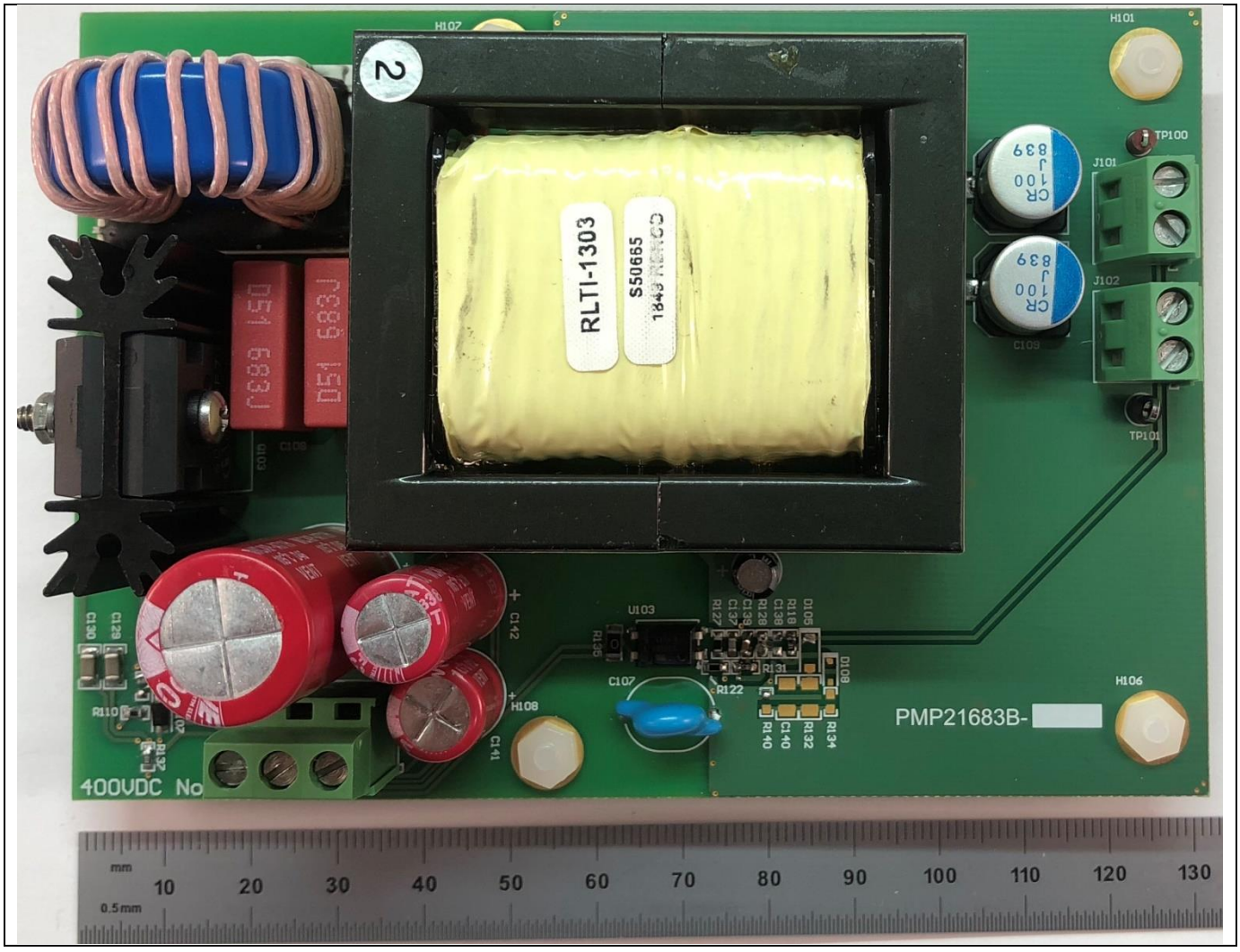
## *Test Report: PMP21683*

# *48-V/550-W Resonant Converter Reference Design*

### Description

This resonant converter reference design takes a 380-V to 420-V DC input and generates a 48-V up to 550-W output. With the UCC256302 driver-integrated resonant converter controller and UCC24624, a two-channel synchronous rectifier (SR) driver, this design can achieve 97.95% peak efficiency.

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# 1 System Specification

## *1.1 Board Dimension:*

3.45" x 4.95" x 1.4"

## *1.2 Input Characteristics*

| Minimum | Nominal | Maximum | |
|---|---|---|---|
| 380 | 400 | 420 | VDC |

## *1.3 Output Characteristics*

The power supply unit should be able to supply 48V+/-5% with 550W maximum output power.


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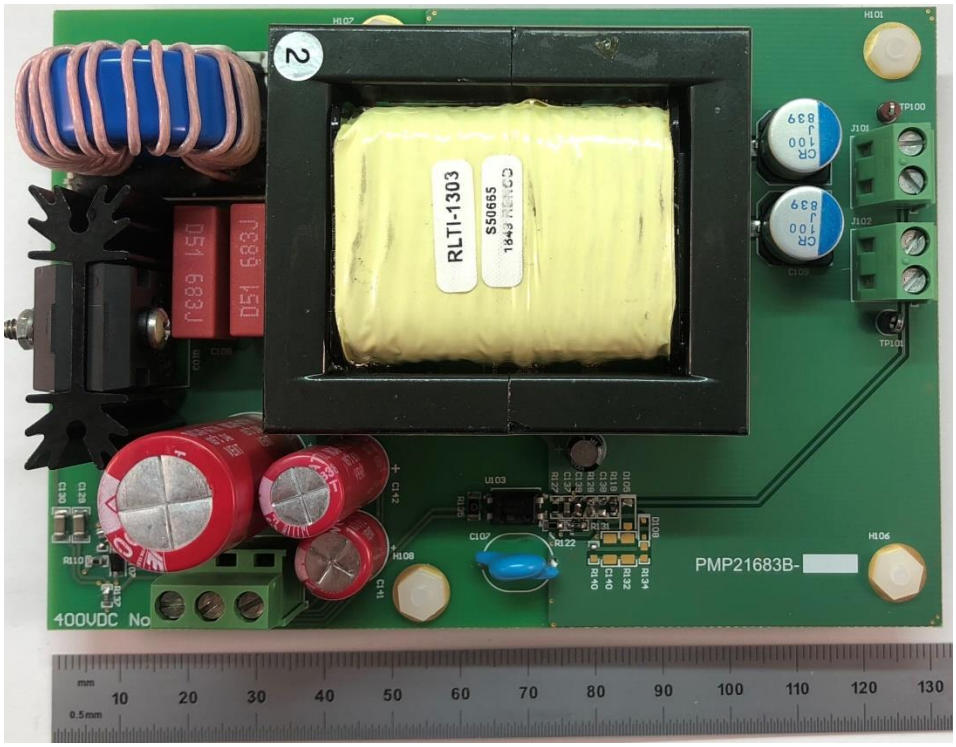
# 2 Testing and Results

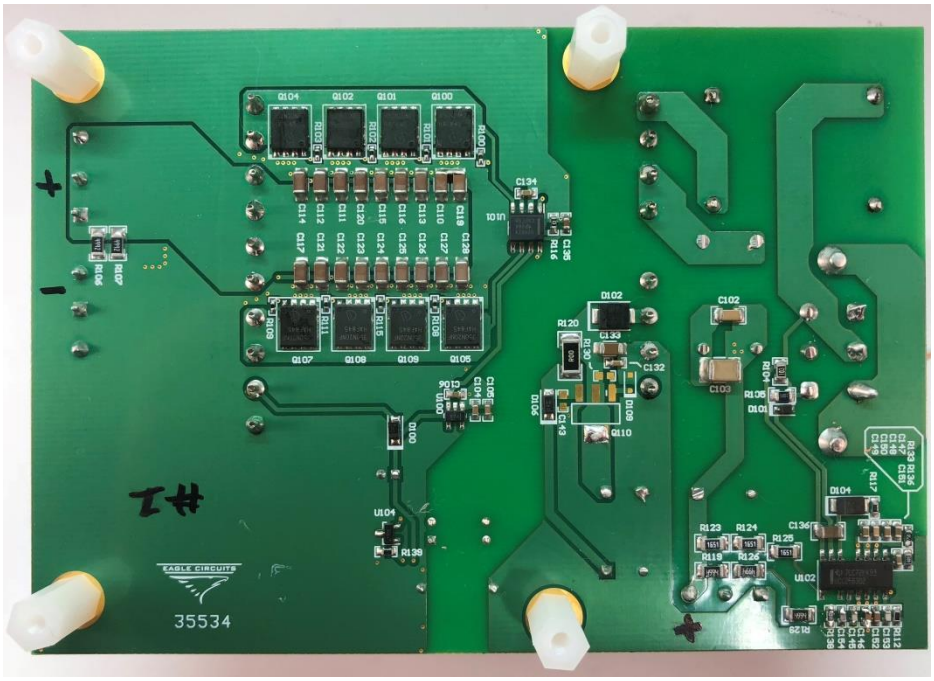
## 2.1 Board Photos

The photographs below show the top and bottom view of the PMP21683 Rev B board.

### 2.1.1 Top Side




### 2.1.2 Bottom Side





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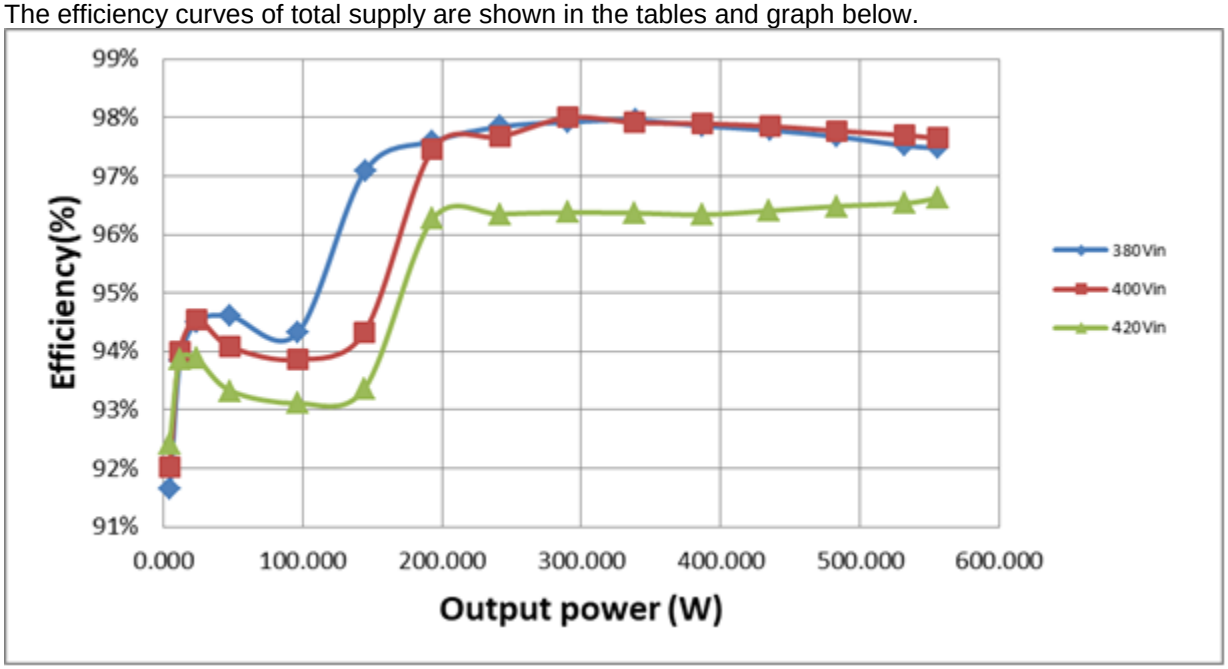
## 2.2 Efficiency

The efficiency curves of total supply are shown in the tables and graph below.




