

# Test Report: PMP23463

## 300W Thin Profile LLC Reference Design



### Description

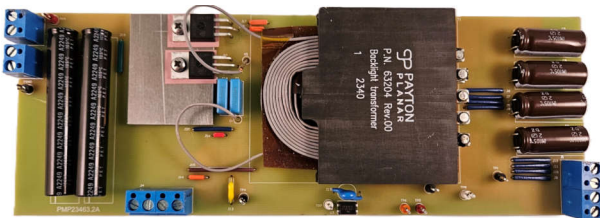
This reference design demonstrates a half-bridge resonant converter on a single copper layer printed circuit board (PCB) that accepts a 385V input and generates an isolated 22.5V output up to 13.5A load. This design is comprised of the UCC256603 half-bridge LLC controller and UCC24612 synchronous rectifier (SR) controller, achieving a peak efficiency of 95.76%. PMP23463 achieves < 1% output ripple at no load and < 3% output voltage deviation during no load to full load transient.

### Features

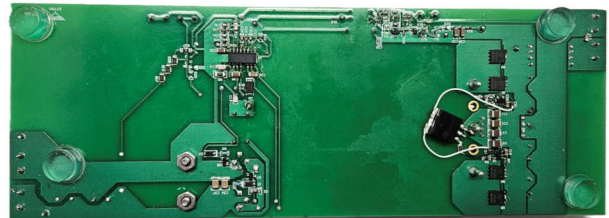
- Single layer PCB
- Less than or equal to 10mm maximum component height
- Less than output voltage deviation during no load to full load transient

### Applications

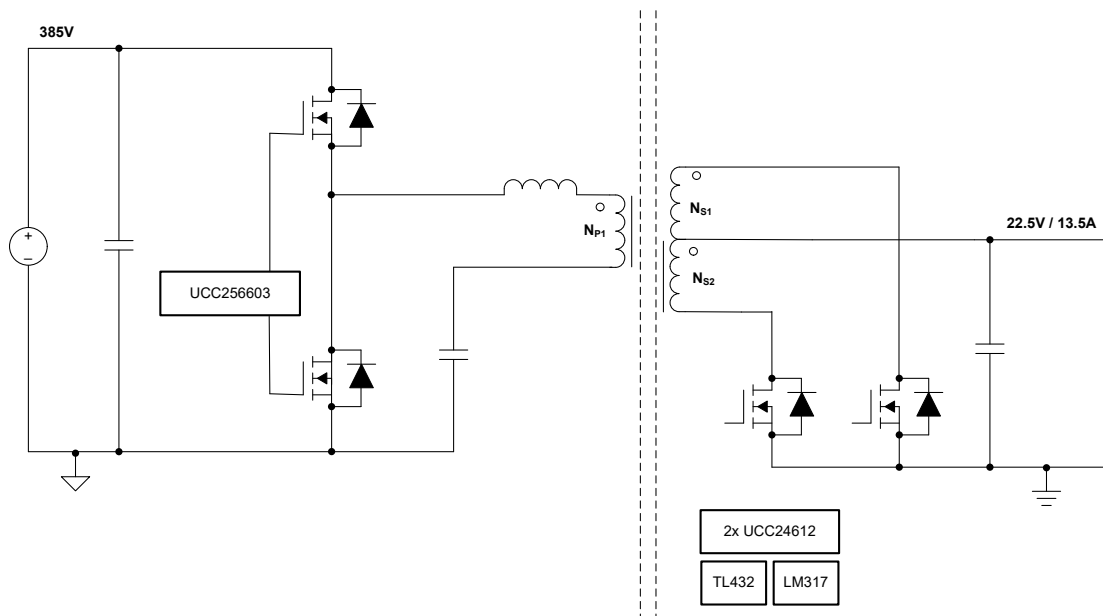
- [SMPS power supply for TV](#)
- [OLED TV](#)
- [Industrial AC-DC](#)



Top of board



Bottom of board



Block Diagram

## 1 Test Prerequisites

### 1.1 Voltage and Current Requirements

**Table 1-1. Voltage and Current Requirements**

PARAMETER	SPECIFICATIONS
Input voltage	350V to 400V
Output voltage	22.5V
Output current	0A to 13.5A
Resonant frequency	168kHz
Loading transient response	±3%

### 1.2 Considerations

**WARNING**

Do not touch the board or the electrical circuits while the board is energized because of high voltages capable of causing an electrical shock hazard. Make sure the high voltage is fully discharged before handling the board.

### 1.3 Dimensions

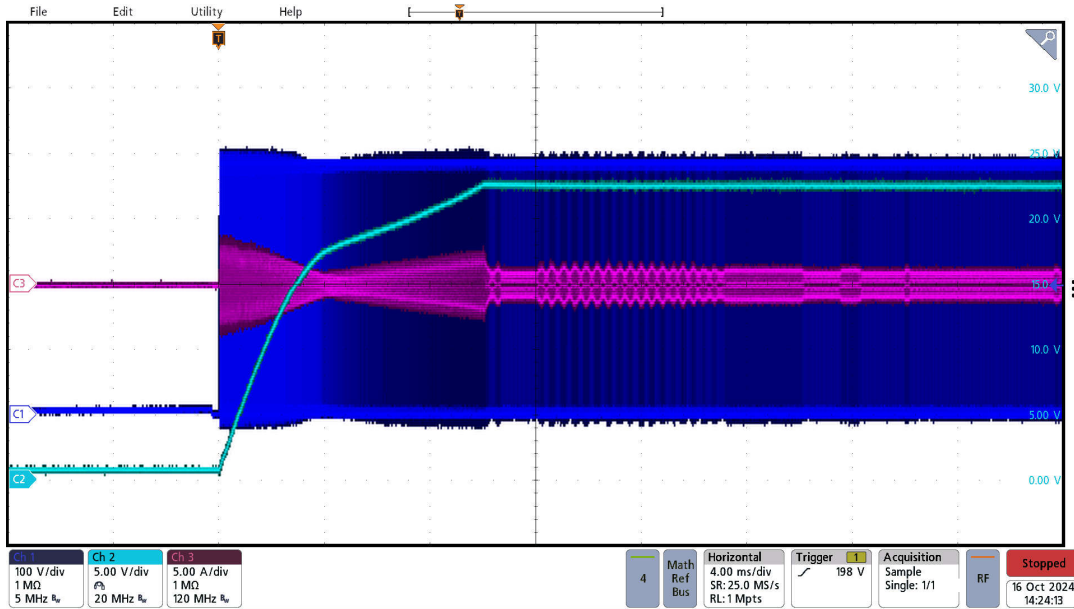
Length × Width × Height: 216mm × 76.2mm × 10mm

