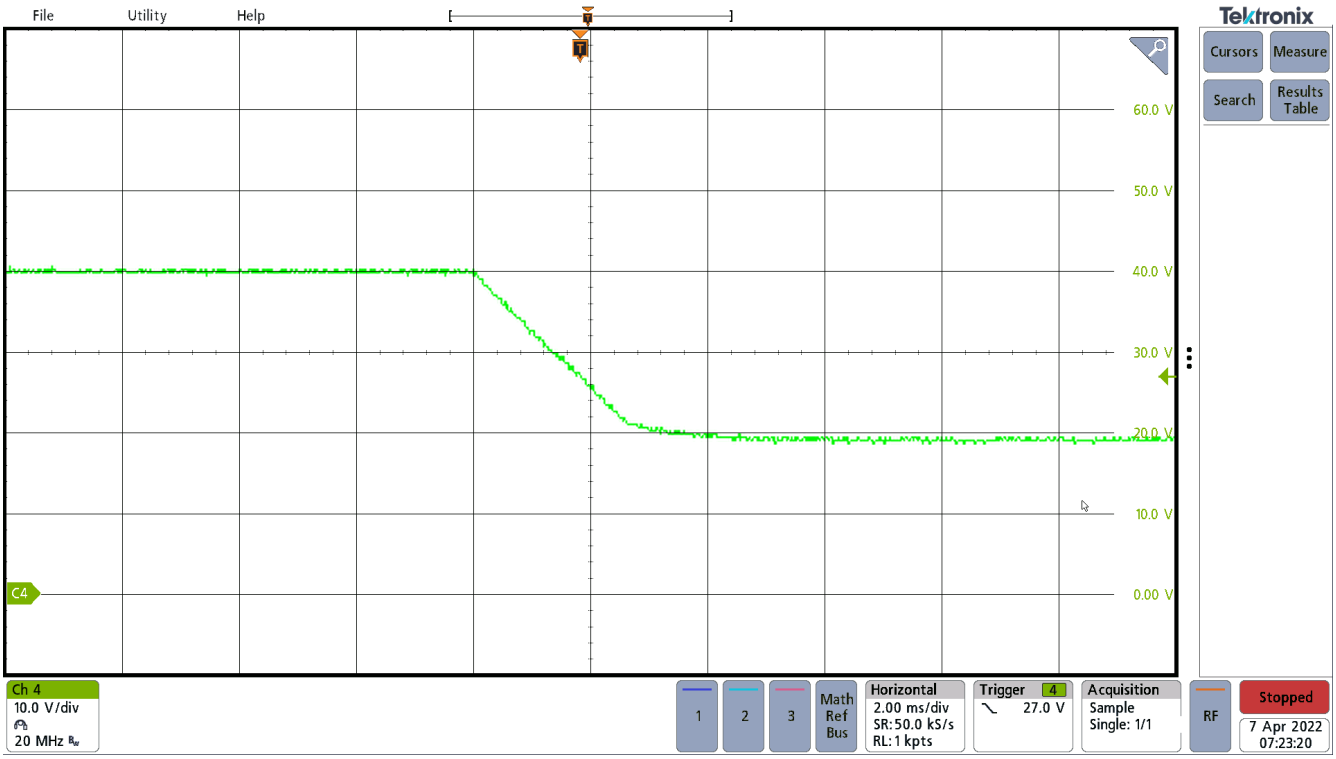


Figure 3-28. 40-V to 19-V Output Voltage Transition. 10 V/div, 2 ms/div

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