**380V$_{in}$**

| Vin(V) | Iin(A) | Pin(W) | Vout1(V) | Iout1(A) | Pout(W) | Eff. (%) |
|---|---|---|---|---|---|---|
| 379.97 | 1.501 | 570.52 | 48.366 | 11.498 | 556.110 | 97.48% |
| 379.98 | 1.436 | 545.48 | 48.369 | 10.998 | 531.960 | 97.52% |
| 379.98 | 1.303 | 495.14 | 48.370 | 9.998 | 483.610 | 97.67% |
| 379.98 | 1.171 | 445.15 | 48.371 | 8.999 | 435.280 | 97.78% |
| 379.99 | 1.041 | 395.39 | 48.372 | 7.999 | 386.920 | 97.86% |
| 380.00 | 0.910 | 345.64 | 48.374 | 6.999 | 338.570 | 97.95% |
| 380.01 | 0.780 | 296.34 | 48.373 | 5.999 | 290.180 | 97.92% |
| 380.01 | 0.650 | 247.14 | 48.373 | 4.999 | 241.810 | 97.84% |
| 380.02 | 0.521 | 198.16 | 48.372 | 3.998 | 193.400 | 97.60% |
| 380.02 | 0.393 | 149.36 | 48.371 | 2.998 | 145.020 | 97.09% |
| 380.03 | 0.270 | 102.22 | 48.231 | 1.998 | 96.410 | 94.31% |
| 380.03 | 0.135 | 51.06 | 48.351 | 0.999 | 48.300 | 94.60% |
| 380.04 | 0.067 | 25.55 | 48.368 | 0.499 | 24.140 | 94.51% |
| 380.04 | 0.034 | 12.83 | 48.356 | 0.249 | 12.040 | 93.83% |
| 380.05 | 0.014 | 5.22 | 48.352 | 0.099 | 4.790 | 91.66% |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**400$V_{in}$**

| Vin(V) | Iin(A) | Pin(W) | Vout1(V) | Iout1(A) | Pout(W) | Eff. (%) |
|---|---|---|---|---|---|---|
| 400.17 | 1.423 | 569.50 | 48.364 | 11.498 | 556.090 | 97.65% |
| 400.17 | 1.361 | 544.48 | 48.366 | 10.998 | 531.930 | 97.70% |
| 400.17 | 1.236 | 494.61 | 48.367 | 9.998 | 483.580 | 97.77% |
| 400.19 | 1.112 | 444.85 | 48.372 | 8.999 | 435.290 | 97.85% |
| 400.19 | 0.988 | 395.22 | 48.371 | 7.998 | 386.890 | 97.89% |
| 400.20 | 0.864 | 345.74 | 48.371 | 6.999 | 338.530 | 97.92% |
| 400.21 | 0.740 | 296.09 | 48.373 | 5.999 | 290.170 | 98.00% |
| 400.22 | 0.619 | 247.58 | 48.373 | 4.999 | 241.800 | 97.67% |
| 400.22 | 0.496 | 198.41 | 48.367 | 3.998 | 193.370 | 97.46% |
| 400.23 | 0.384 | 153.05 | 48.142 | 2.998 | 144.360 | 94.33% |
| 400.23 | 0.258 | 102.69 | 48.226 | 1.998 | 96.380 | 93.86% |
| 400.24 | 0.129 | 51.31 | 48.352 | 0.998 | 48.270 | 94.08% |
| 400.24 | 0.064 | 25.51 | 48.368 | 0.499 | 24.120 | 94.55% |
| 400.24 | 0.032 | 12.79 | 48.371 | 0.248 | 12.020 | 94.00% |
| 400.25 | 0.013 | 5.16 | 48.373 | 0.098 | 4.750 | 92.02% |

**420$V_{in}$**

| Vin(V) | Iin(A) | Pin(W) | Vout1(V) | Iout1(A) | Pout(W) | Eff. (%) |
|---|---|---|---|---|---|---|
| 420.02 | 1.369 | 575.05 | 48.329 | 11.498 | 555.610 | 96.62% |
| 420.02 | 1.311 | 550.52 | 48.323 | 10.996 | 531.440 | 96.53% |
| 420.02 | 1.192 | 500.82 | 48.330 | 9.998 | 483.210 | 96.48% |
| 420.04 | 1.074 | 451.14 | 48.332 | 8.999 | 434.930 | 96.41% |
| 420.04 | 0.956 | 401.33 | 48.336 | 7.999 | 386.630 | 96.34% |
| 420.05 | 0.836 | 351.09 | 48.339 | 6.999 | 338.330 | 96.37% |
| 420.06 | 0.717 | 300.92 | 48.347 | 5.998 | 290.010 | 96.37% |
| 420.06 | 0.597 | 250.83 | 48.344 | 4.999 | 241.670 | 96.35% |
| 420.06 | 0.478 | 200.79 | 48.345 | 3.998 | 193.290 | 96.27% |
| 420.07 | 0.370 | 154.50 | 48.098 | 2.998 | 144.240 | 93.36% |
| 420.08 | 0.247 | 103.47 | 48.198 | 1.998 | 96.340 | 93.12% |
| 420.09 | 0.124 | 51.72 | 48.354 | 0.998 | 48.270 | 93.33% |
| 420.09 | 0.061 | 25.69 | 48.377 | 0.498 | 24.120 | 93.88% |
| 420.10 | 0.031 | 12.80 | 48.383 | 0.248 | 12.010 | 93.87% |
| 420.09 | 0.012 | 5.15 | 48.392 | 0.098 | 4.760 | 92.43% |


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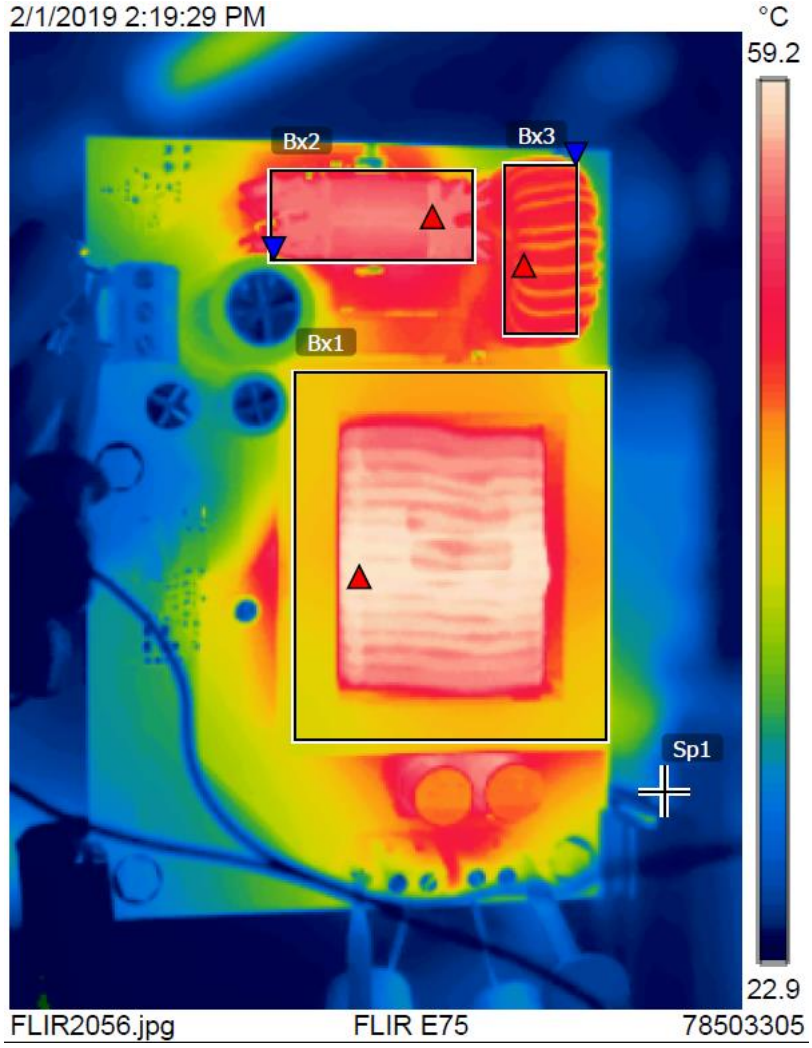
## 2.3 Thermal Images

The thermal images below show a top view and bottom view of the board. The board is placed vertically during the test. The ambient temperature was 25ºC without forced air flow. The output was loaded with 48V/11.5A.

### 2.3.1 380VDC input, Top Side




| Measurements | | |
|---|---|---|
| Bx1 | Max | 60.1 °C |
| Bx2 | Max | 56.2 °C |
| | Min | 35.8 °C |
| | Average | 53.8 °C |
| Bx3 | Max | 51.1 °C |
| | Min | 45.7 °C |
| | Average | 48.5 °C |
| Sp1 | | 28.1 °C |

| Alarm (Custom) | °C |
|---|---|
| Custom mode: | Below |
| Limit: | 22.8 |

| Parameters | |
|---|---|
| Emissivity | 0.95 |
| Refl. temp. | 20 °C |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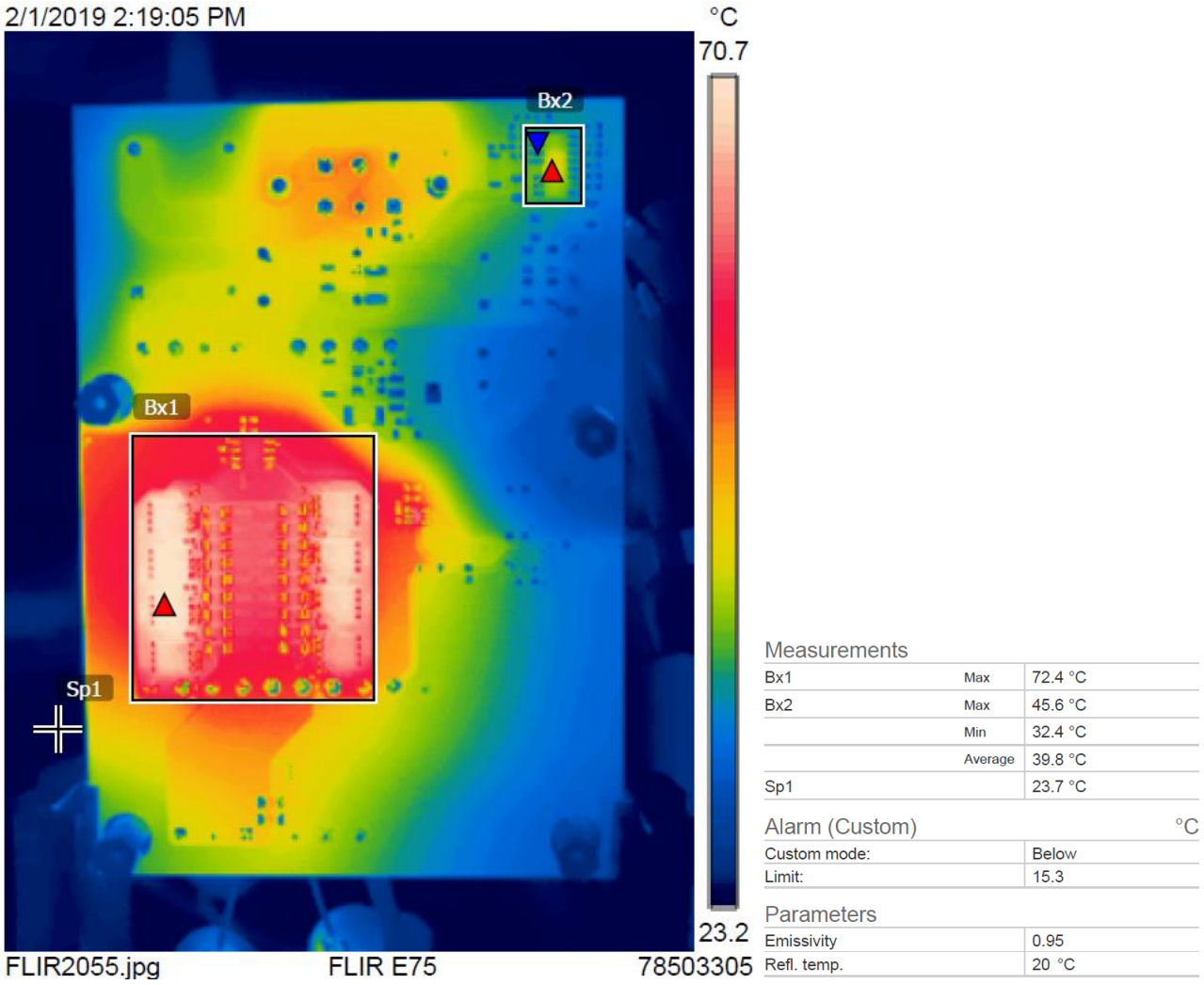
### 2.3.2 380$V_{DC}$ Input, Bottom Side





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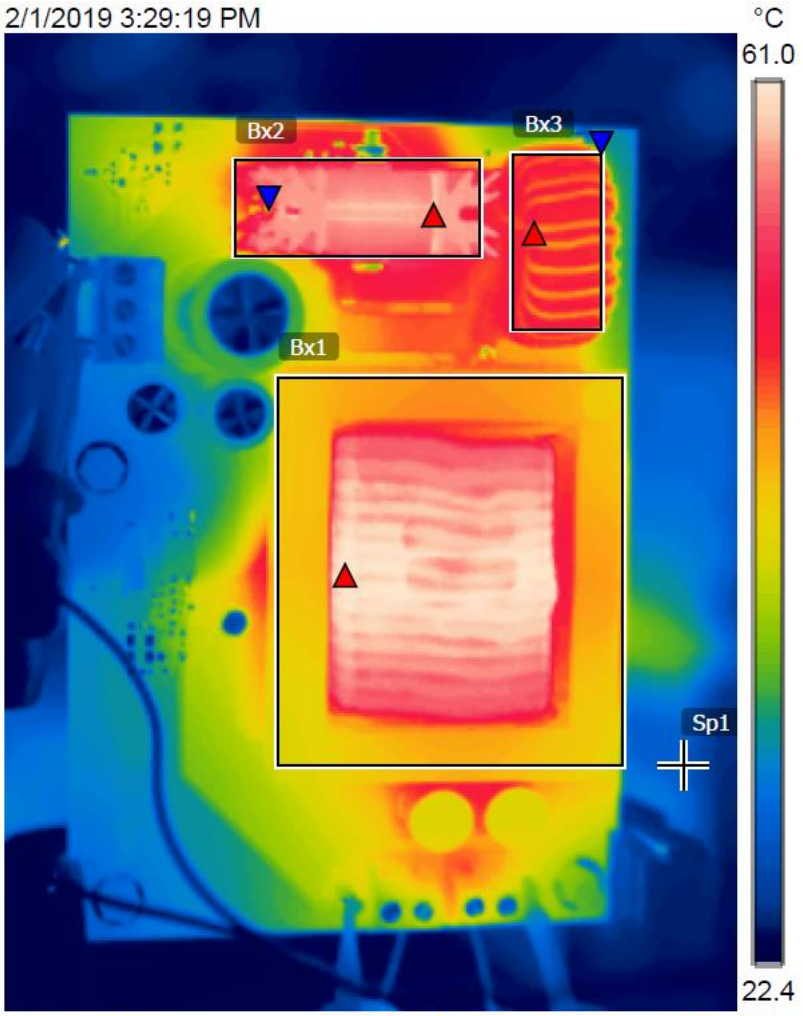
### 2.3.3 400$V_{DC}$ Input, Top Side