## 2 Testing and Results

### 2.1 Waveforms

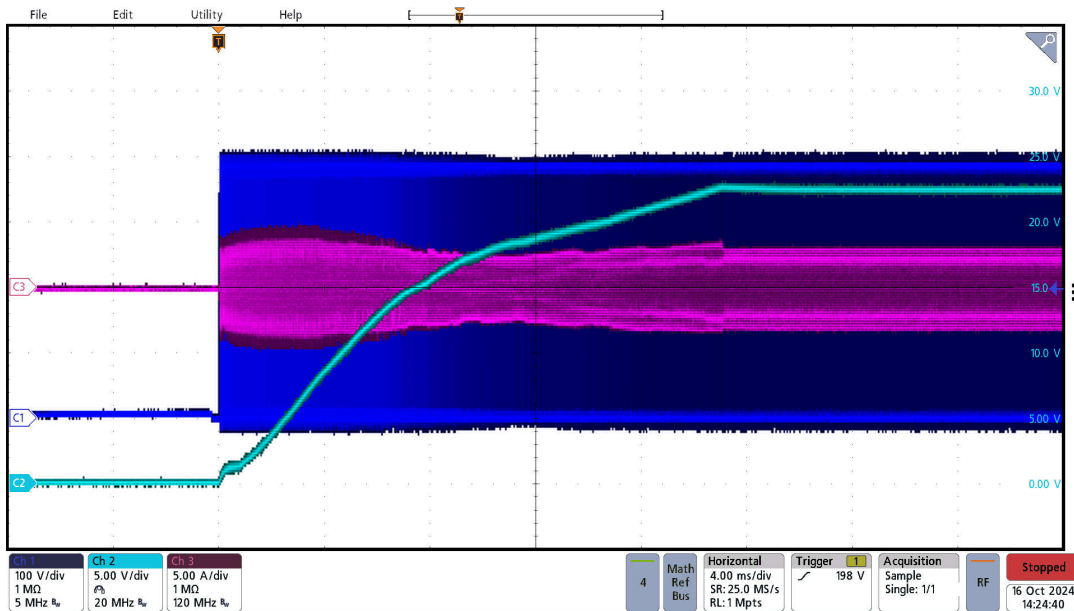
#### 2.1.1 Start-Up

Start-up behavior waveforms are shown in [Figure 2-1](#) and [Figure 2-2](#).



C1 = switch node, C2 =  $V_{out}$ , C3 = resonant current

**Figure 2-1. 385V<sub>in</sub>, No Load**

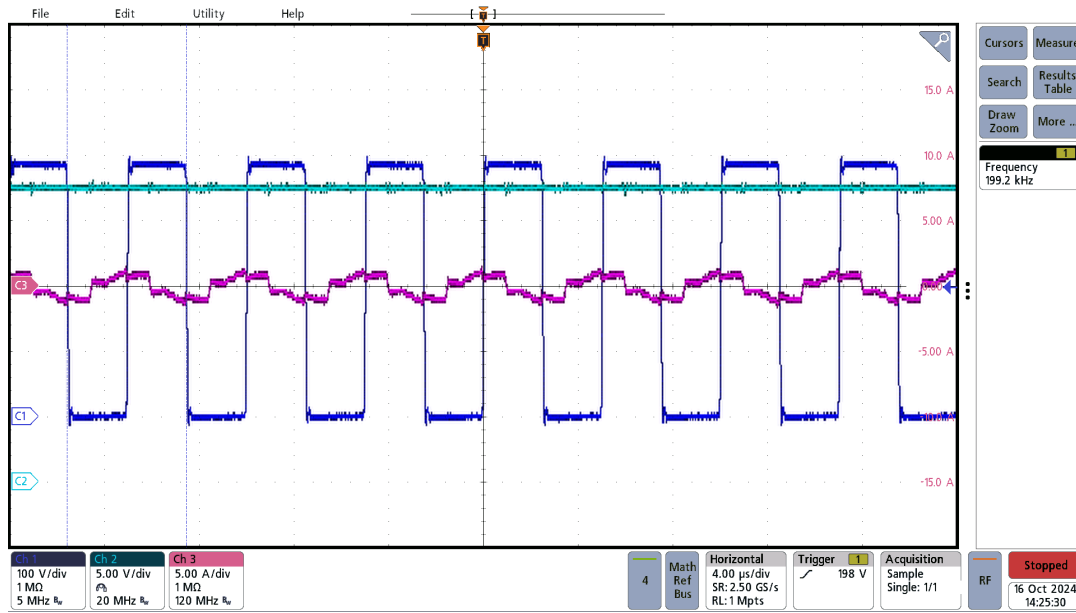


C1 = switch node, C2 =  $V_{out}$ , C3 = resonant current

**Figure 2-2. 385V<sub>in</sub>, full load**

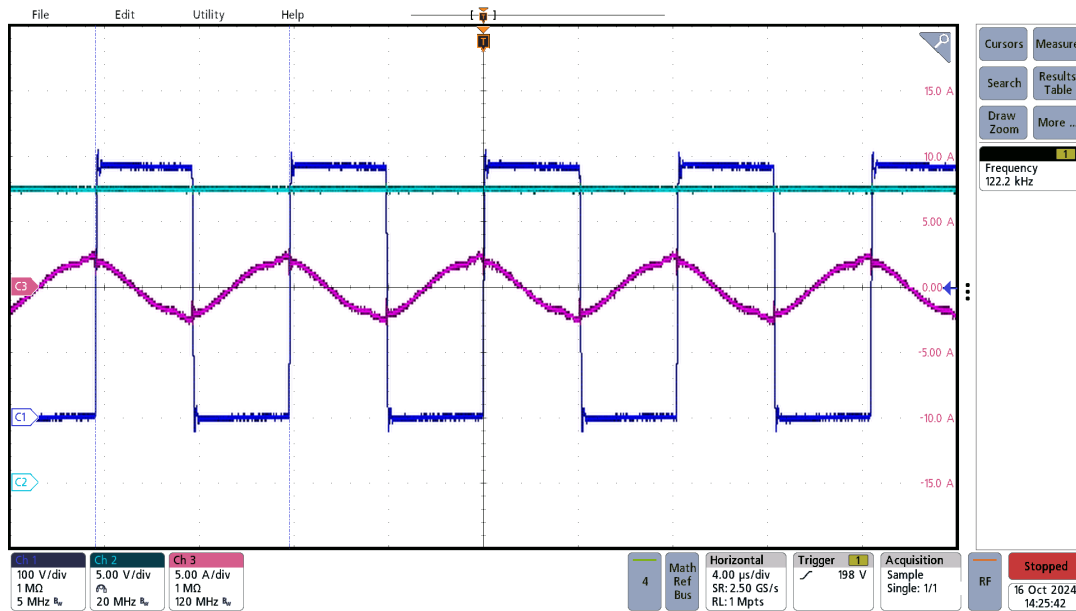
### 2.1.2 Steady State Waveforms

Steady state switching waveforms are shown in Figure 2-3 through Figure 2-7.



