**Test Report: 13W / 5V**

Class 3 PoE PD (5-V/2.3-A) and Passive 24-V (5-V/2.3-A) Supply Reference Design

**Description**

This reference design utilizes a sync flyback converter for a standard Class 4 Power over Ethernet (PoE) Powered Device (PD) with a 5-V/2.3-A output. In addition, a 24-V passive PoE input can supply a 5-V/2.3-A output. A TPS23730 combination PD/PWM controller provides all PoE PD functions such as Detection, Class and In-rush limiting and the flyback PWM controller in one package. The PWM utilizes opto-less primary side regulation. This reference design is ideally suited for PoE applications such as wireless access points and IP cameras.

# Test Prerequisites

## Voltage and Current Requirements

1. Voltage and Current Requirements

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| --- | --- |
| PARAMETER | SPECIFICATIONS |
| Class 4 standard PoE input voltage | 42.5-57 V on pairs 1/2 and 3/6 |
| Passive PoE input voltage | 16-30 V on pairs 4/5 and 7/8 |
| Vout | 5 V |
| Iout (Custom/Class4/Passive) | 2.6.0 A/2.3 A/2.3 A |
| Nominal Switching Frequency | 250 kHz |

## Required Equipment

* IEEE802.3.bt Type 2 PSE
* Isolated DC power source, 16-30 V, 2.0 A minimum
* CAT5e ethernet cables (<100m)
* 5 V/2.6 A electronic load

## Considerations

All measurements taken at approximately 25 C ambient.

# Testing and Results

## Efficiency Graph

## Efficiency Data

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| PoE (V) | IIN (A) | DCDC (V) | VOUT (V) | IOUT (A) | Input Power (W) | Output Power (W) | Eff PoE | Eff DCDC |
| 16.002 | 0.02853 | 15.256 | 5.3339 | 0 | 0.46 | 0.00 | 0.00% | 0.00% |
| 16.008 | 0.2068 | 15.065 | 5.308 | 0.5012 | 3.31 | 2.66 | 80.36% | 85.39% |
| 15.999 | 0.2979 | 15 | 5.2891 | 0.7491 | 4.77 | 3.96 | 83.13% | 88.67% |
| 16 | 0.3946 | 14.94 | 5.2681 | 1.0054 | 6.31 | 5.30 | 83.89% | 89.84% |
| 15.996 | 0.4884 | 14.878 | 5.2438 | 1.2501 | 7.81 | 6.56 | 83.91% | 90.21% |
| 15.917 | 0.592 | 14.742 | 5.2148 | 1.5101 | 9.42 | 7.87 | 83.57% | 90.23% |
| 16.004 | 0.6813 | 14.776 | 5.1873 | 1.7477 | 10.90 | 9.07 | 83.15% | 90.06% |
| 16.004 | 0.7885 | 14.703 | 5.1535 | 2.0202 | 12.62 | 10.41 | 82.50% | 89.80% |
| 15.999 | 0.9028 | 14.636 | 5.1151 | 2.3057 | 14.44 | 11.79 | 81.65% | 89.26% |
| 15.998 | 1.0191 | 14.56 | 5.0743 | 2.59 | 16.30 | 13.14 | 80.61% | 88.57% |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| PoE (V) | IIN (A) | DCDC (V) | VOUT (V) | IOUT (A) | Input Power (W) | Output Power (W) | Eff PoE | Eff DCDC |
| 24.011 | 0.0232 | 23.26 | 5.319 | 0 | 0.56 | 0.00 | 0.00% | 0.00% |
| 24.012 | 0.1403 | 23.116 | 5.298 | 0.5086 | 3.37 | 2.69 | 79.98% | 83.08% |
| 24.014 | 0.1969 | 23.08 | 5.283 | 0.7511 | 4.73 | 3.97 | 83.92% | 87.32% |
| 24.001 | 0.2564 | 23.024 | 5.2691 | 1.0042 | 6.15 | 5.29 | 85.98% | 89.63% |
| 24.001 | 0.3166 | 22.986 | 5.2548 | 1.256 | 7.60 | 6.60 | 86.86% | 90.69% |
| 23.999 | 0.3757 | 22.944 | 5.2397 | 1.4991 | 9.02 | 7.85 | 87.12% | 91.12% |
| 24.012 | 0.4373 | 22.926 | 5.2221 | 1.7506 | 10.50 | 9.14 | 87.06% | 91.19% |
| 24.013 | 0.5018 | 22.889 | 5.2021 | 2.0179 | 12.05 | 10.50 | 87.12% | 91.39% |
| 24.024 | 0.5706 | 22.857 | 5.1798 | 2.3024 | 13.71 | 11.93 | 87.00% | 91.44% |
| 24.016 | 0.6452 | 22.808 | 5.1551 | 2.6031 | 15.50 | 13.42 | 86.60% | 91.19% |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| PoE (V) | IIN (A) | DCDC (V) | VOUT (V) | IOUT (A) | Input Power (W) | Output Power (W) | Eff PoE | Eff DCDC |
| 48.942 | 0.02044 | 48.063 | 5.289 | 0 | 1.00 | 0.00 | 0.00% | 0.00% |
| 48.908 | 0.07555 | 48.073 | 5.2717 | 0.5019 | 3.69 | 2.65 | 71.61% | 72.85% |
| 48.8892 | 0.1028 | 48.027 | 5.262 | 0.7481 | 5.03 | 3.94 | 78.33% | 79.73% |
| 48.935 | 0.1311 | 48.046 | 5.2517 | 1.0038 | 6.42 | 5.27 | 82.17% | 83.69% |
| 48.98 | 0.15811 | 48.07 | 5.242 | 1.2491 | 7.74 | 6.55 | 84.55% | 86.15% |
| 48.963 | 0.1865 | 48.031 | 5.2326 | 1.5042 | 9.13 | 7.87 | 86.19% | 87.87% |
| 49.022 | 0.21467 | 48.07 | 5.2233 | 1.7596 | 10.52 | 9.19 | 87.34% | 89.07% |
| 49.005 | 0.2409 | 48.036 | 5.2146 | 1.9948 | 11.81 | 10.40 | 88.11% | 89.89% |
| 49.033 | 0.2707 | 48.044 | 5.2044 | 2.2711 | 13.27 | 11.82 | 89.05% | 90.88% |
| 49.099 | 0.3116 | 48.084 | 5.19 | 2.6244 | 15.30 | 13.62 | 89.03% | 90.91% |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| PoE (V) | IIN (A) | DCDC (V) | VOUT (V) | IOUT (A) | Input Power (W) | Output Power (W) | Eff PoE | Eff DCDC |
| 57.001 | 0.02061 | 56.258 | 5.2859 | 0 | 1.17 | 0.00 | 0.00% | 0.00% |
| 57.0003 | 0.06755 | 56.175 | 5.2694 | 0.4987 | 3.85 | 2.63 | 68.25% | 69.25% |
| 57.003 | 0.092 | 56.152 | 5.2596 | 0.7564 | 5.24 | 3.98 | 75.86% | 77.01% |
| 57.008 | 0.11744 | 56.133 | 5.249 | 1.0251 | 6.70 | 5.38 | 80.37% | 81.62% |
| 57.0004 | 0.1387 | 56.108 | 5.241 | 1.2499 | 7.91 | 6.55 | 82.86% | 84.18% |
| 57.0004 | 0.1615 | 56.089 | 5.232 | 1.491 | 9.21 | 7.80 | 84.74% | 86.12% |
| 57.008 | 0.18634 | 56.082 | 5.2228 | 1.7505 | 10.62 | 9.14 | 86.06% | 87.49% |
| 57.001 | 0.2168 | 56.05 | 5.211 | 2.062 | 12.36 | 10.75 | 86.95% | 88.42% |
| 57.004 | 0.2372 | 56.05 | 5.2039 | 2.273 | 13.52 | 11.83 | 87.48% | 88.97% |
| 57.007 | 0.26873 | 56.022 | 5.1917 | 2.598 | 15.32 | 13.49 | 88.04% | 89.59% |