| Measurements | | |
|---|---|---|
| Bx1 | Max | 61.9 °C |
| Bx2 | Max | 59.8 °C |
| | Min | 38.2 °C |
| | Average | 56.2 °C |
| Bx3 | Max | 52.9 °C |
| | Min | 38.2 °C |
| | Average | 49.9 °C |
| Sp1 | | 28.6 °C |

| Alarm (Custom) | °C |
|---|---|
| Custom mode: | Below |
| Limit: | 15.3 |

| Parameters | |
|---|---|
| Emissivity | 0.95 |
| Refl. temp. | 20 °C |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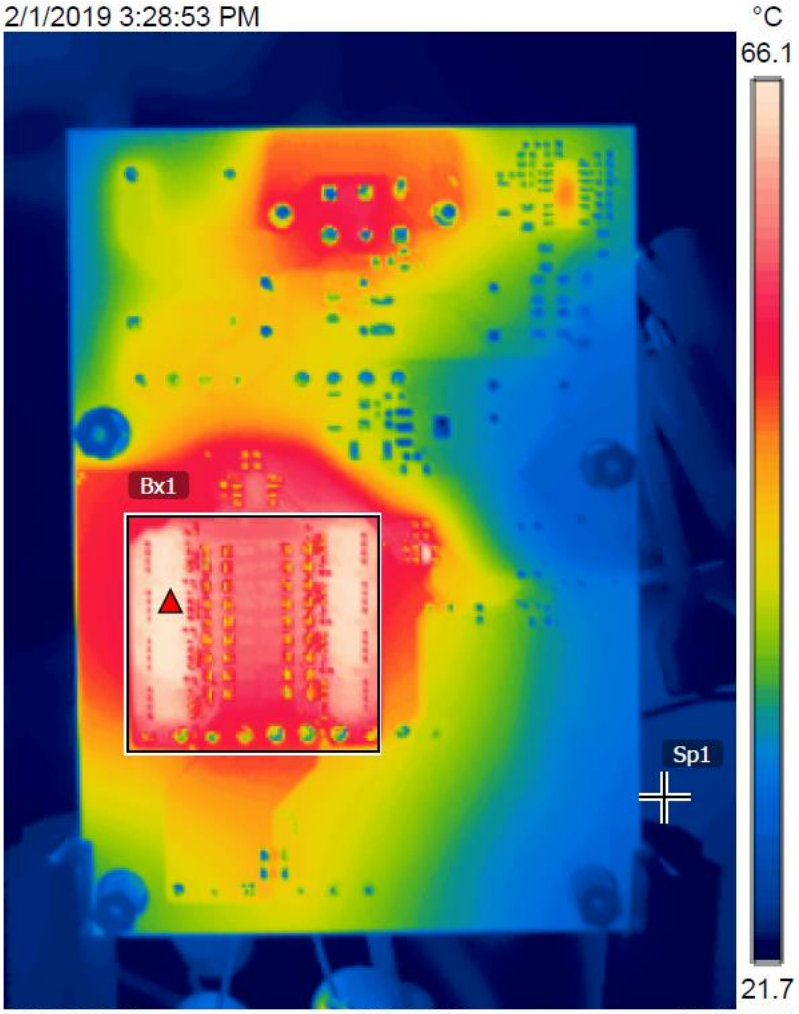
### 2.3.4 400$V_{DC}$ Input, Bottom Side




| Measurements | | |
|---|---|---|
| Bx1 | Max | 67.0 °C |
| Sp1 | | 24.3 °C |

| Alarm (Custom) | °C |
|---|---|
| Custom mode: | Below |
| Limit: | 15.3 |

| Parameters | |
|---|---|
| Emissivity | 0.95 |
| Refl. temp. | 20 °C |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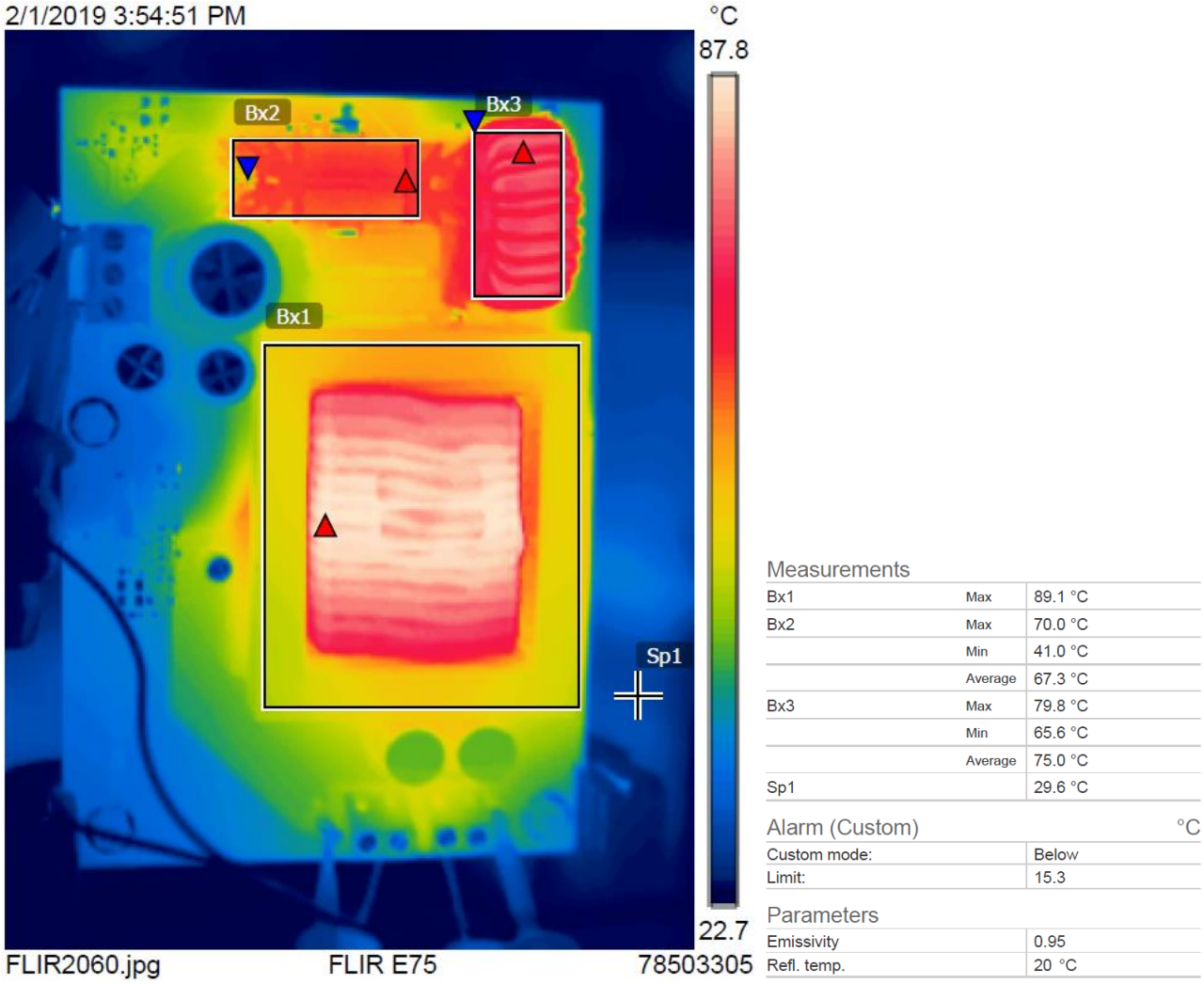
### 2.3.5 420$V_{DC}$ Input, Top Side





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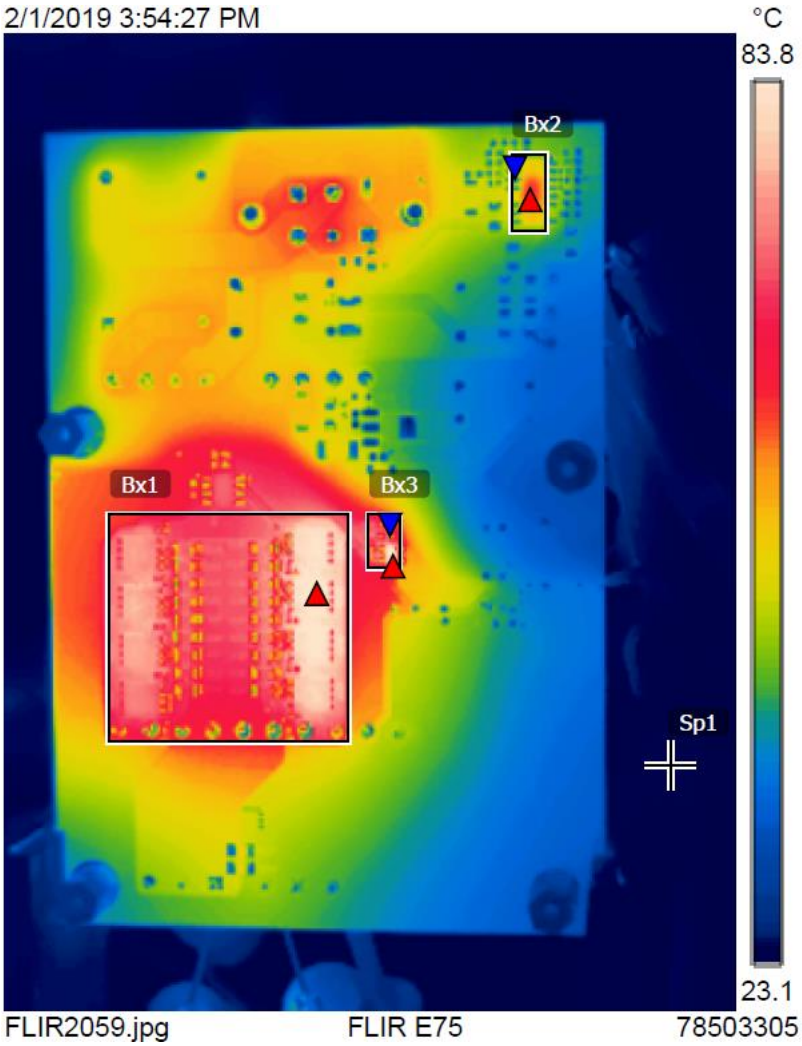
### 2.3.6 420$V_{DC}$ Input, Bottom Side




| Measurements | | |
|---|---|---|
| Bx1 | Max | 85.3 °C |
| Bx2 | Max | 64.7 °C |
| | Min | 39.7 °C |
| | Average | 53.9 °C |
| Bx3 | Max | 88.7 °C |
| | Min | 49.6 °C |
| | Average | 70.1 °C |
| Sp1 | | 24.1 °C |