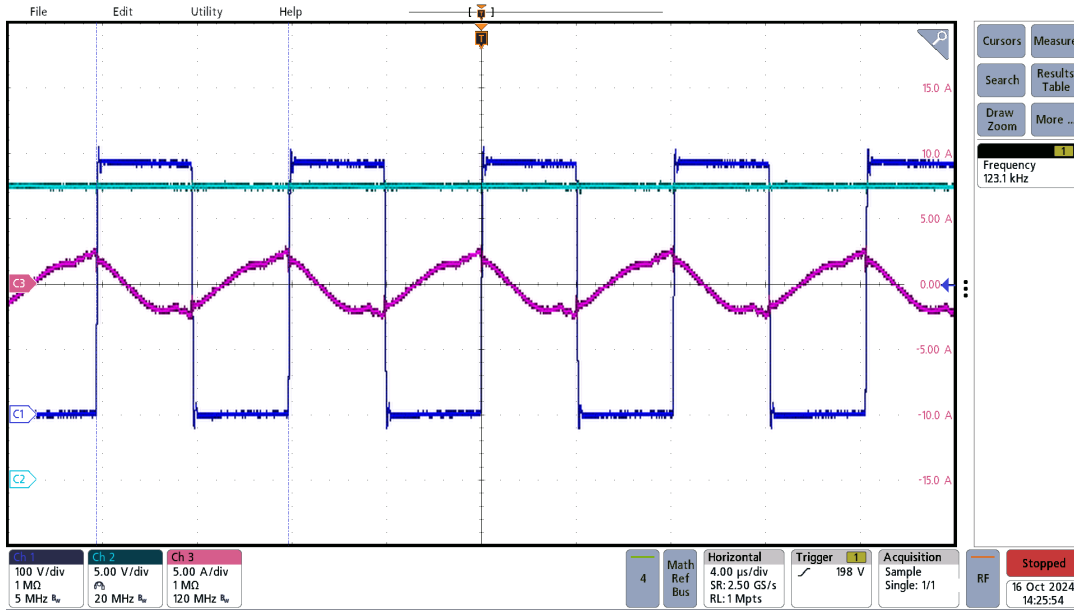
C1 = switch node, C2 = V<sub>out</sub>, C3 = resonant current

Figure 2-3. 385V<sub>in</sub>, No Load



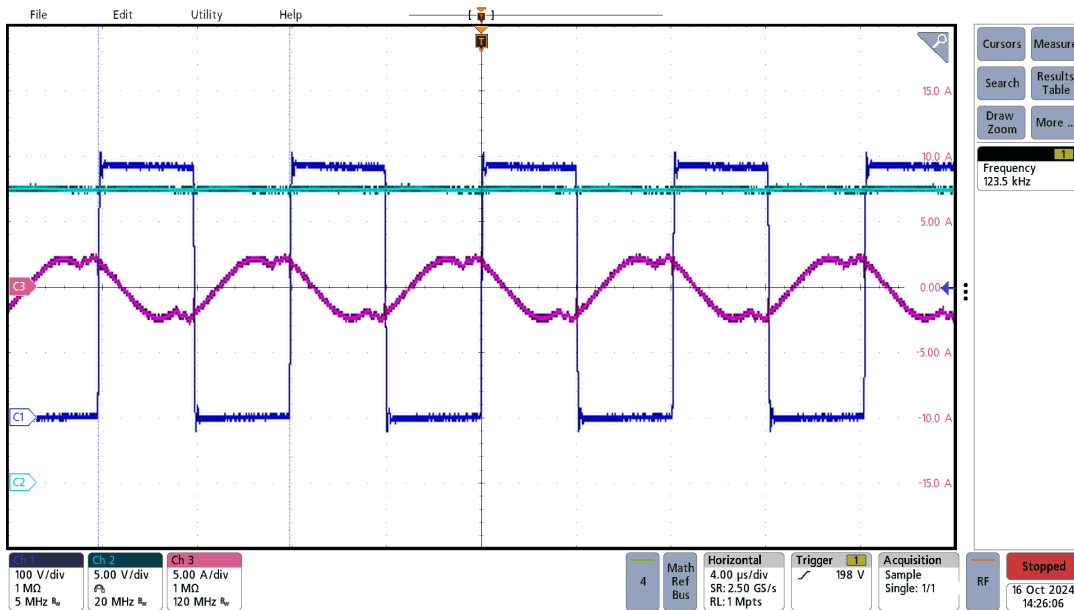
C1 = switch node, C2 = V<sub>out</sub>, C3 = resonant current