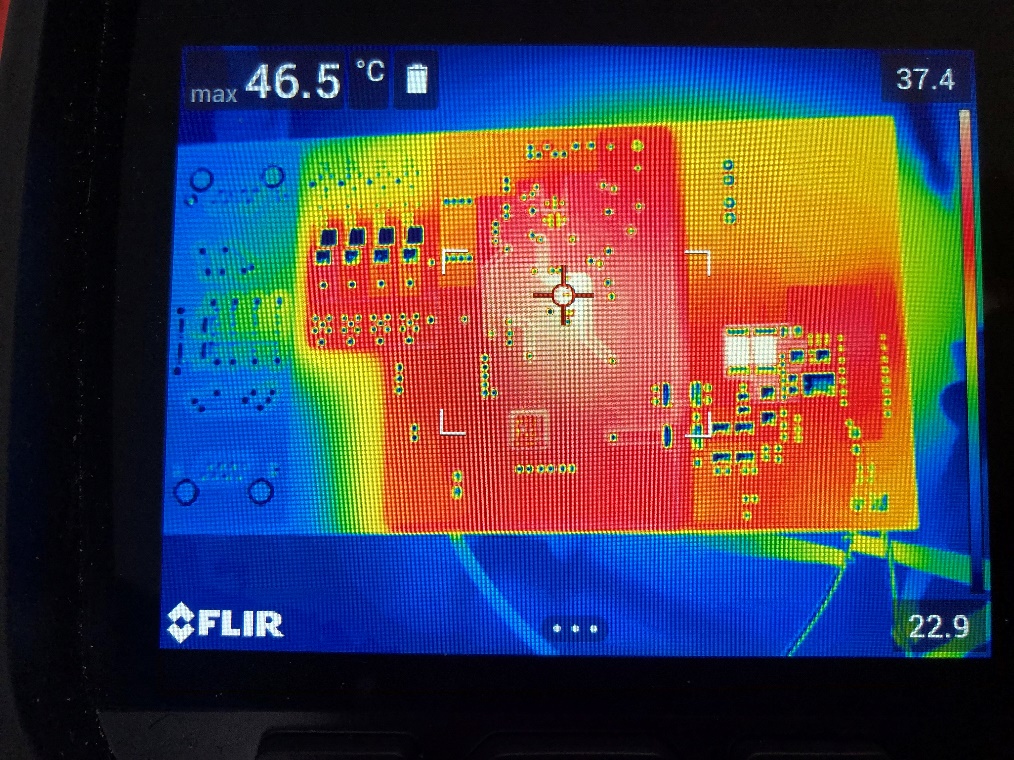
## Regulation

## Thermal Images

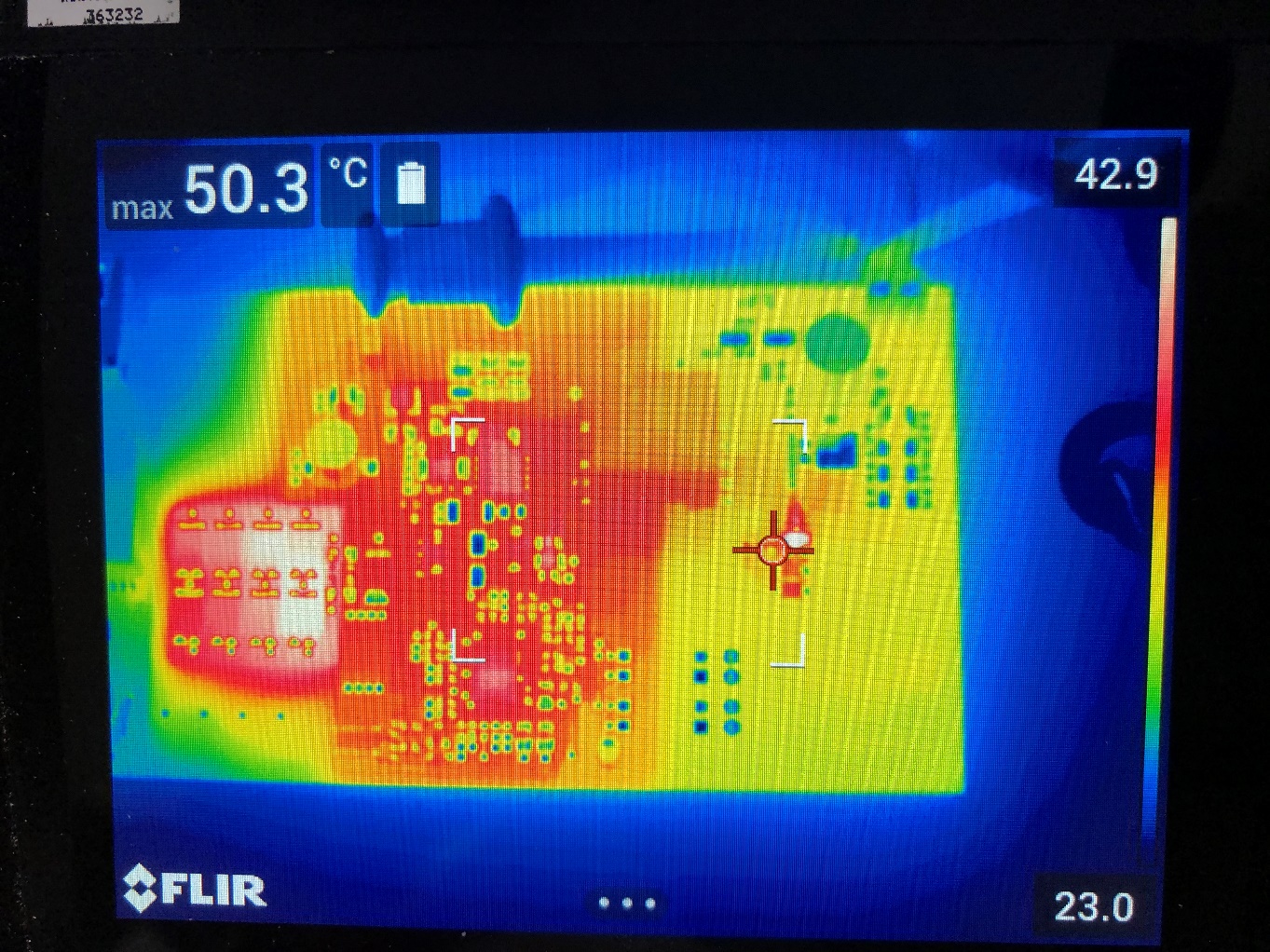
48 V Input, 5 A Load, Top:



48 V Input, 5 A Load, Bottom:



24 V Input, 3.6 A Load, Top:



24 V Input, 3.6 A Load, Bottom:



## Photo

The board measures 66 mm x 122 mm.