| Alarm (Custom) | °C |
|---|---|
| Custom mode: | Below |
| Limit: | 15.3 |

| Parameters | |
|---|---|
| Emissivity | 0.95 |
| Refl. temp. | 20 °C |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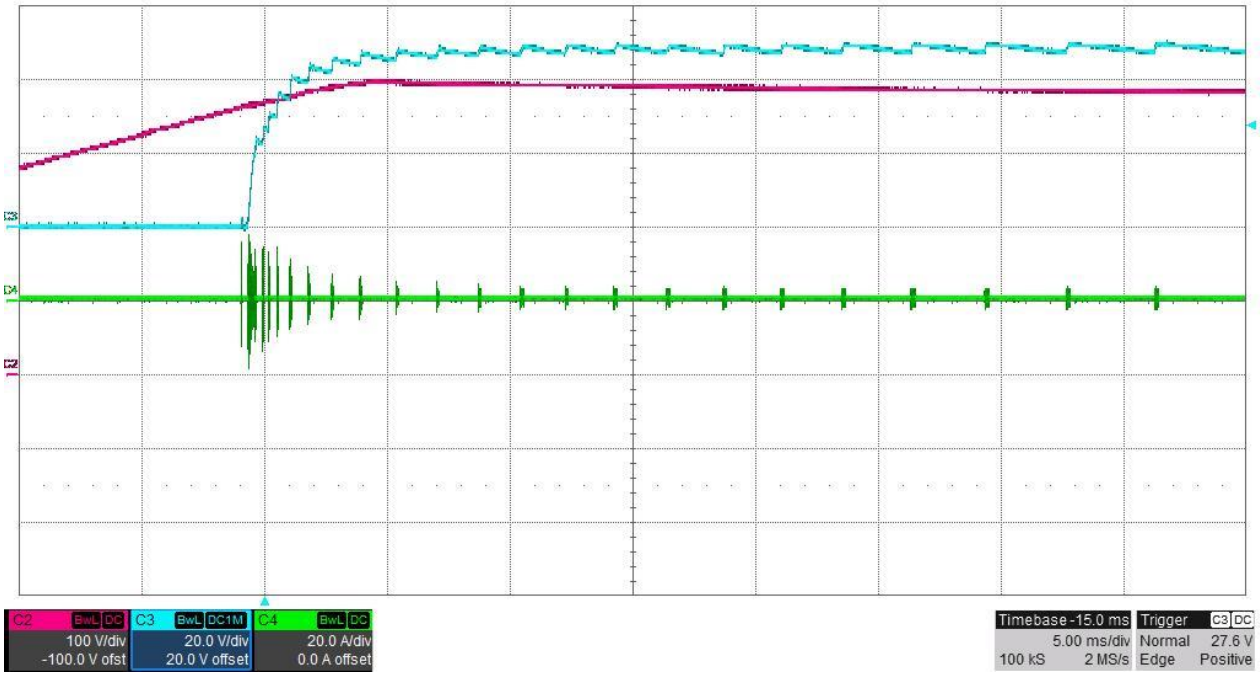
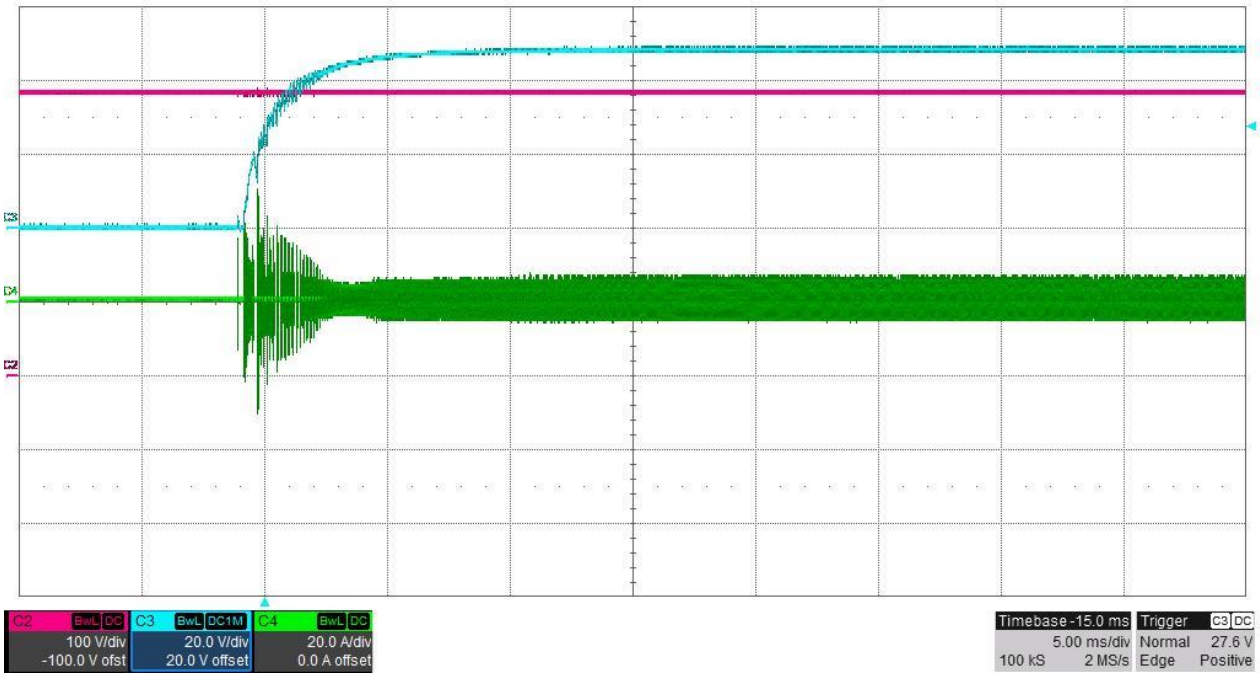
## 2.4 Startup

The voltages at startup are shown in the images below, where C2 is the input voltage, C3 is output voltage, and C4 is the inductor current of L100.

### 2.4.1 380Vin, 0.1A Load




### 2.4.2 380Vin, 11.5A Load





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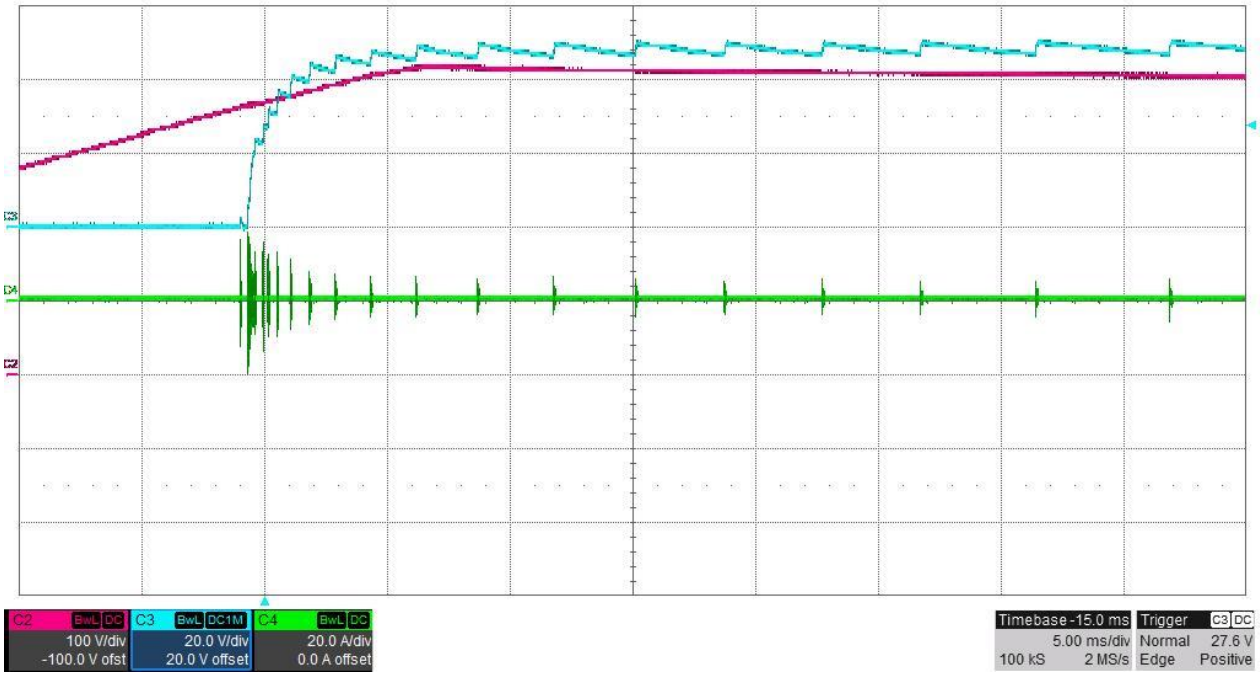
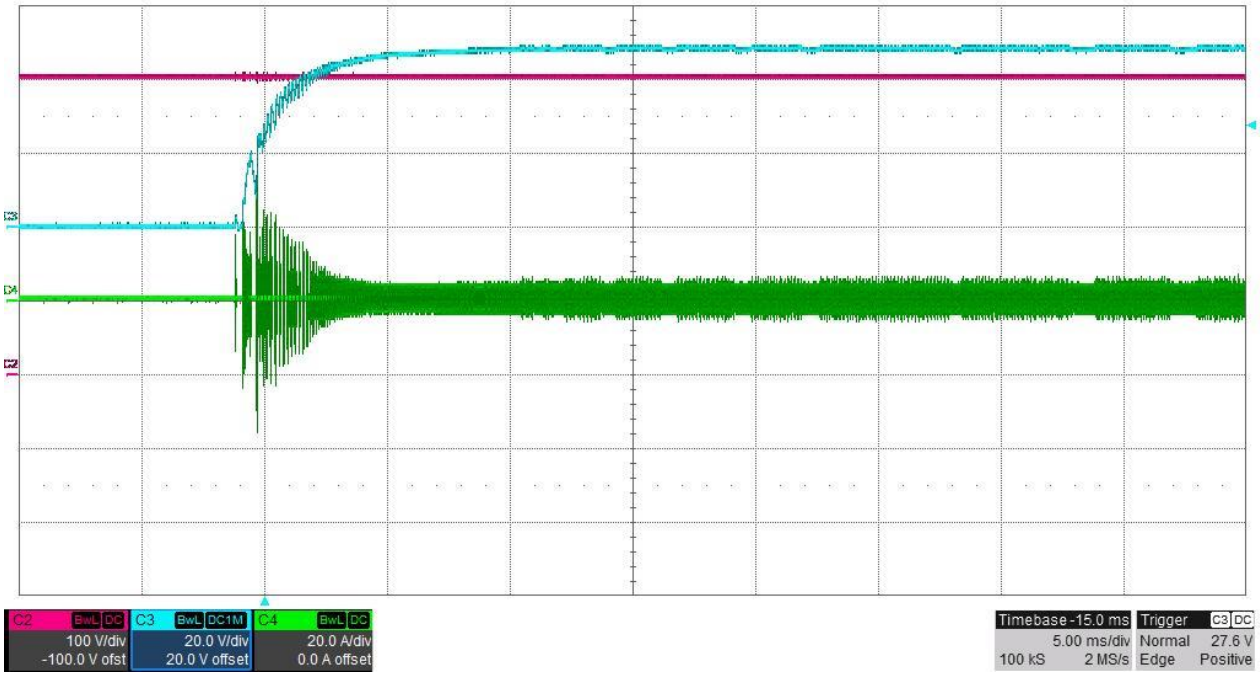
### 2.4.3 400Vin, 0.1A Load




### 2.4.4 400Vin, 11.5A Load





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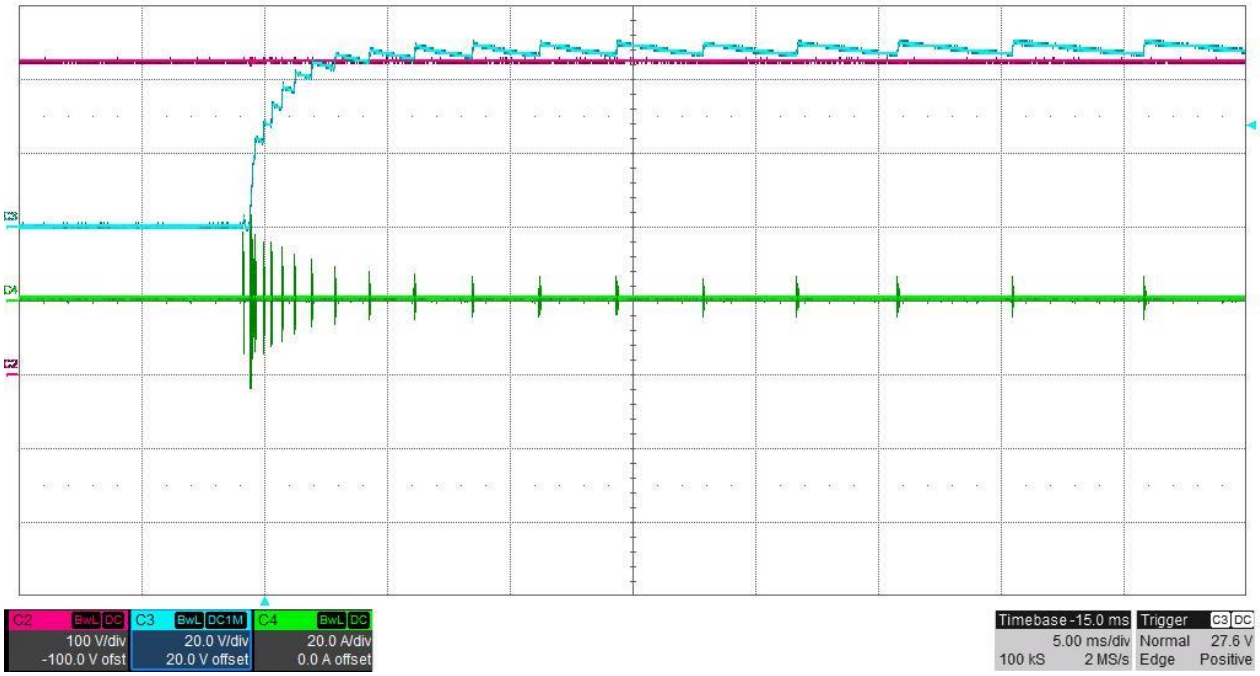
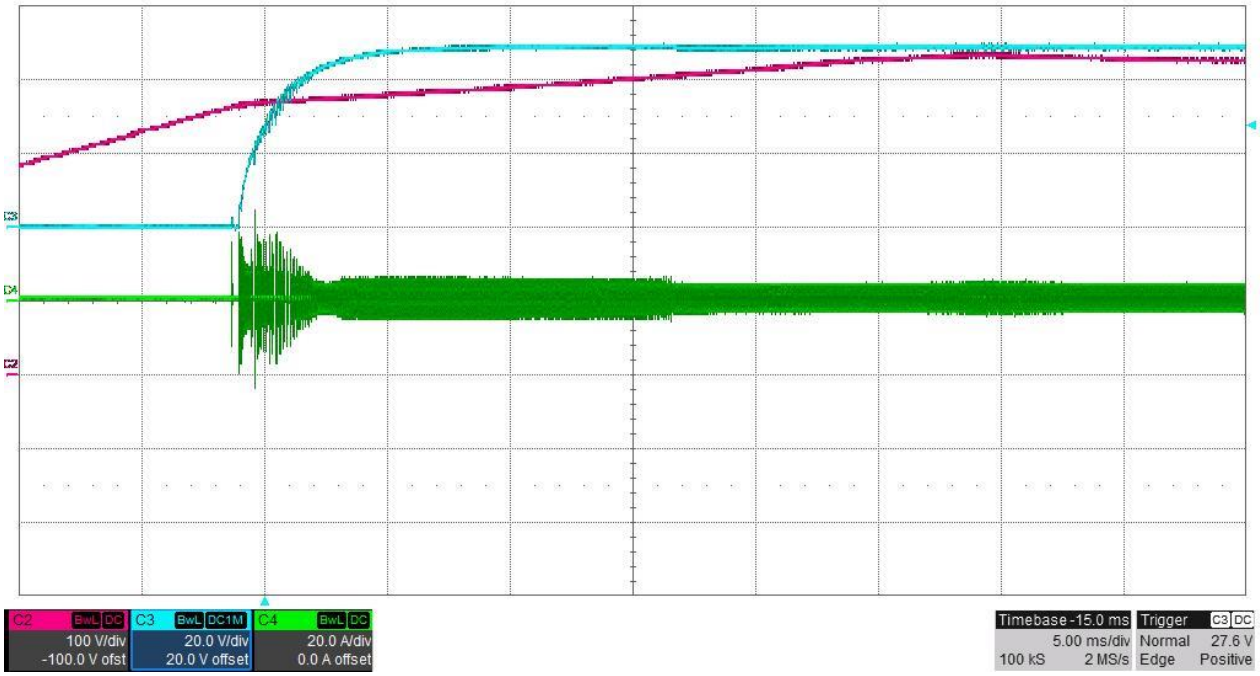
### 2.4.5 420Vin, 0.1A Load