Figure 2-4. 385V<sub>in</sub>, 3A Load



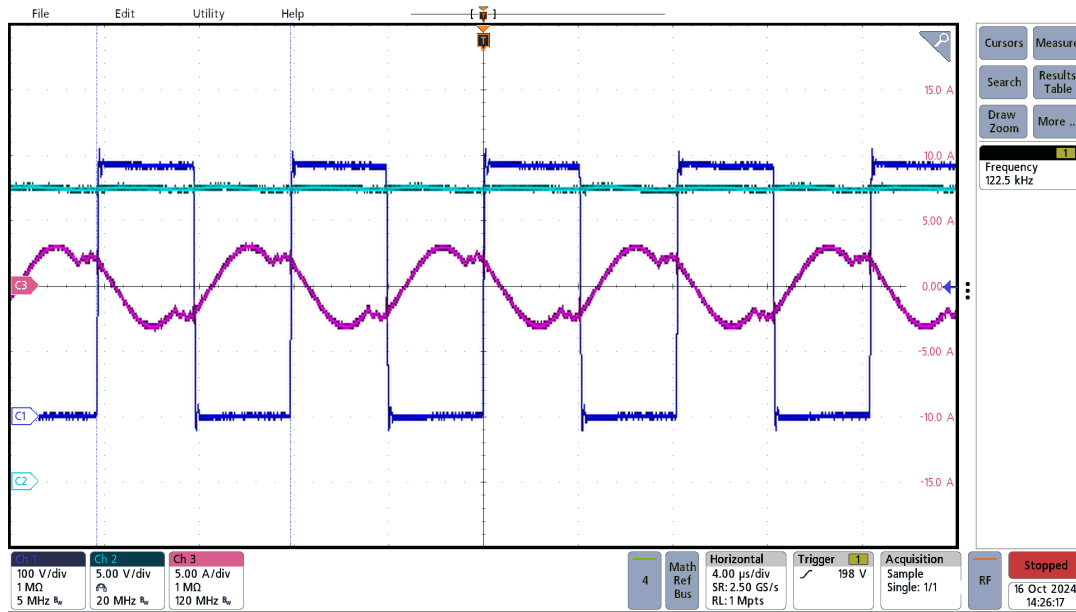
C1 = switch node, C2 =  $V_{out}$ , C3 = resonant current

Figure 2-5. 385V<sub>in</sub>, 6A Load



C1 = switch node, C2 =  $V_{out}$ , C3 = resonant current

Figure 2-6. 385V<sub>in</sub>, 9A Load

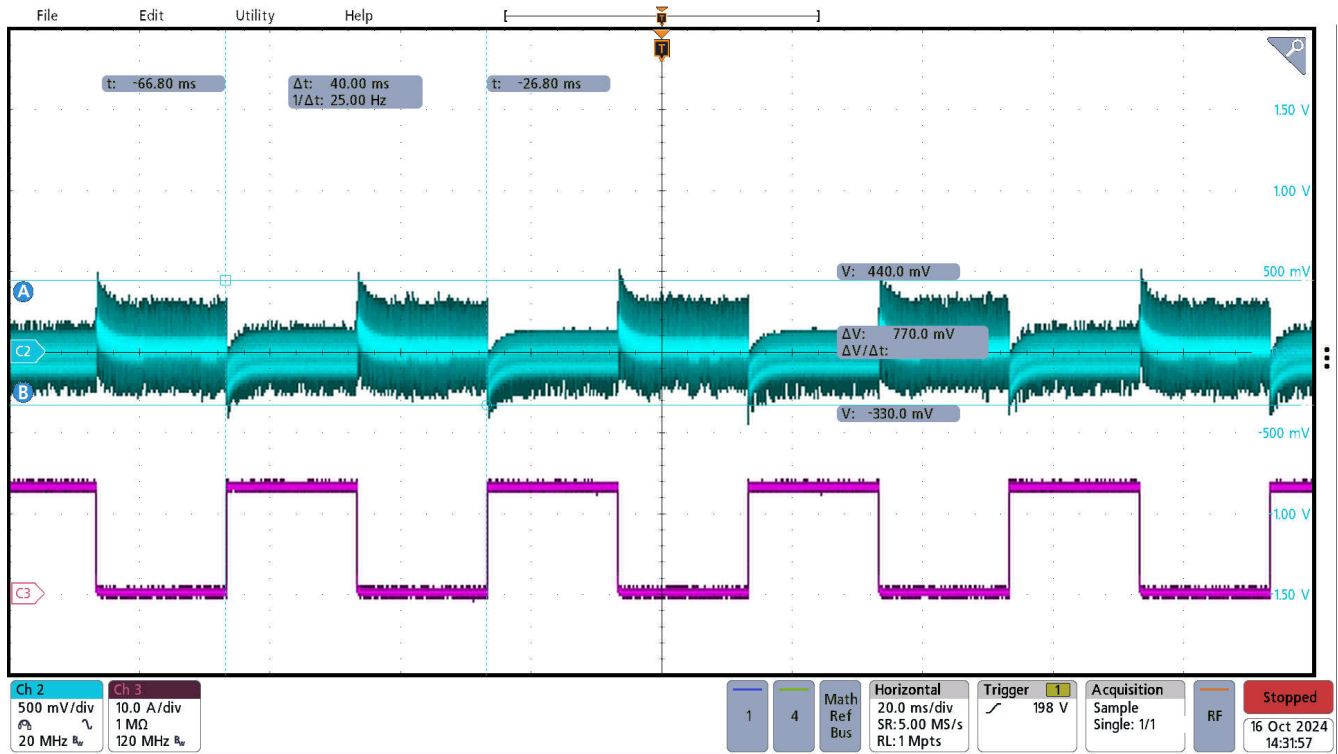


C1 = switch node, C2 =  $V_{out}$ , C3 = resonant current

**Figure 2-7. 385V<sub>in</sub>, 13.5A Load**

### 2.1.3 Load Transient

Figure 2-8 illustrates output voltage deviation under no load to full load transient.



C2 =  $V_{out}$  AC coupled, C4 = output current

Figure 2-8. 25ms 13.5A Load, 25ms 0A Load

### 2.1.4 Output Voltage Ripple

Figure 2-9 and Figure 2-10 illustrate the output voltage ripple of PMP23463, measured with tip and barrel across C12, AC coupled.