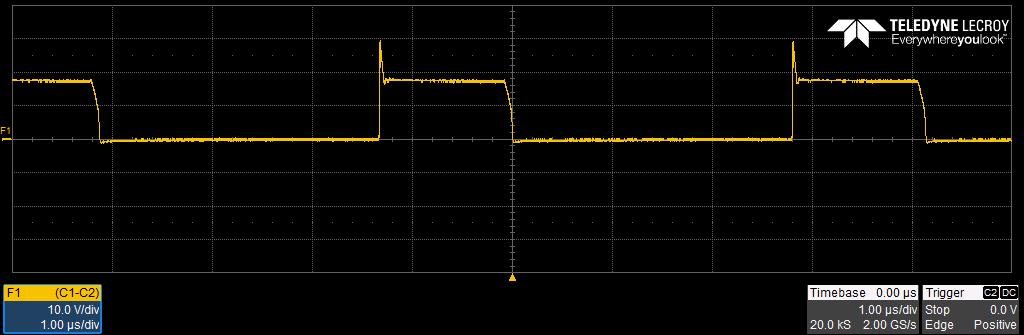
Top:

Bottom:

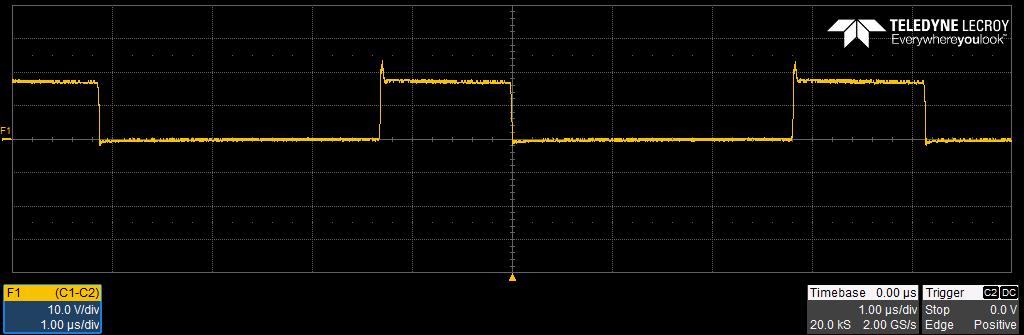
# Waveforms

## Switching

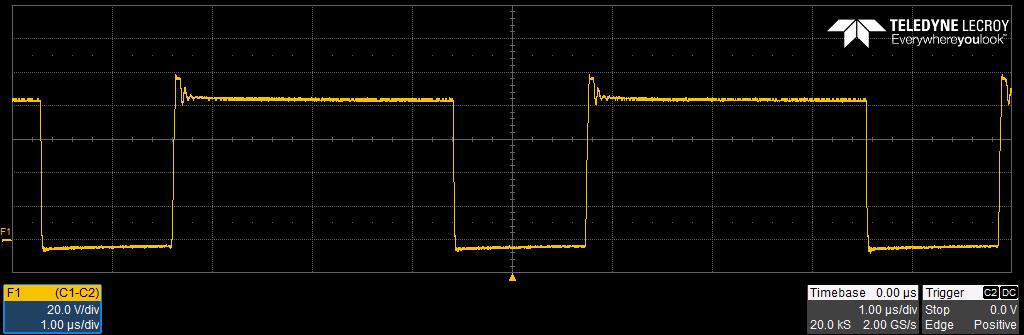
VDS, Q11, 57 V input, 0 A load, 10 V/div, 1 usec/div, Measured 30 Vpeak:



VDS, Q11, 57 V input, 2.3 A load, 10 V/div, 1 usec/div, Measured 24 Vpeak:

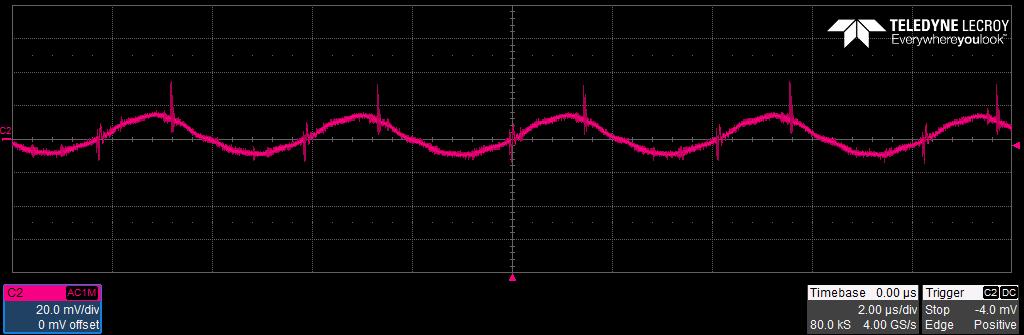


VDS, Q10, 57 V input, 2.3 A load, 20 V/div, 1 usec/div, Measured 100 Vpeak:

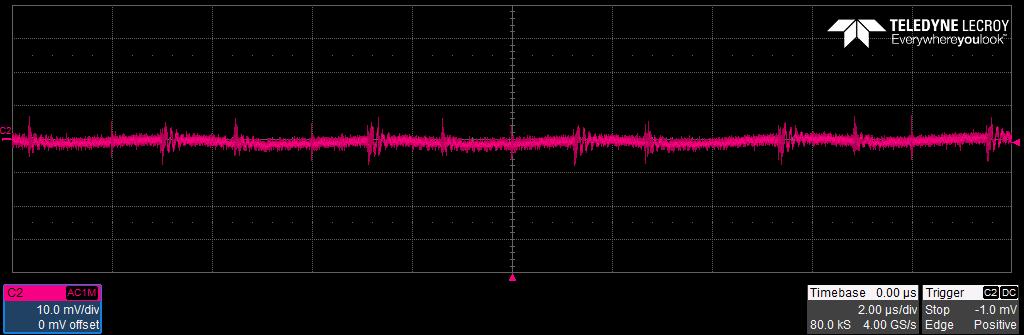


## Voltage Ripple

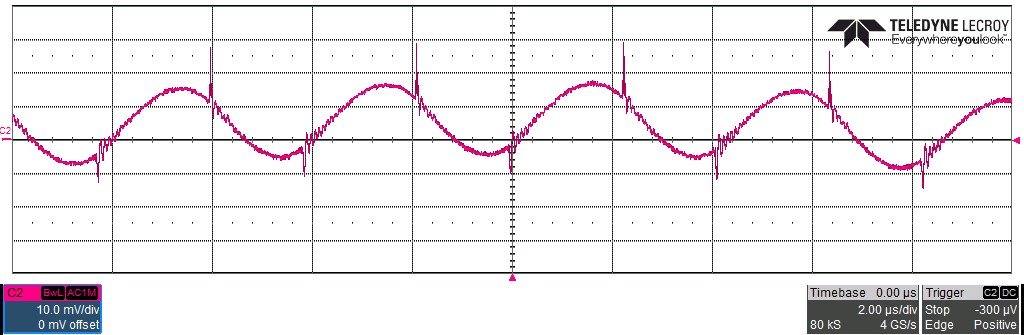
Input ripple (C18), 48 V input, 2.3 A output, 10 mV/div, 2 usec/div, measured 40 mVpp:



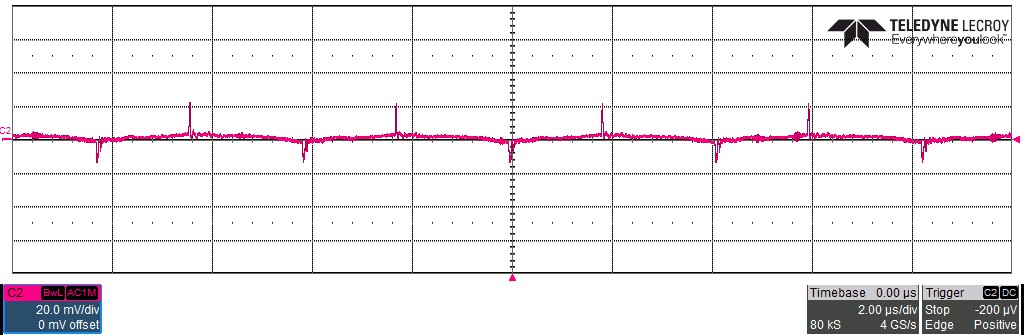
Output ripple (J7), 48 V input, 2.3 A output, 10 mV/div, 2 usec/div, measured 15 mVpp:



Input ripple (C18), 24 V input, 2.3 A output, 10 mV/div, 2 usec/div, measured 40 mVpp:



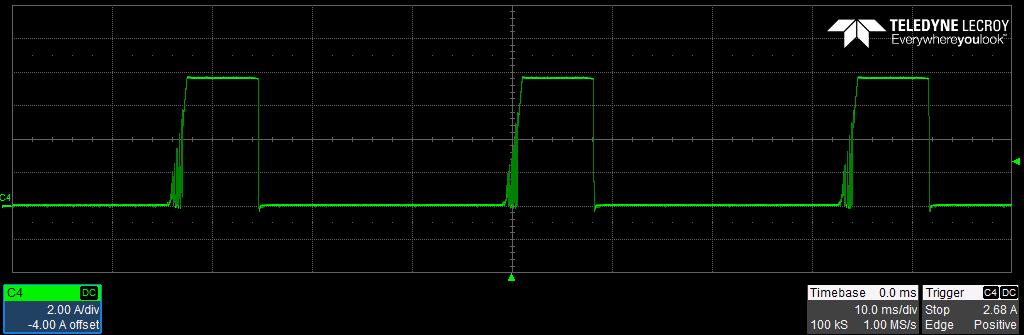
Output ripple (J7), 24 V input, 2.3A output, 20 mV/div, 2 usec/div, measured 30 mVpp:



## Short Circuit Current and Thermal

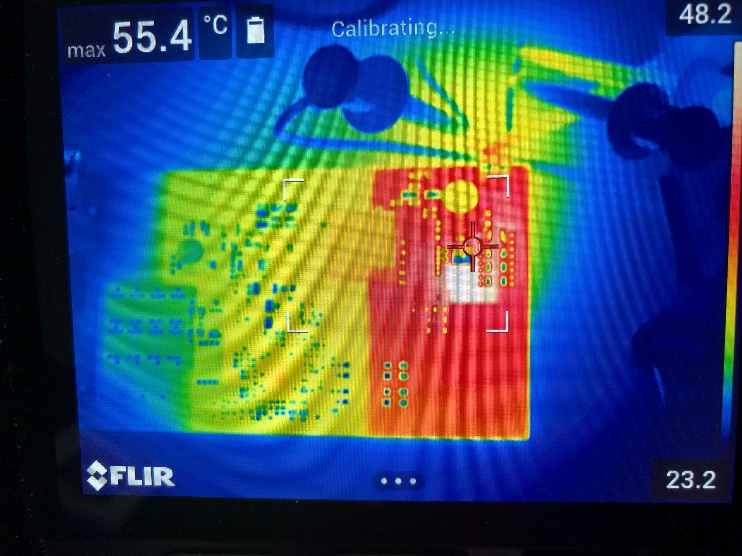
Short circuit measurements were taken 5 minutes after short was applied to a board.

Short circuit output current, 48 V input, 2 A/div, 10 msec/div, measured 9.5 A peak:

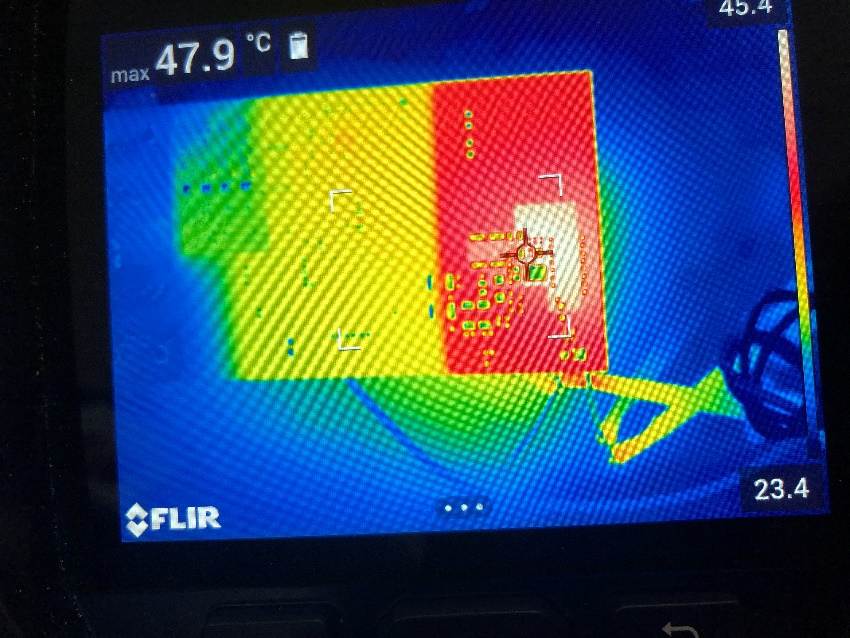


Measured input power: 48.00 V x 108 mA = 5.184 W

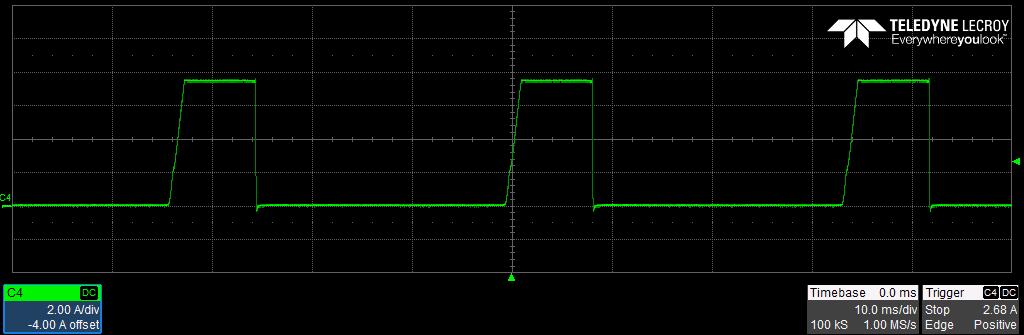
Thermal measurement, 48 V input Top:



Thermal measurement, 48 V input Bottom:



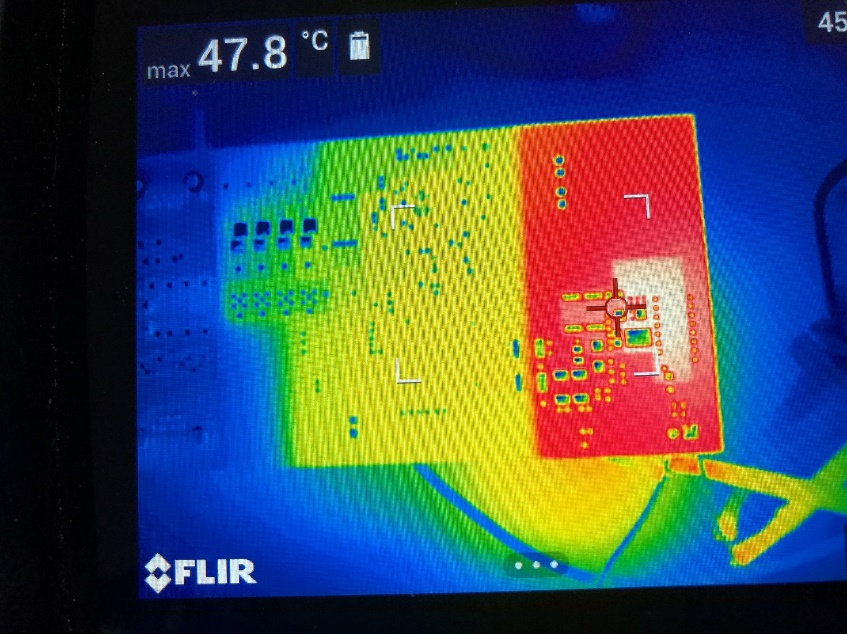
Short circuit output current, 24 V input, 2 A/div, 10 msec/div, measured 9.5 A peak:

 Measured input power: 24.00 V x 224 mA = 5.36 W

Thermal measurement, 24 V input Top:

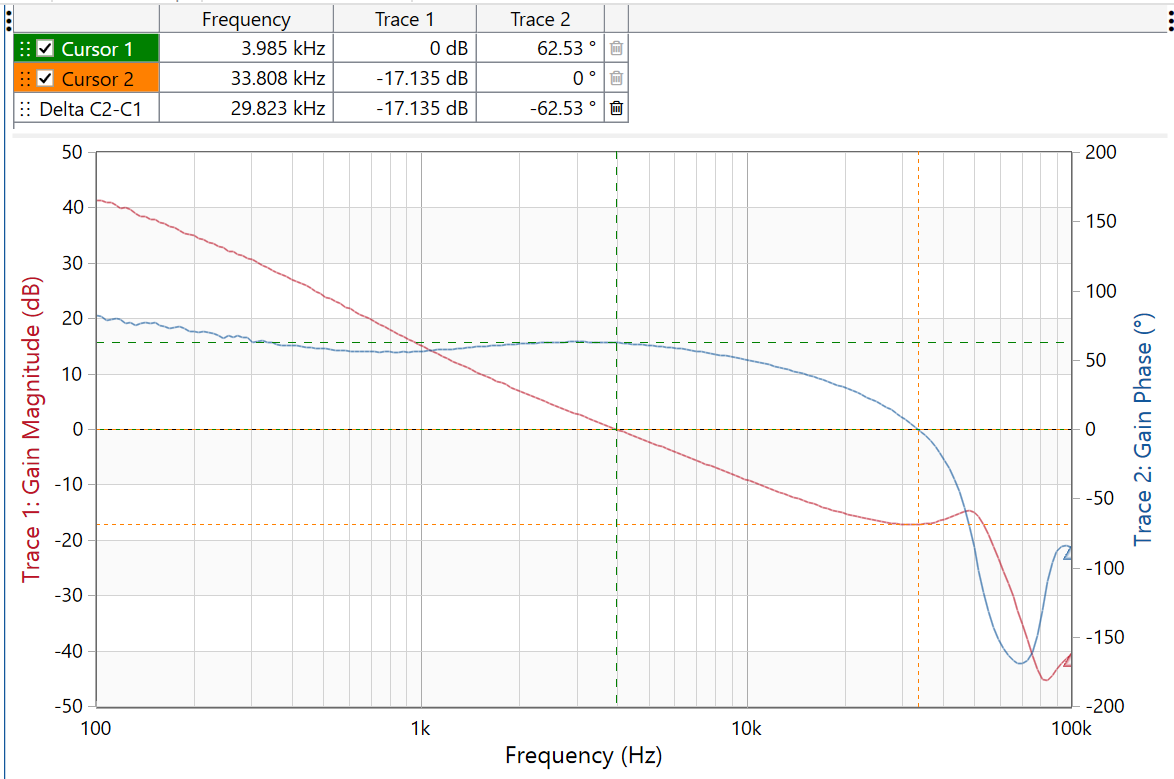


Thermal measurement, 24 V input Bottom:



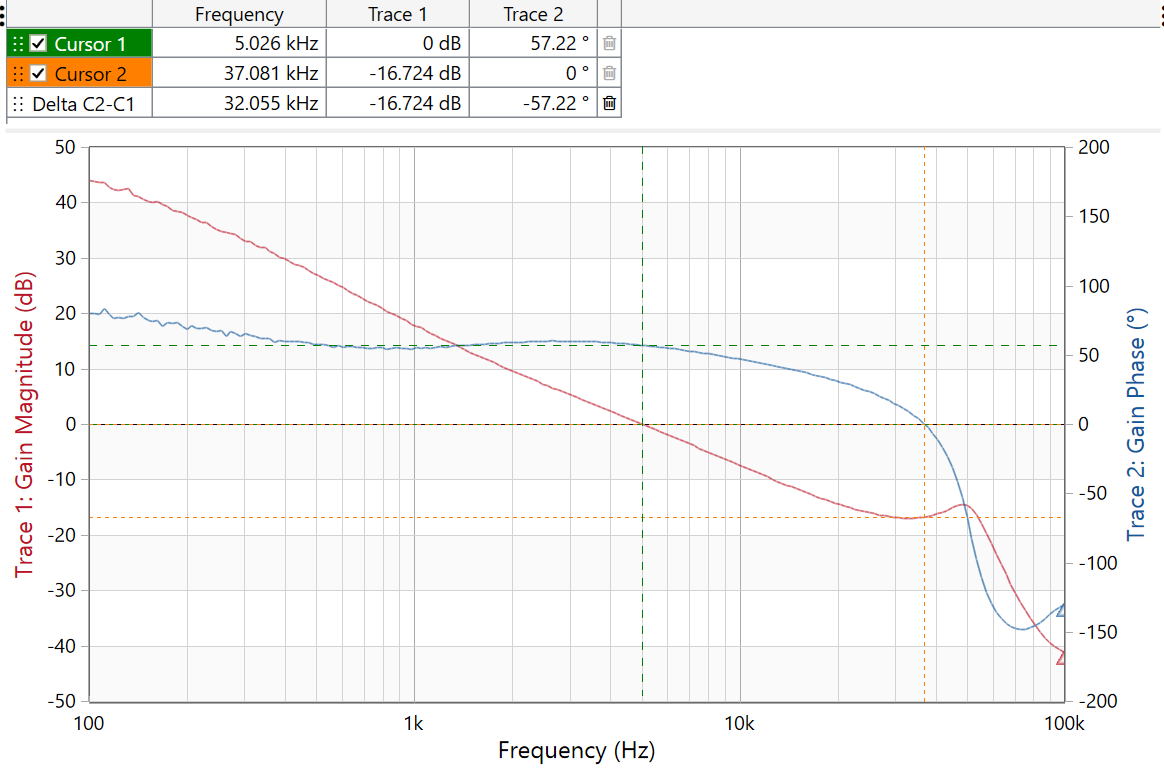
## Bode Plot

16 V Input, 2.3 A Load:



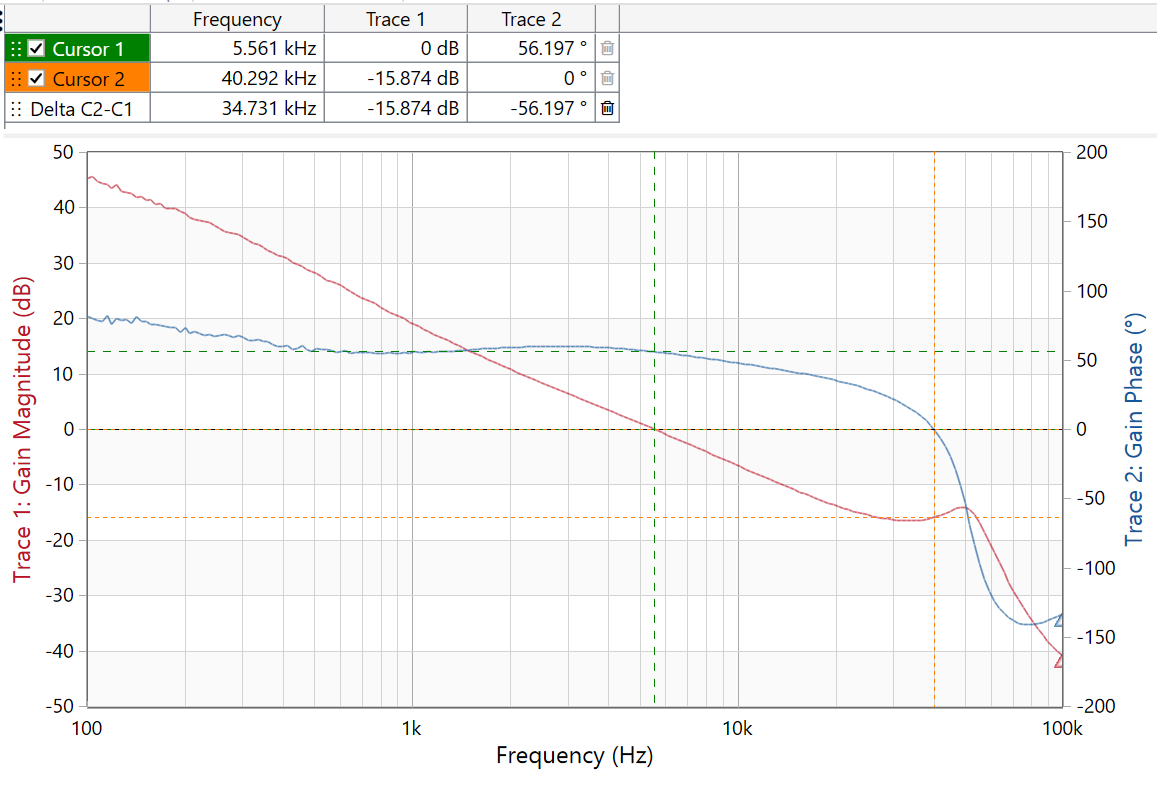
Bandwidth = 3.98 kHz Phase Margin = 62.53 degrees Gain Margin = 17.14 dB

24 V Input, 2.3 A Load:



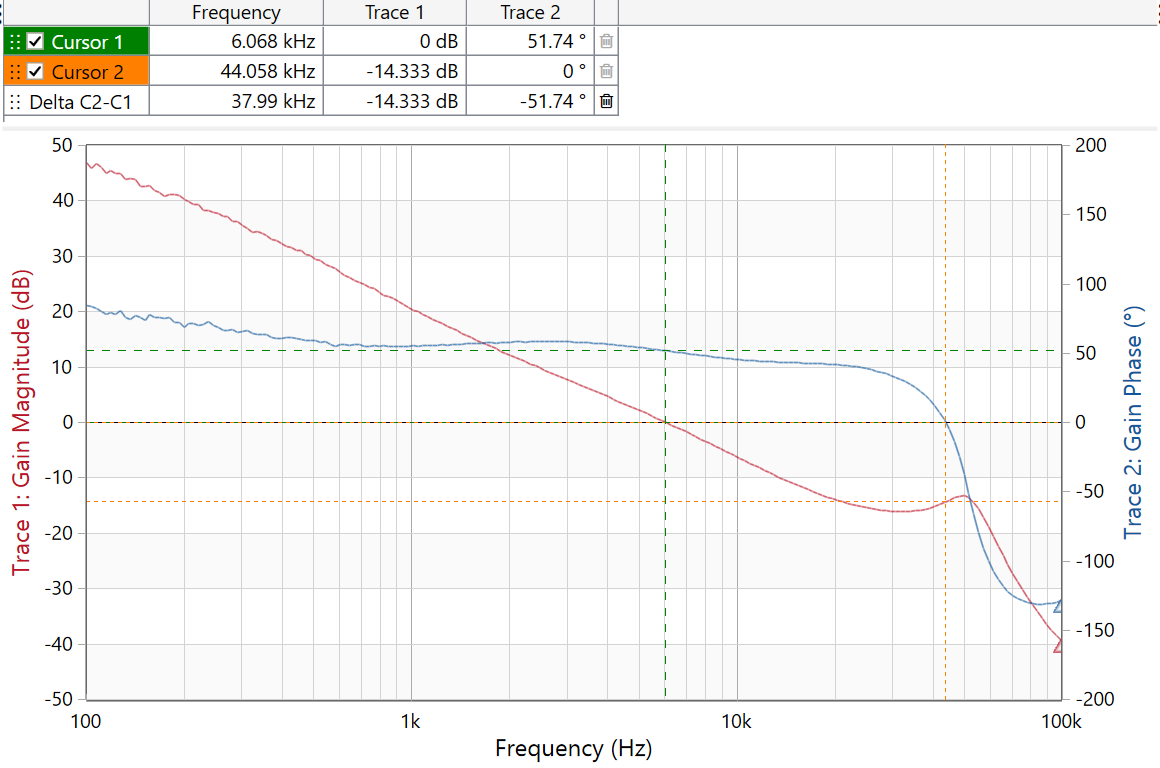
Bandwidth = 5.0 kHz Phase Margin = 57.2 degrees Gain Margin = 16.7 dB