### 2.4.6 420Vin, 11.5A Load





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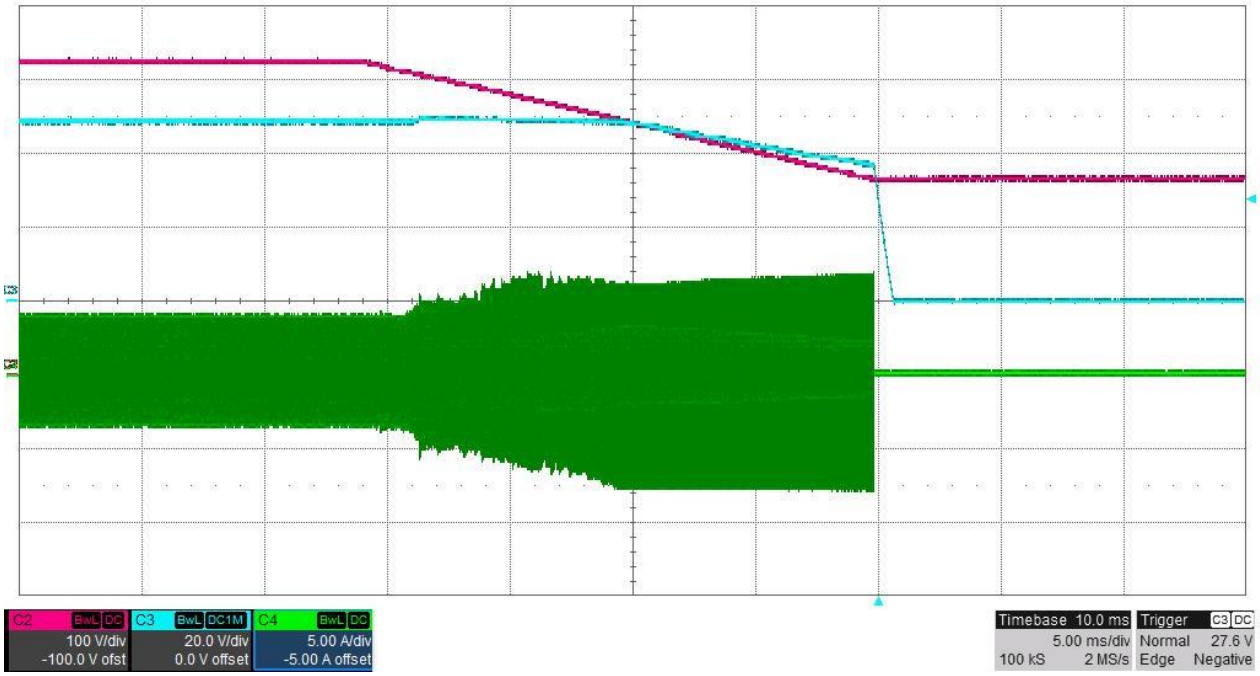
### *2.5 Turn Off*

The voltages at turn-off are shown in the images below with 48V/11.5A load (Electronic load with CC mode), where C2 is input voltage, C3 is output voltage, and C4 is the inductor current of L100.





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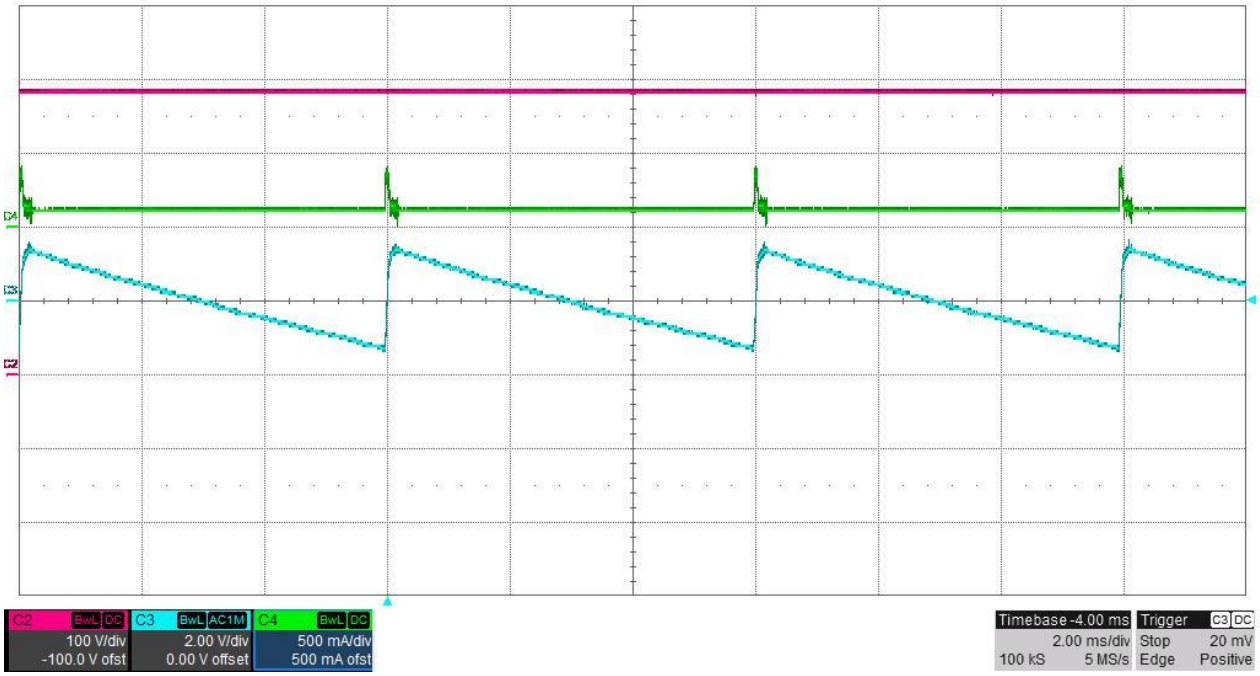
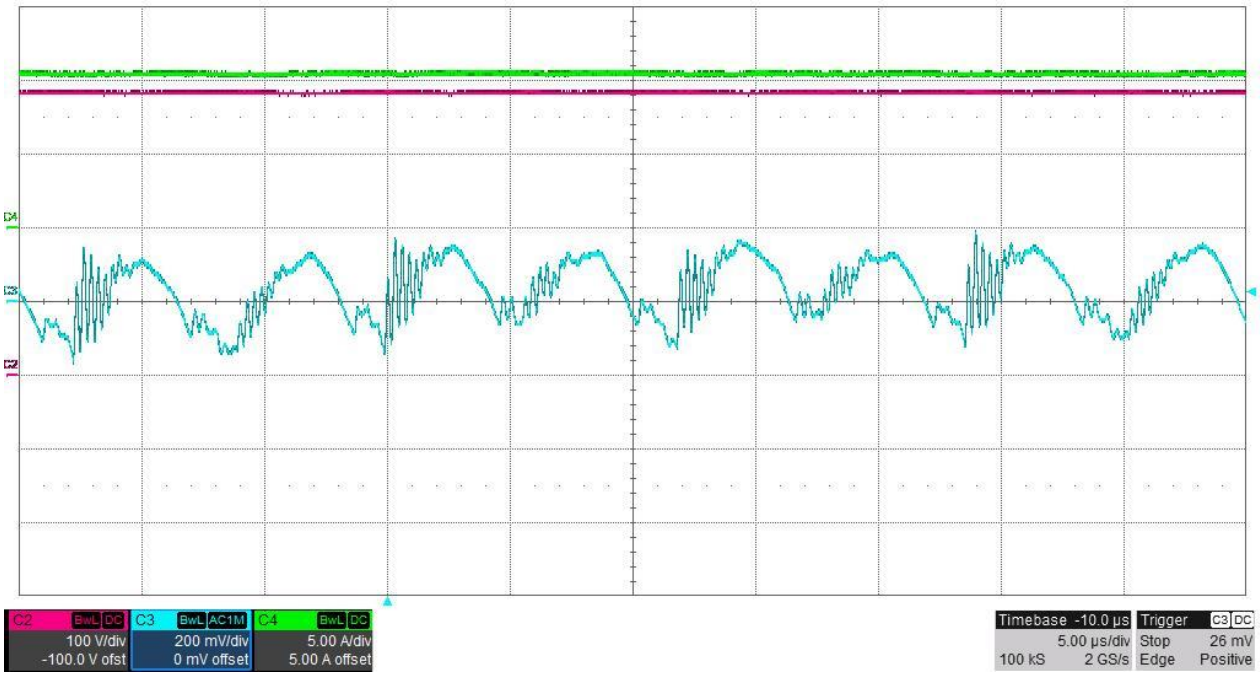
## 2.6 Output Ripple Voltages

2 x 0.1uF/100V (0805) ceramic capacitors are applied on the ripple test board. C2 is Vin, C3 is Vout and C4 is the output current.

### 2.6.1 48V output ripple at 0.1A load and 380$V_{in}$




### 2.6.2 48V output ripple at 11.5A load and 380$V_{in}$





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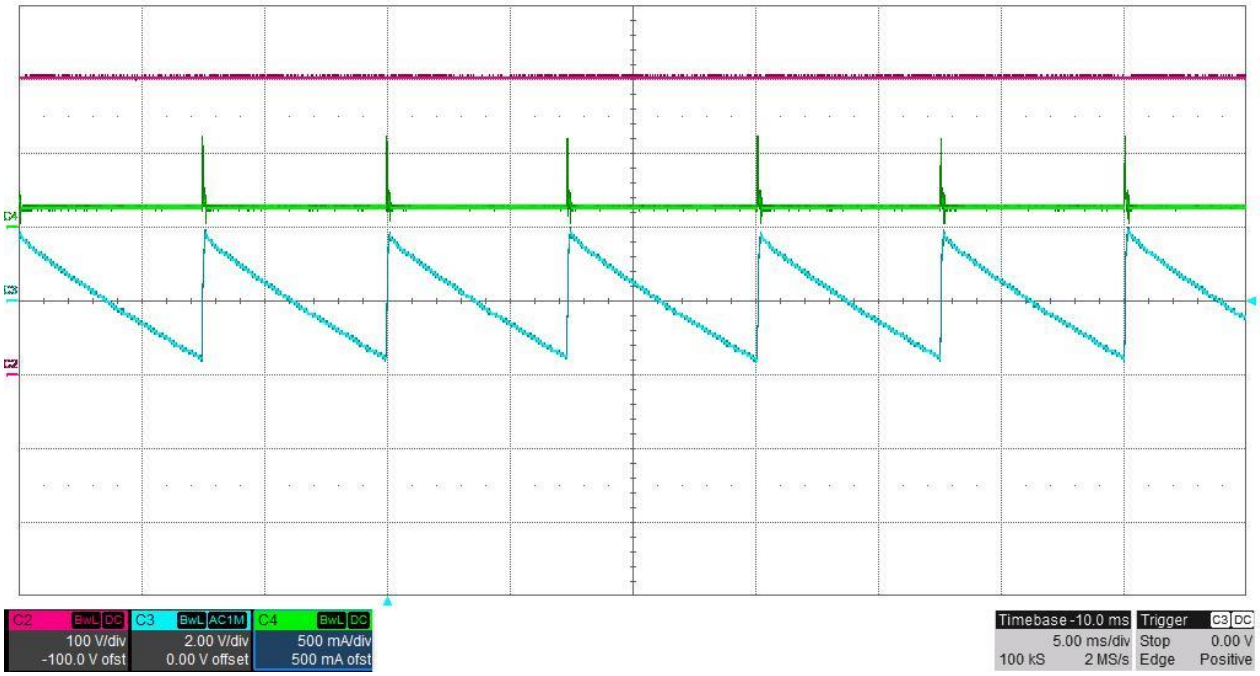
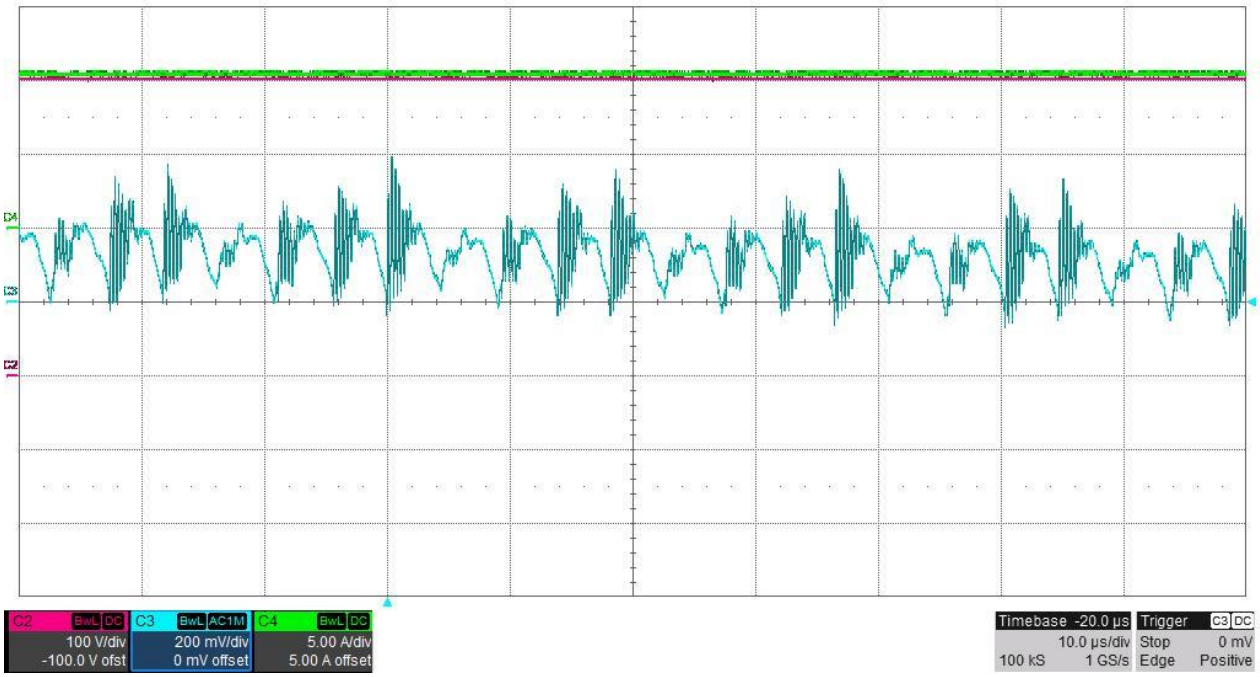
### 2.6.3 48V output ripple at 0.1A load and 400$V_{in}$