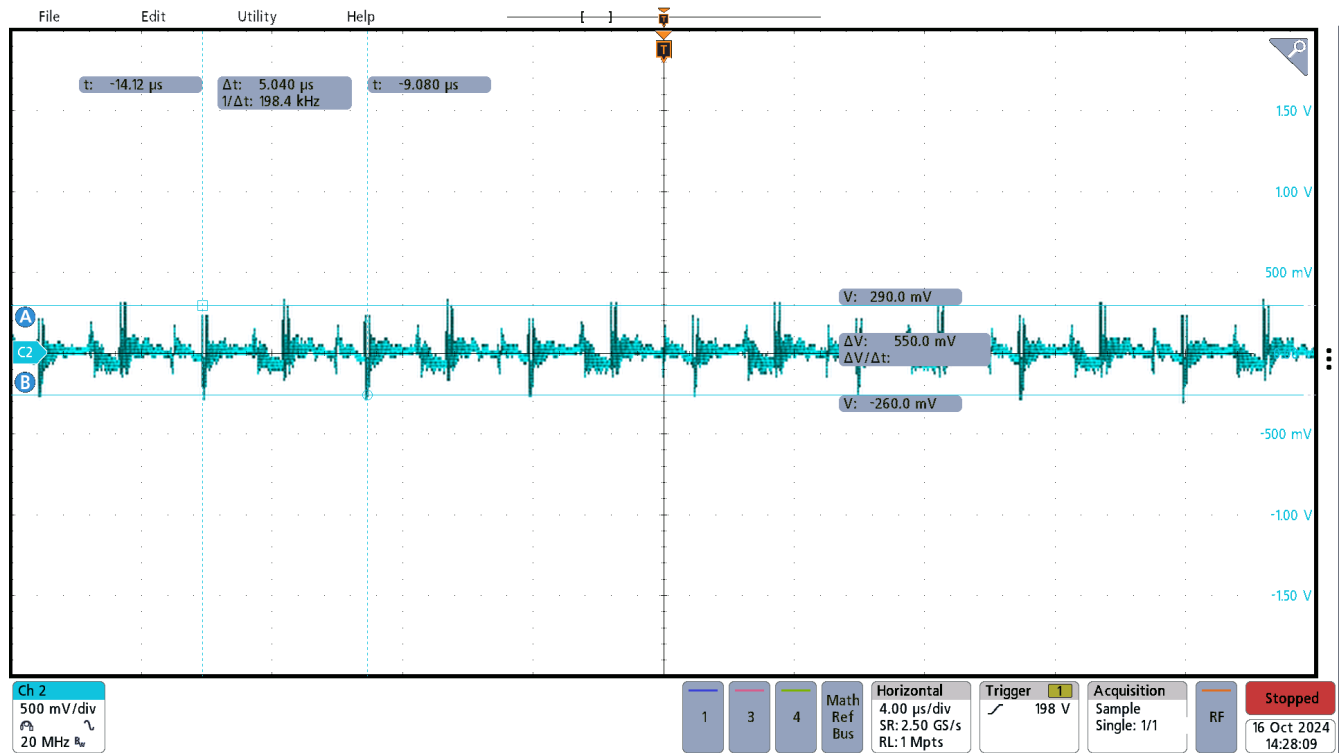


Figure 2-9. Output Ripple, No Load

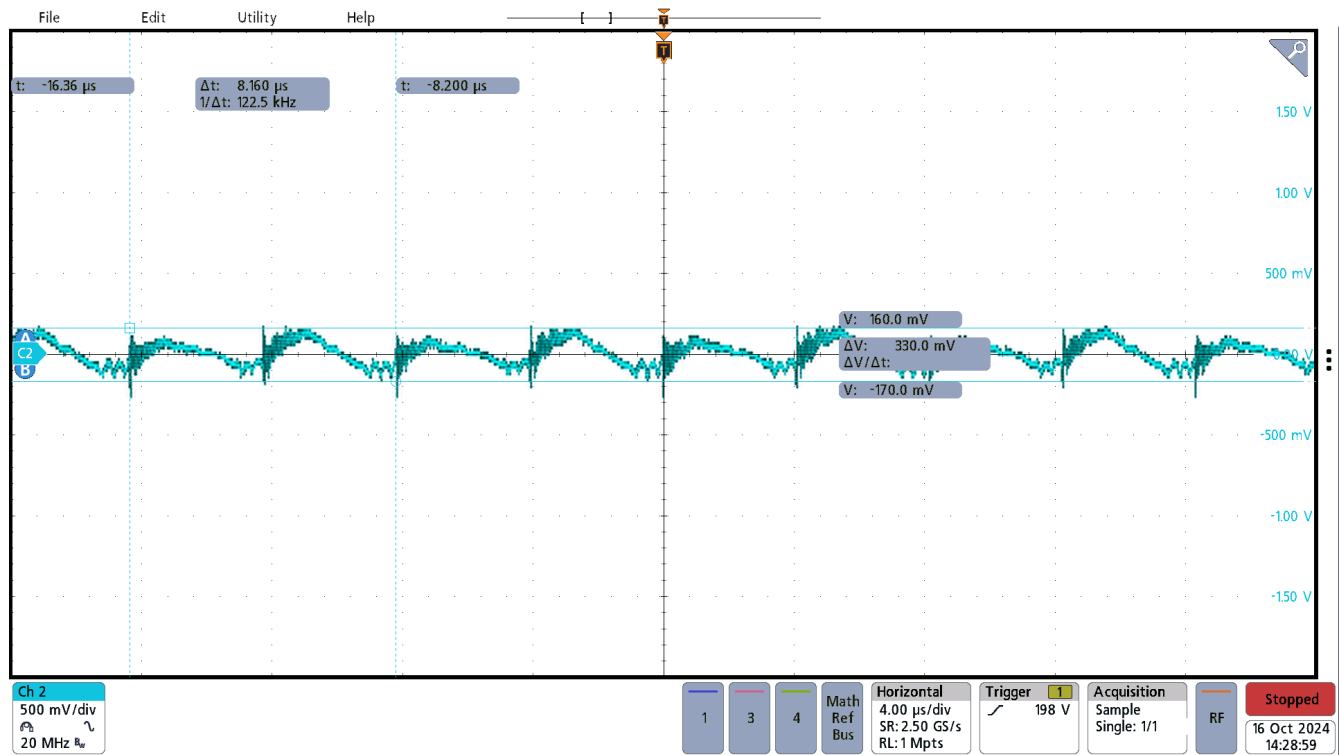


Figure 2-10. Output Ripple, Full Load



## 2.2 Loop Response

Figure 2-11 through Figure 2-13 illustrate the gain and phase margin of the PMP23463 control loop.