30 V Input, 2.3 A Load:



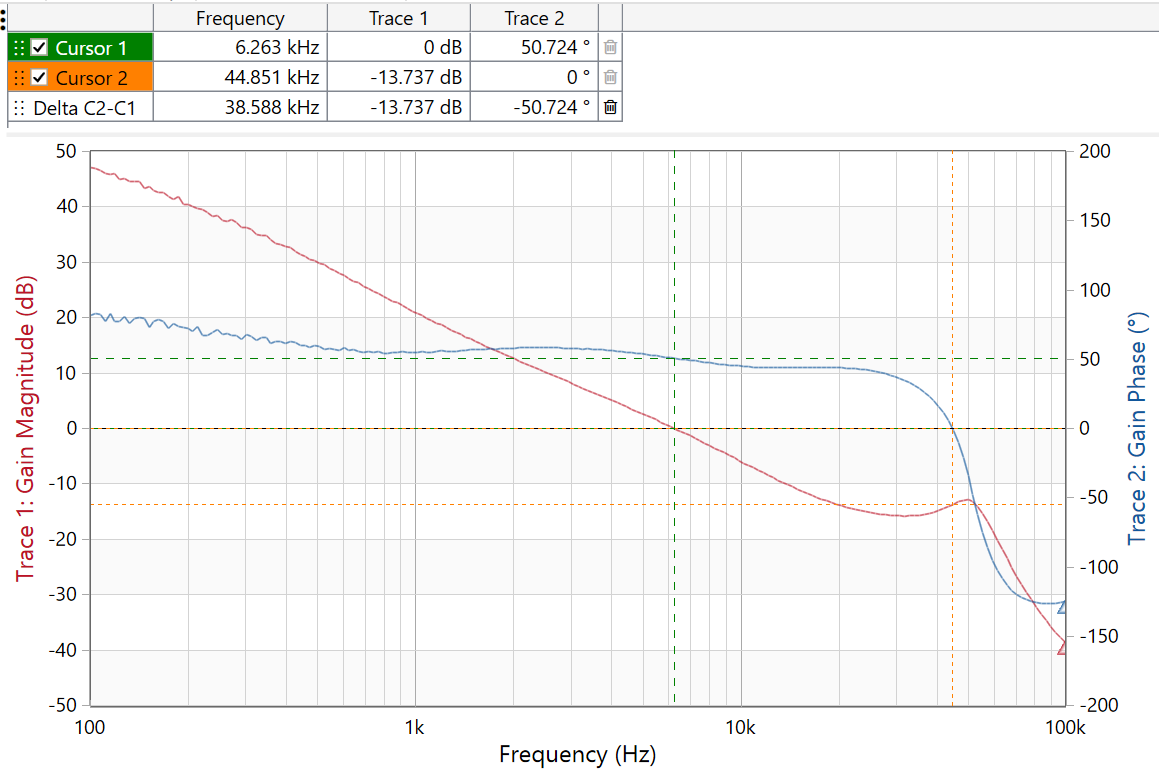
Bandwidth = 5.6 kHz Phase Margin = 56 degrees Gain Margin = 15.9 dB

42.5 V Input, 2.3 A Load:



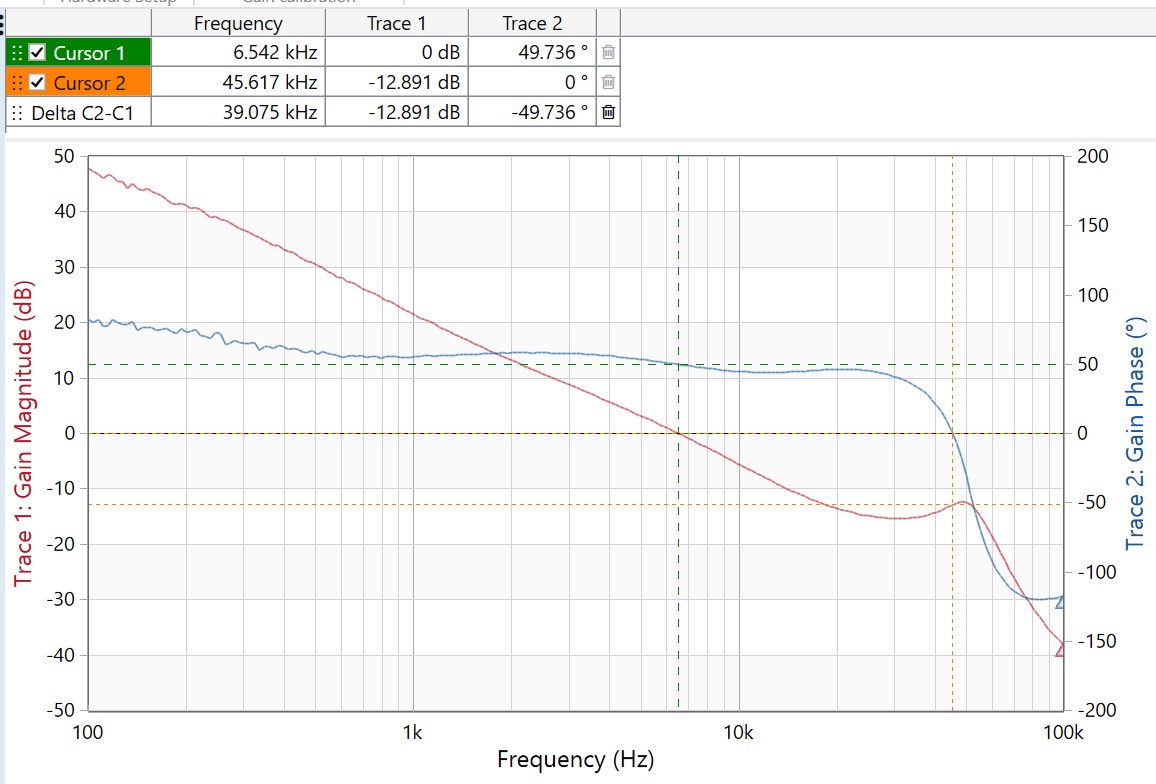
Bandwidth = 6.07 kHz Phase Margin = 51.74 degrees Gain Margin = 14.3 dB

48 V Input, 2.3 A Load:



Bandwidth = 6.26 kHz Phase Margin = 50.7 degrees Gain Margin = 13.7 dB

57 V Input, 2.3 A Load:

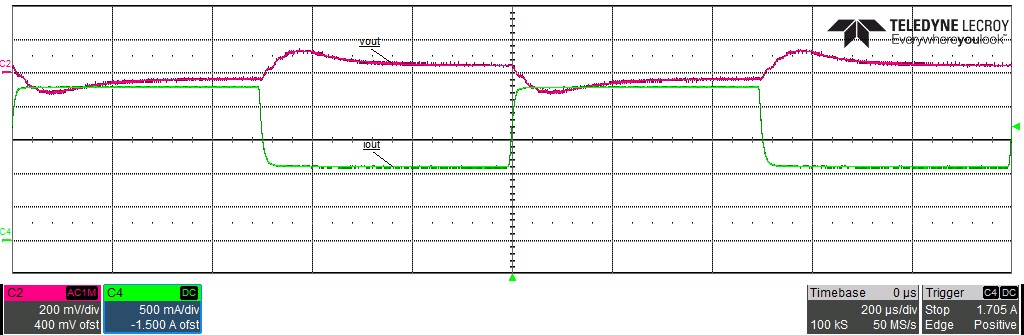


Bandwidth = 6.54 kHz Phase Margin = 49.7 degrees Gain Margin = 12.9 dB

## Load Transients

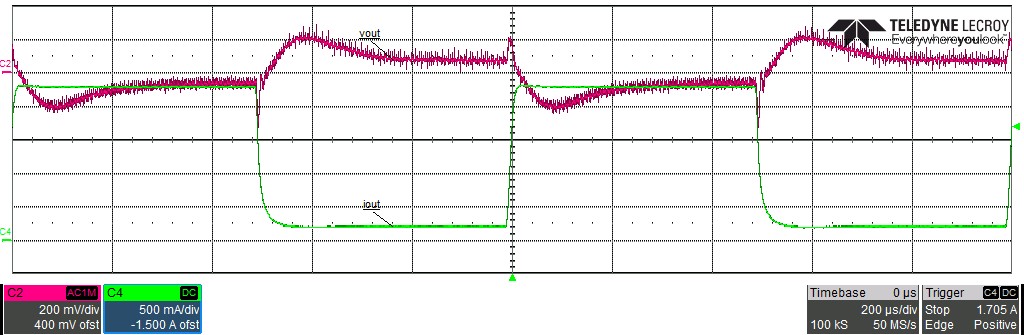
Output load step response, 24 V input, 1.115A to 2.3 A load step

200 mV/div, 500 mA/div, 200 usec/div, slew rate = 360 mA/usec, measured +153 mVpp/-167 mVpp:



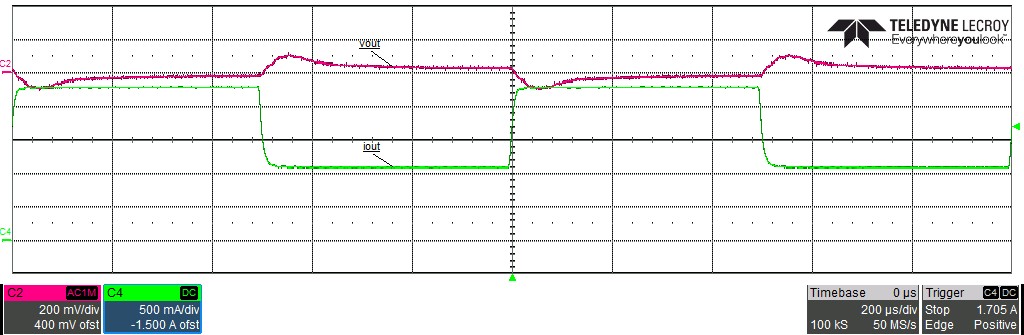
Output load step response, 24 V input, 230 mA to 2.3 A load step

200 mV/div, 500 mA/div, 200 usec/div, slew rate = 360 mA/usec, measured +220 mVpp/-220 mVpp:



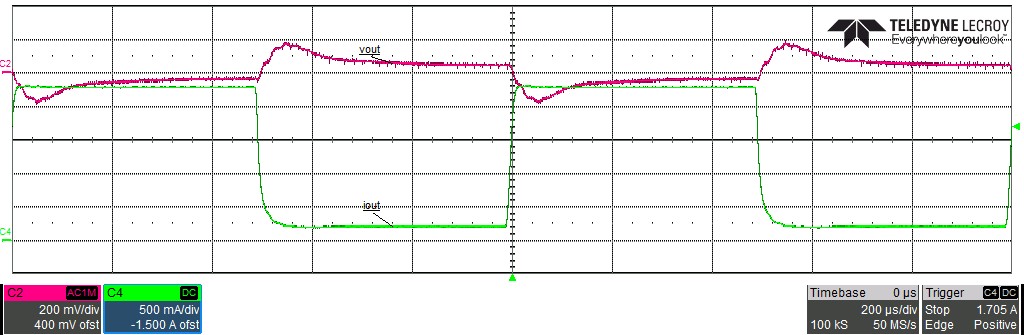
Output load step response, 48 V input 1.115 A to 2.3 A load step

200 mV/div, 500 mA/div, 200 usec/div, slew rate = 360 mA/usec, measured +150 mVpp/-140 mVpp:



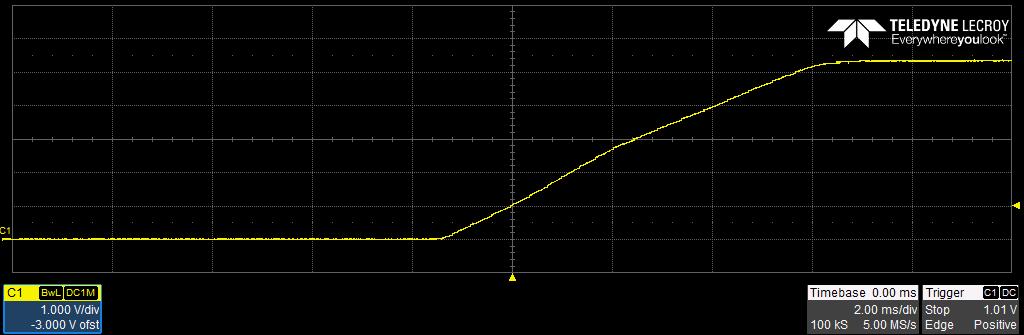
Output load step response, 48 V input, 230 mA to 2.3 A load step

200 mV/div, 500 mA/div, 200 usec/div, slew rate = 360 mA/usec, measured +190 mVpp/--190 mVpp:

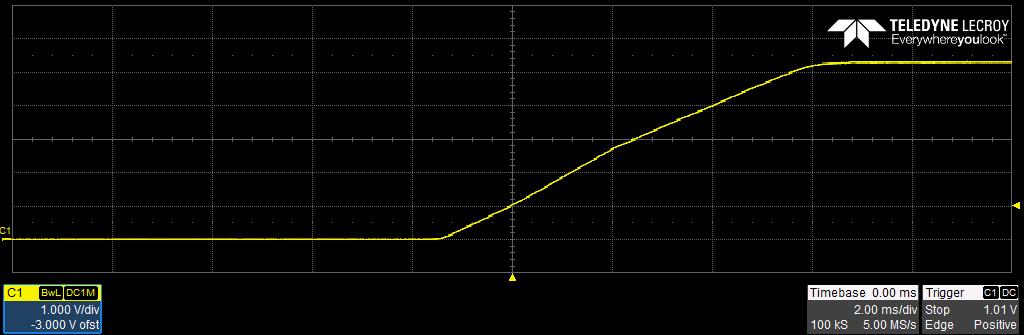


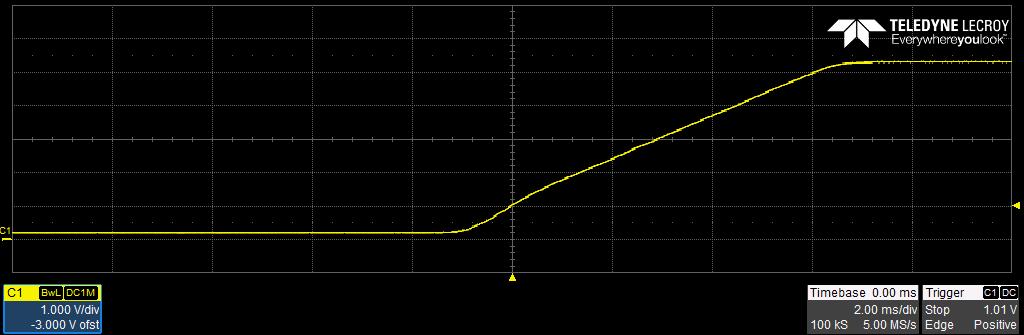
## Start-up

24 V Input, 0 A load, 2 msec/div, 1 V/div:

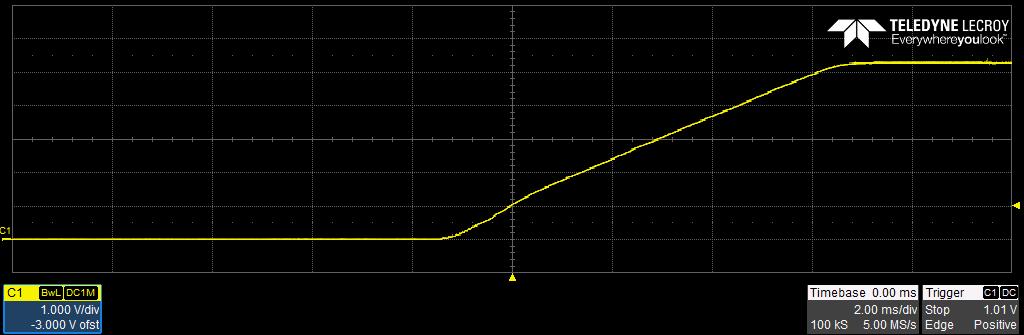


24 V Input, 2.3 A load, 2 msec/div, 1 V/div:



48 V Input, 0 A load, 2 msec/div, 1 V/div:

48 V Input, 2.3 A load, 2 msec/div, 1 V/div:



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