### 2.6.4 48V output ripple at 11.5A load and 400$V_{in}$





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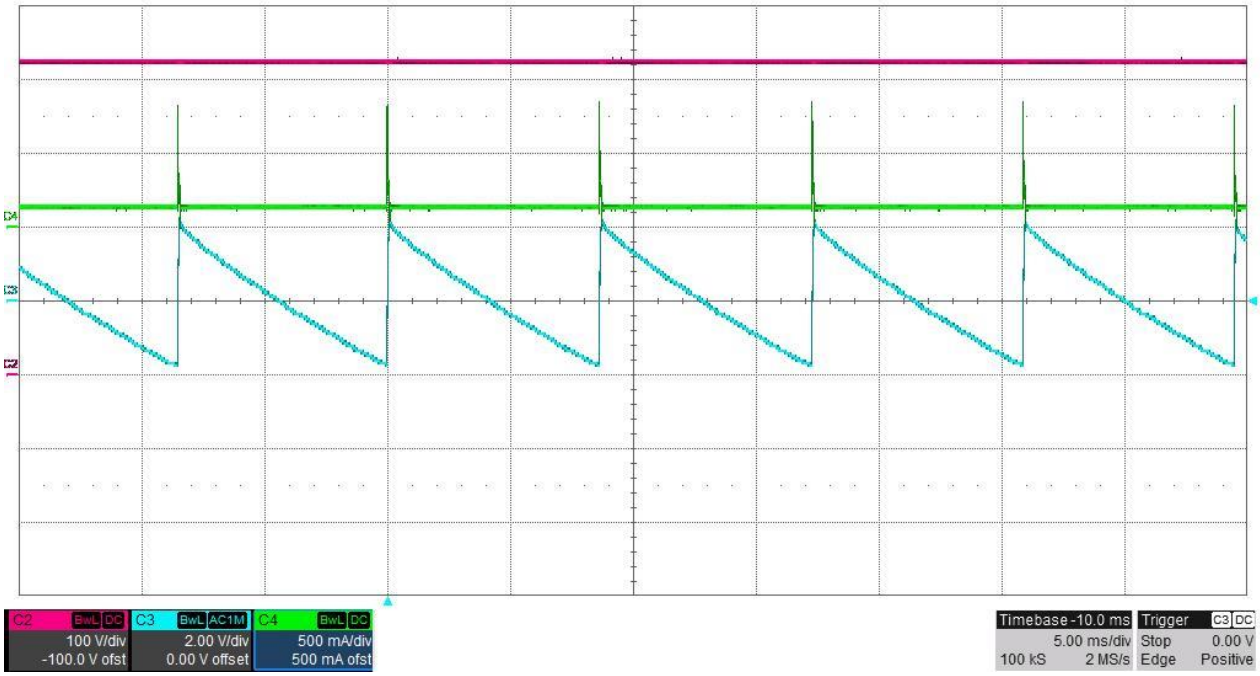
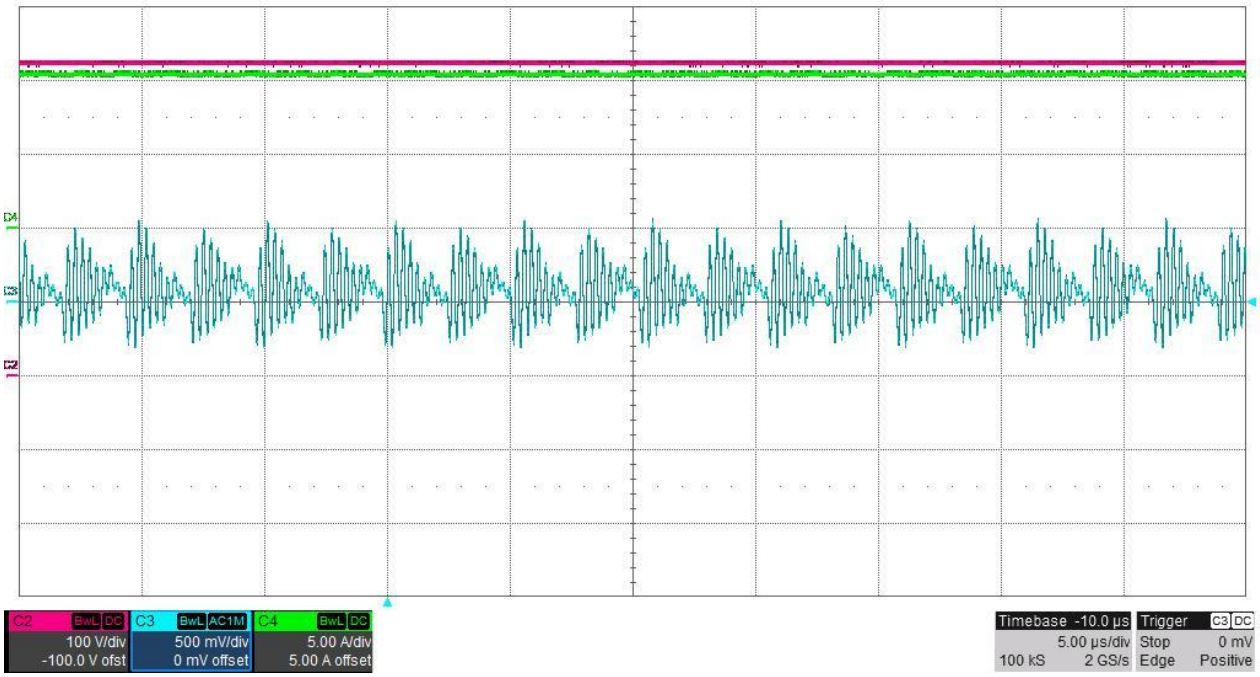
### 2.6.5 48V output ripple at 0.1A load and 420$V_{in}$




### 2.6.6 48V output ripple at 11.5A load and 420$V_{in}$





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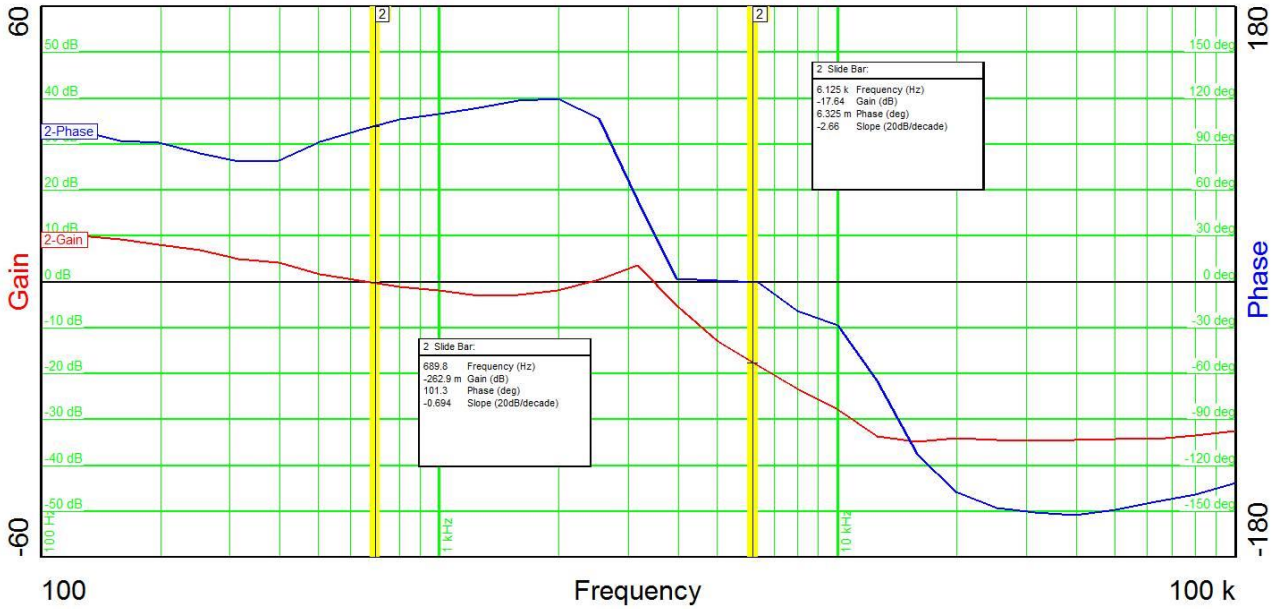
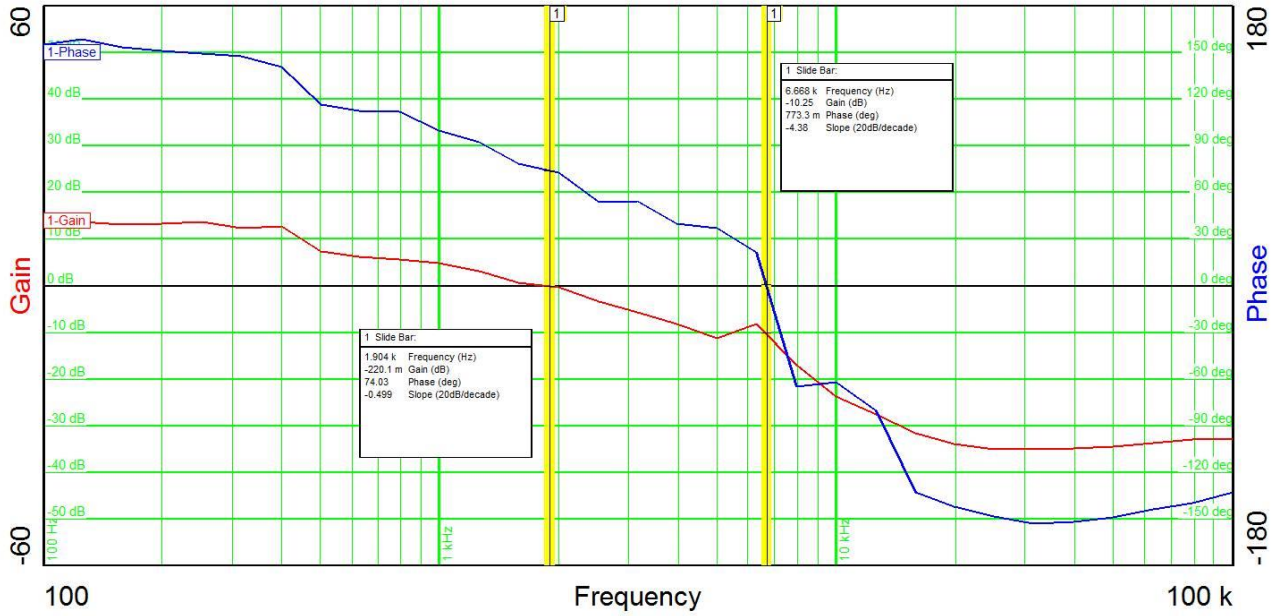
## 2.7 Frequency Response

Frequency response is tested with 11.5A load.