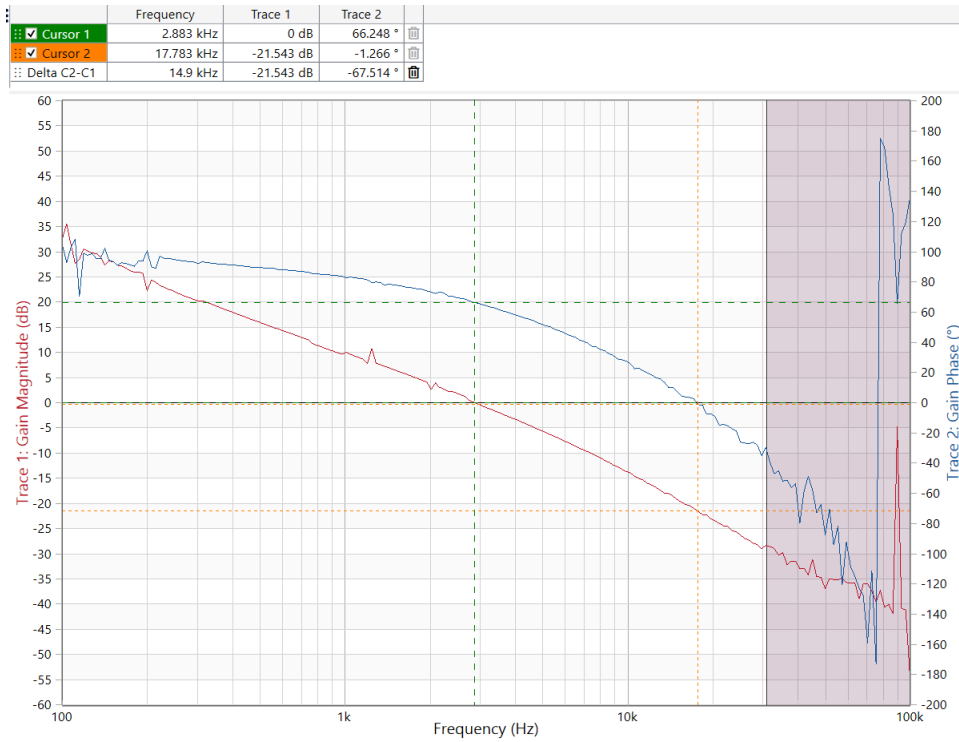


Figure 2-11. 350V<sub>in</sub>, Full Load

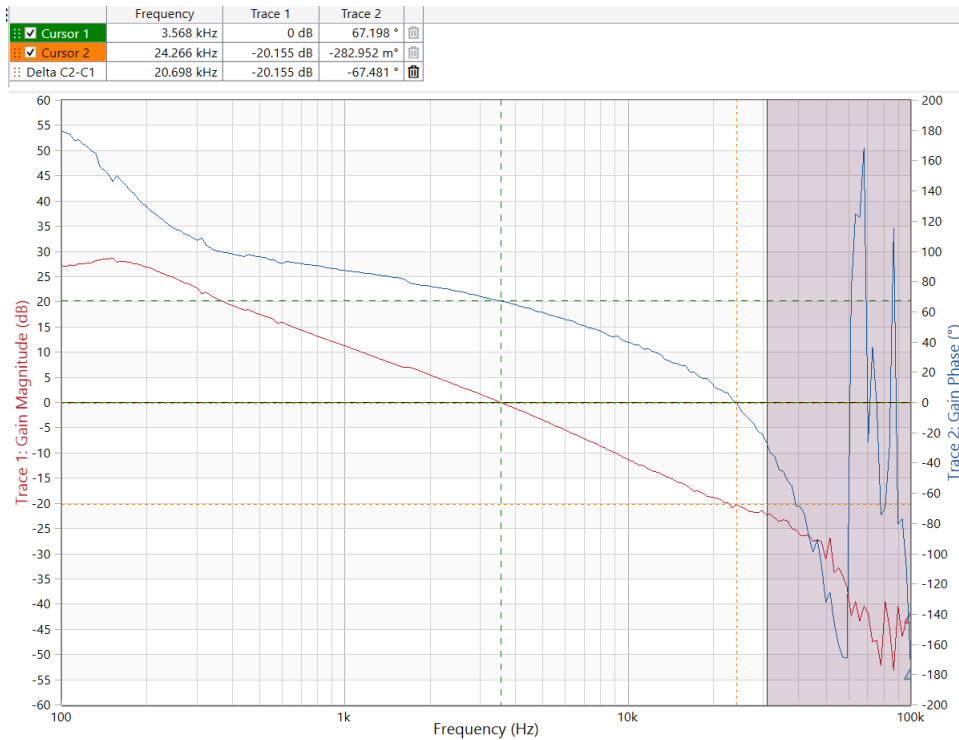
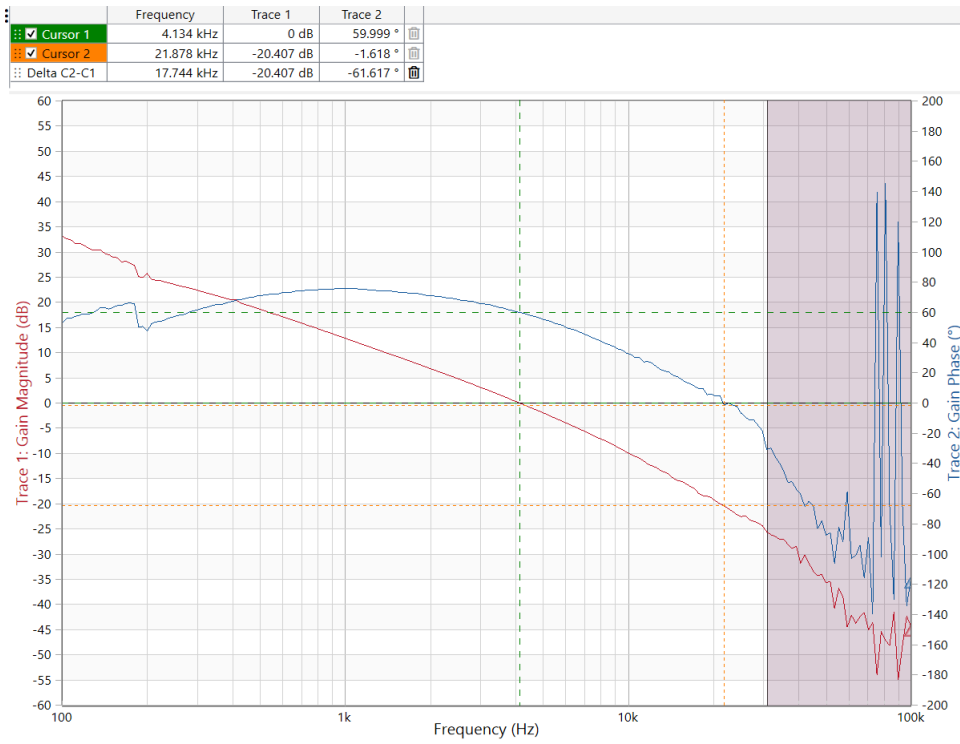


Figure 2-12. 385V<sub>in</sub>, Full Load



**Figure 2-13. 400V<sub>in</sub>, Full Load**

### 2.3 Efficiency

Figure 2-14 illustrates PMP23463 efficiency at different input voltages.

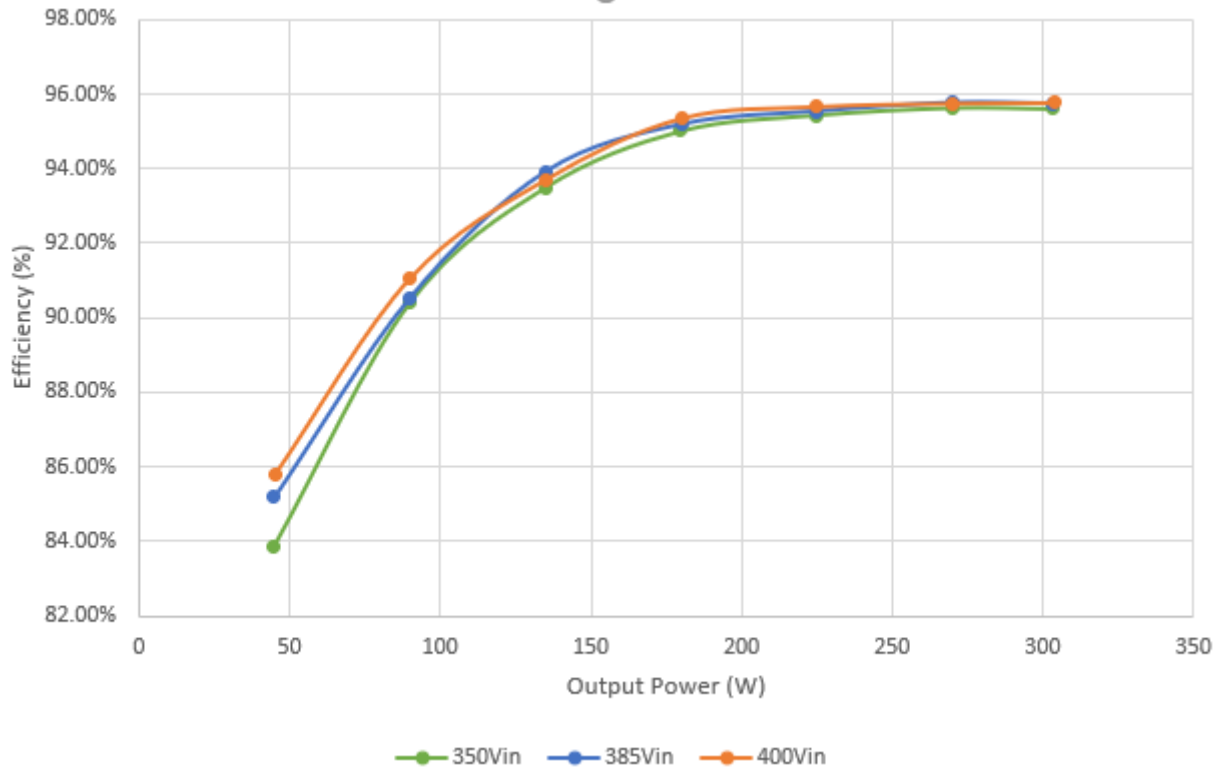


Figure 2-14. Efficiency(%) Versus Load Current (A)

Table 2-1. Efficiency (%) Versus Load Current (A) Data

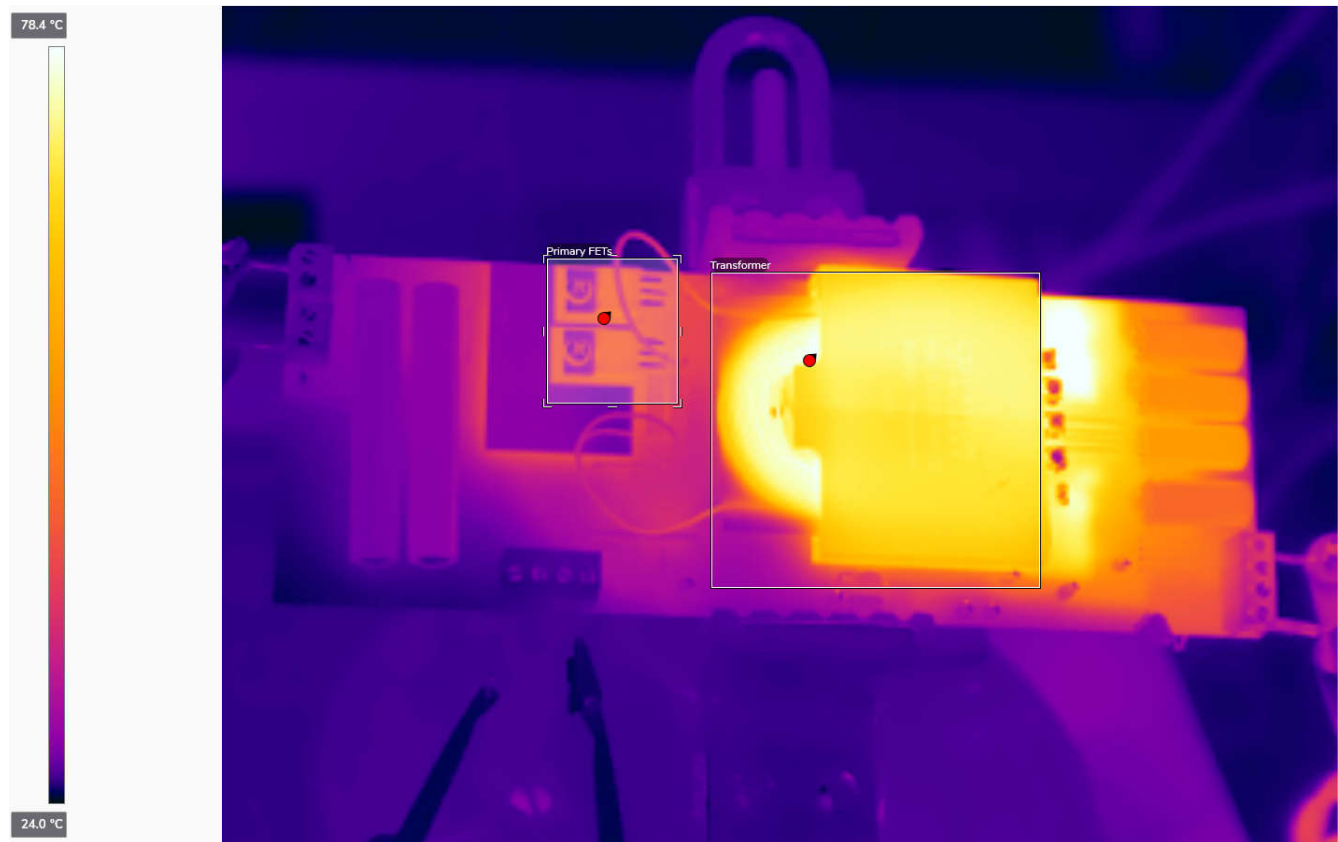
Input Voltage (V)	Input Current (A)	Output Voltage (V)	Output Current (A)	Input Power (W)	Output Power (W)	Efficiency (%)
350	0.153	22.49	1.997	53.55	44.913	83.87%
350	0.284	22.48	3.997	99.40	89.853	90.39%
350	0.412	22.48	5.997	144.20	134.81	93.49%
349.9	0.541	22.49	7.997	189.30	179.85	95.01%
349.9	0.673	22.48	9.997	235.48	224.73	95.43%
349.9	0.806	22.48	11.997	282.02	269.69	95.63%
349.9	0.907	22.48	13.497	317.36	303.41	95.61%
385	0.137	22.50	1.997	52.745	44.933	85.19%
385	0.258	22.50	3.997	99.33	89.933	90.54%
385	0.373	22.49	5.997	143.61	134.87	93.92%
385	0.491	22.50	7.997	189.04	179.93	95.18%
385	0.611	22.48	9.997	235.24	224.73	95.54%
384.9	0.732	22.49	11.997	281.75	269.81	95.76%
384.9	0.823	22.47	13.497	316.77	303.28	95.74%
400	0.131	22.51	1.997	52.40	44.952	85.79%
400	0.247	22.51	3.997	98.80	89.972	91.07%