### 2.7.1 390Vin




### 2.7.2 410Vin





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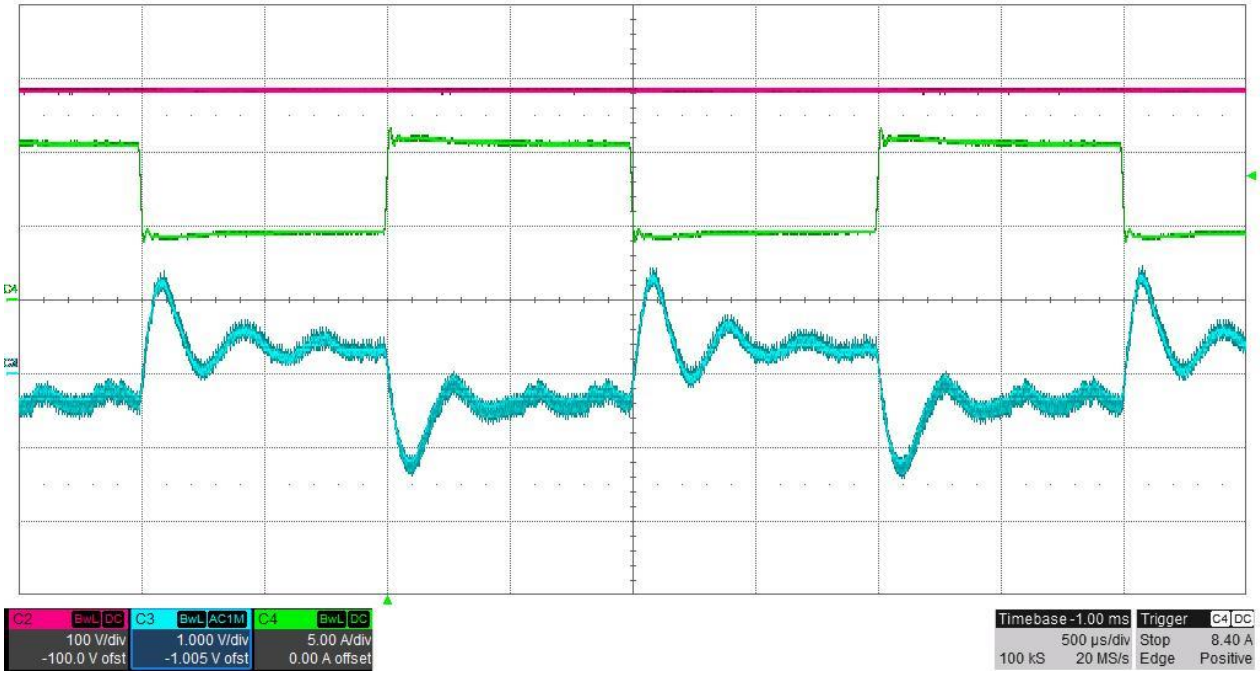
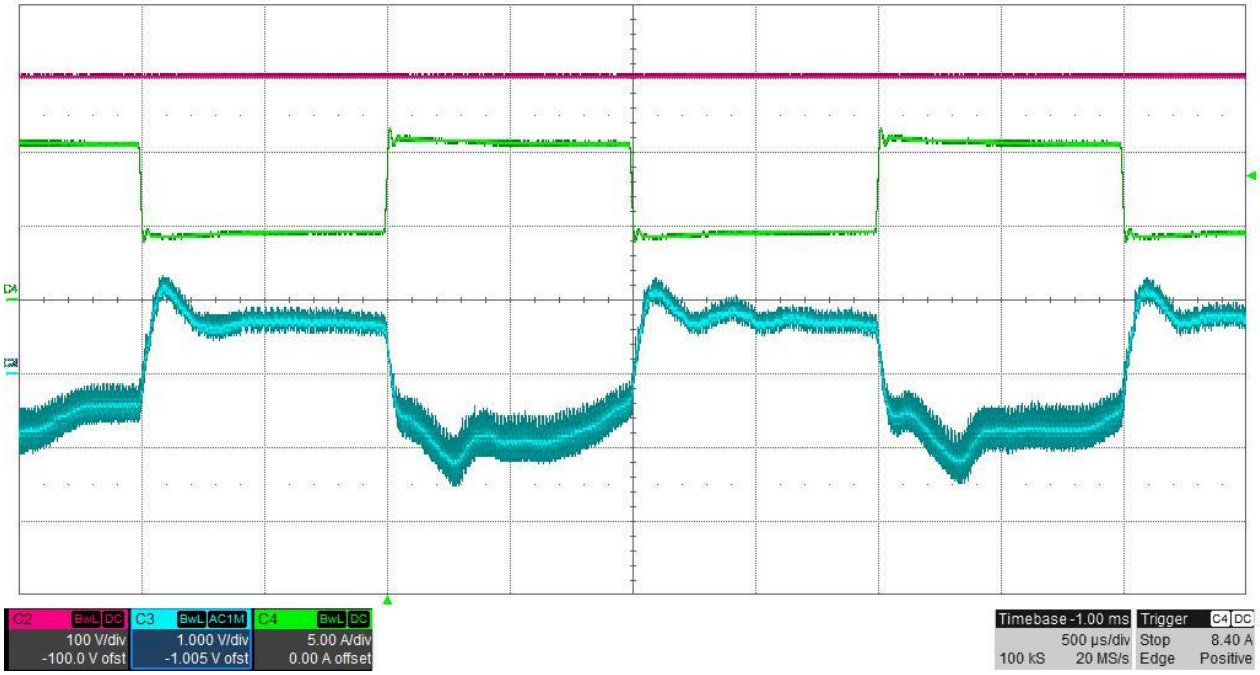
## *2.8 Load Response*

Load response is tested with 5A to 11.5A step load change. C2 is Vin, C3 is Vout and C4 is the output current.

### 2.8.1 380Vin




### 2.8.2 400Vin





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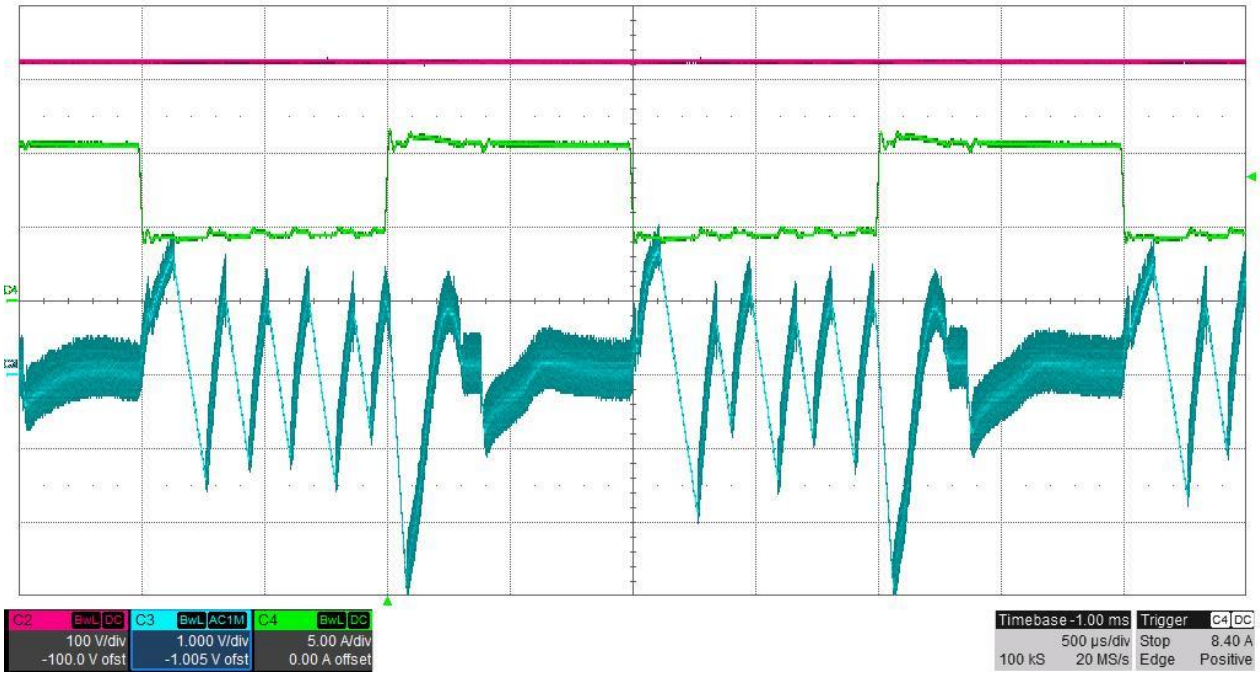
### 2.8.3 420Vin





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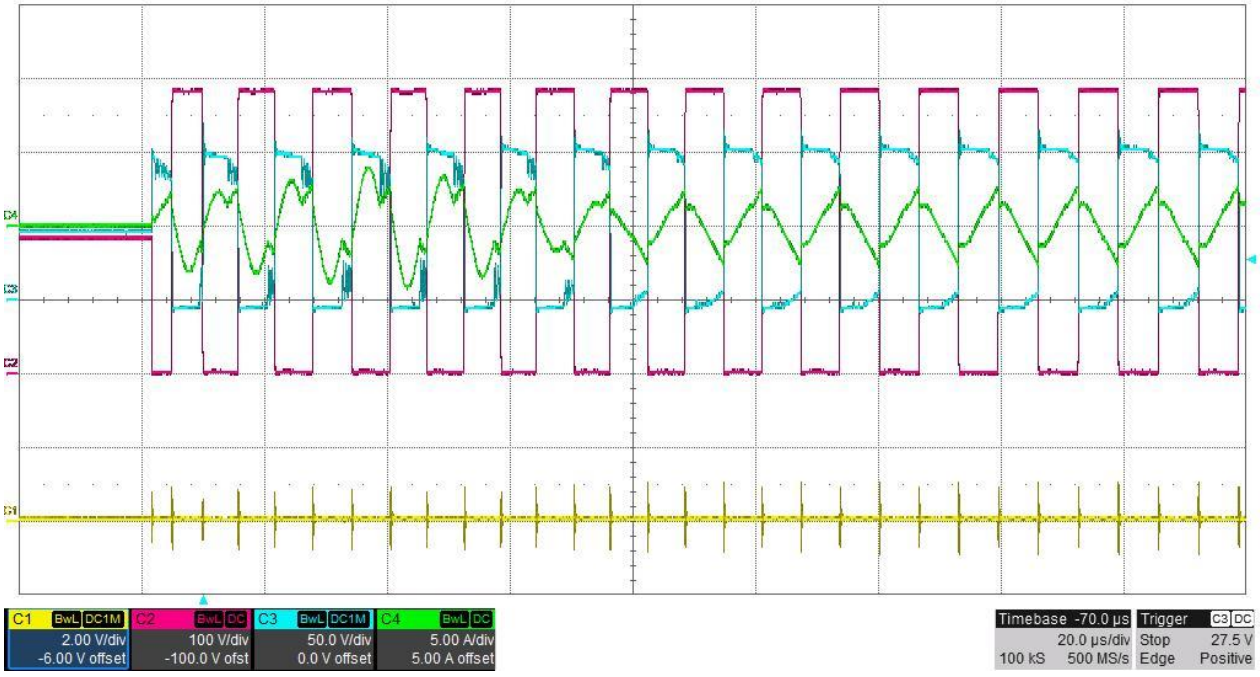
## 2.9 Key Waveforms

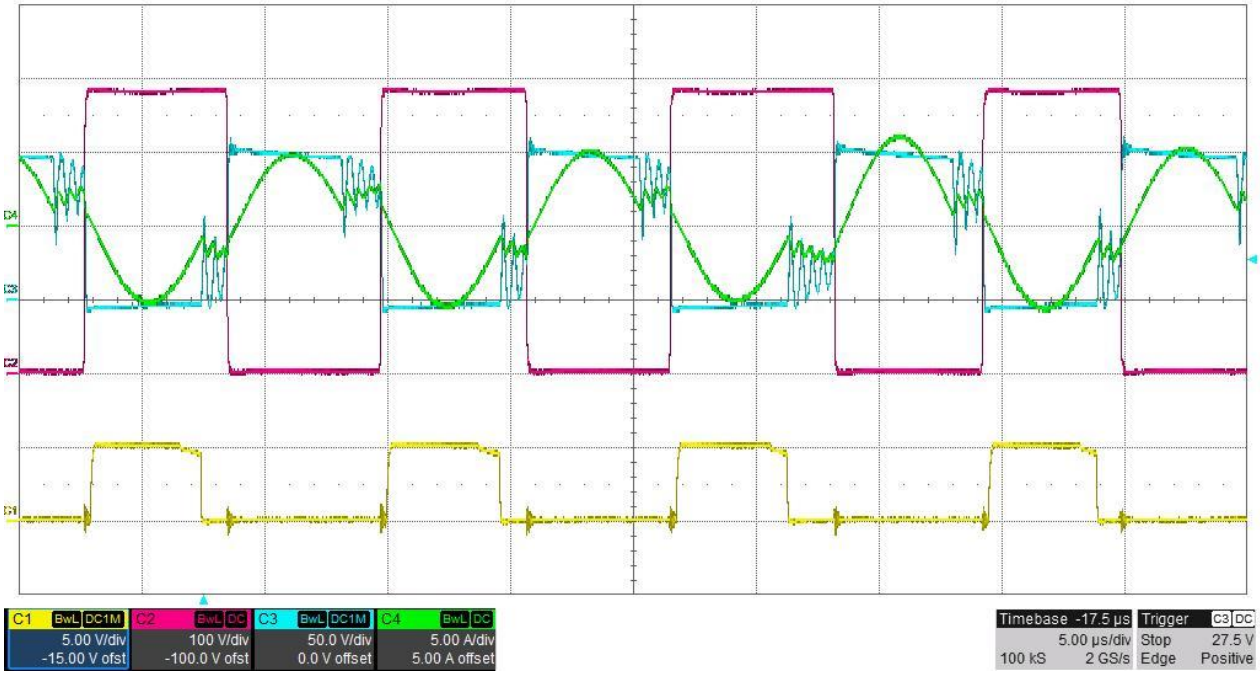
### 2.9.1 Normal operation (380$V_{in}$, 48V/0.1A)

C1: $V_{G\ SR2}$, C2: Q106_$V_{DS}$, C3: $V_{D\ SR2}$; C4: $I_{pri}$.




### 2.9.2 Normal operation (380$V_{in}$, 48V/11.5A)

C1: $V_{G\ SR2}$, C2: Q106_$V_{DS}$, C3: $V_{D\ SR2}$; C4: $I_{pri}$.





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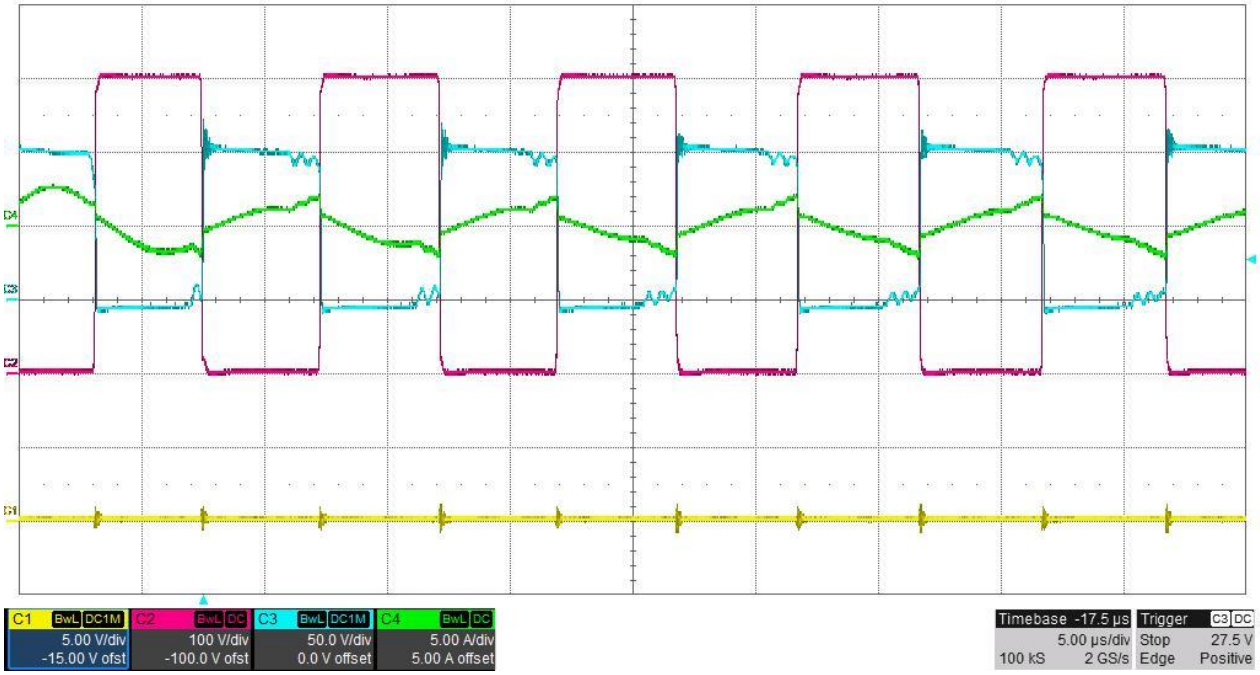
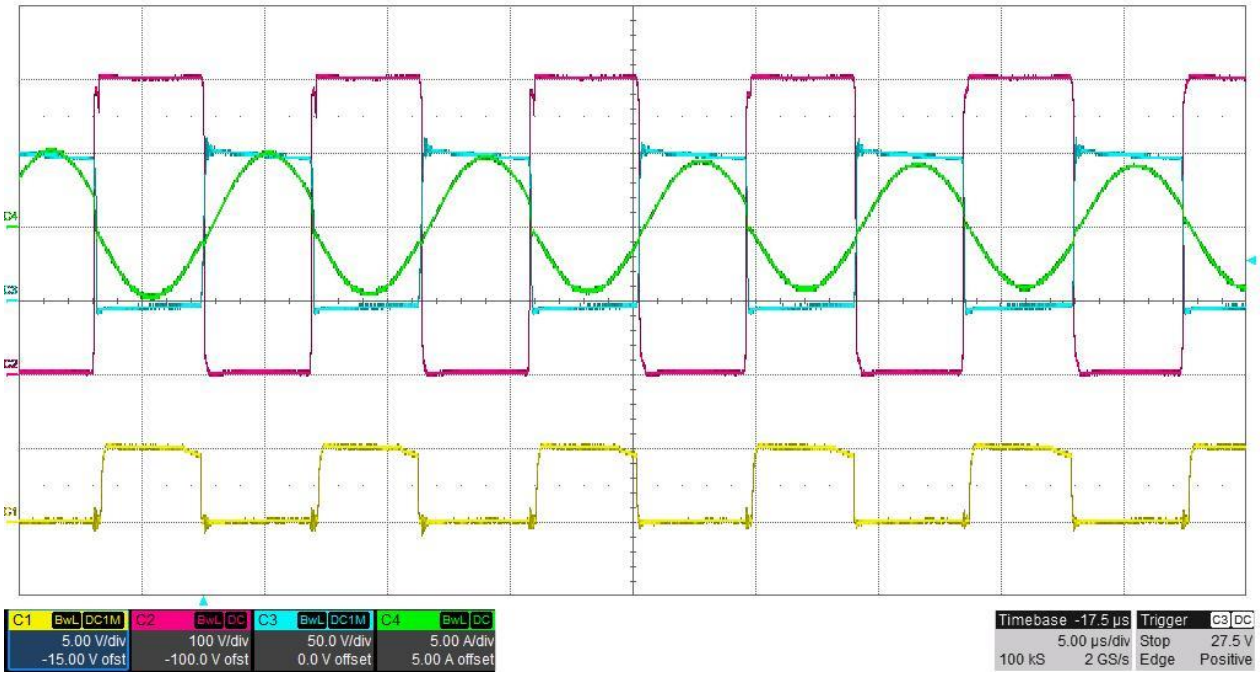
### 2.9.3 Normal operation (400$V_{in}$, 48V/0.1A)

C1: $V_{G\ SR2}$, C2: Q106_$V_{DS}$, C3: $V_{D\ SR2}$; C4: $I_{pri}$.




### 2.9.4 Normal operation (400$V_{in}$, 48V/11.5A)

C1: $V_{G\ SR2}$, C2: Q106_$V_{DS}$, C3: $V_{D\ SR2}$; C4: $I_{pri}$.





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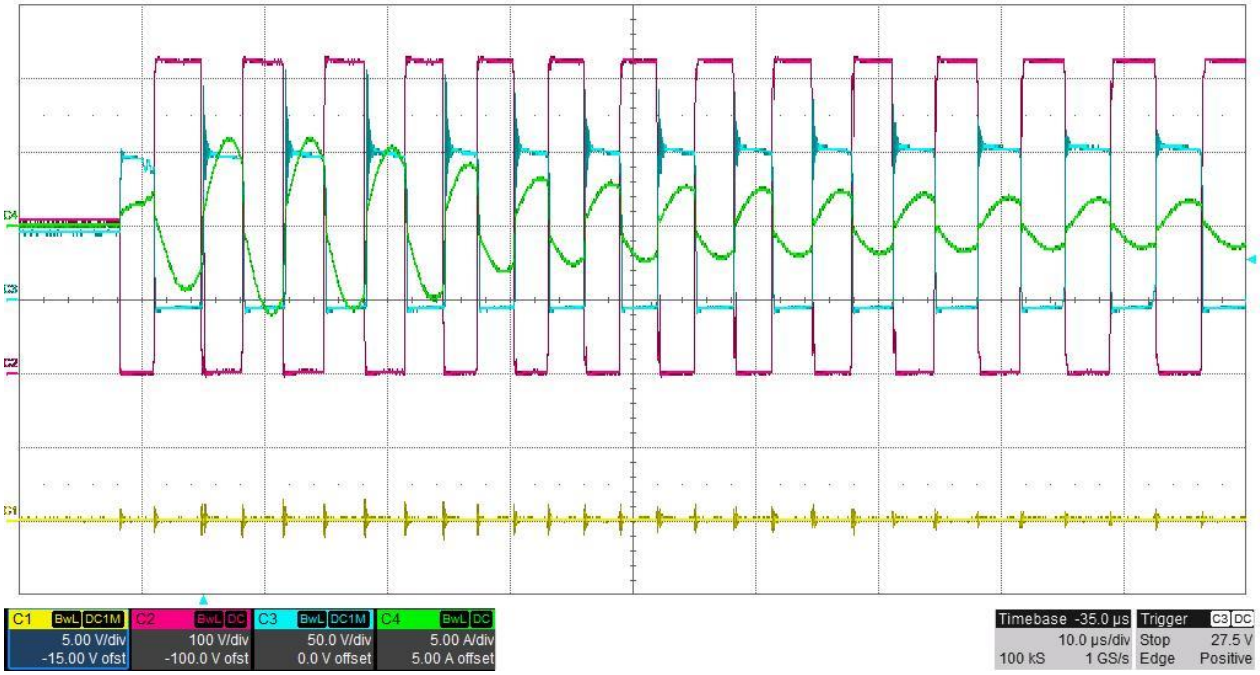
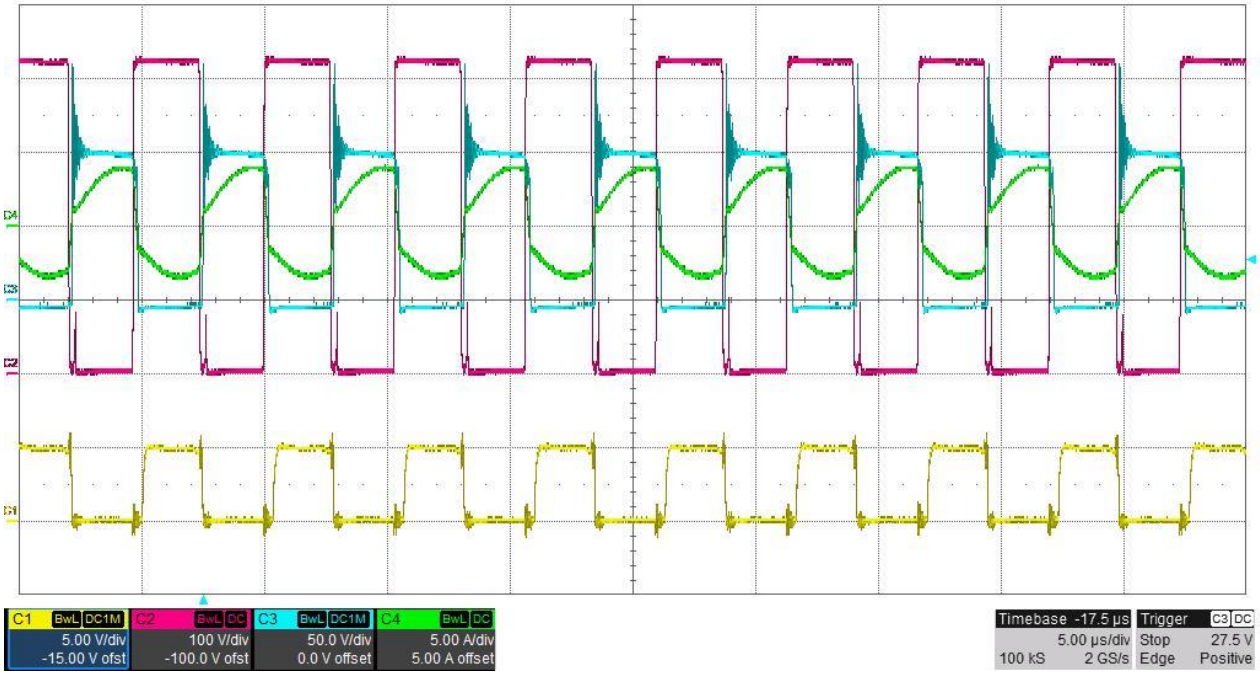
### 2.10 Normal operation ($420V_{in}$, 48V/0.1A)

C1: $V_{G\ SR2}$, C2: Q106_$V_{DS}$, C3: $V_{D\ SR2}$; C4: $I_{pri}$.




### 2.11 Normal operation ($420V_{in}$, 48V/11.5A)

C1: $V_{G\ SR2}$, C2: Q106_$V_{DS}$, C3: $V_{D\ SR2}$; C4: $I_{pri}$.





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