**Table 2-1. Efficiency (%) Versus Load Current (A) Data (continued)**

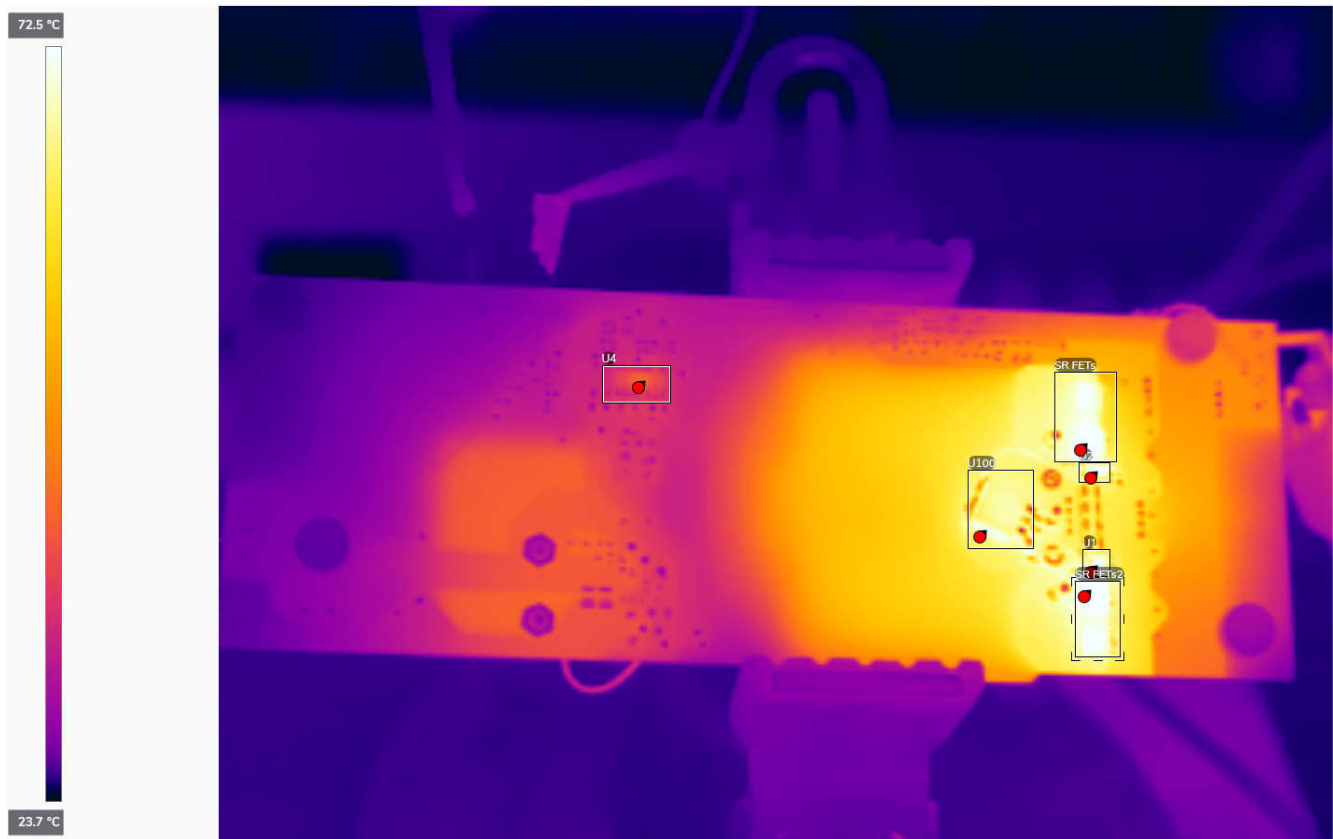
Input Voltage (V)	Input Current (A)	Output Voltage (V)	Output Current (A)	Input Power (W)	Output Power (W)	Efficiency (%)
400	0.360	22.50	5.997	144.00	134.93	93.70%
400	0.472	22.51	7.997	188.80	180.01	95.35%
399.9	0.588	22.50	9.997	235.14	224.93	95.66%
399.9	0.705	22.50	11.997	281.93	269.93	95.74%
399.9	0.793	22.50	13.497	317.12	303.68	95.76%

## 2.4 Thermal Images

Thermal images are shown in [Figure 2-15](#) and [Figure 2-16](#).


**Figure 2-15. 385V<sub>in</sub>, Full Load, Top Side, 20 Minute Soak**
**Table 2-2. Component Temperature, 385V<sub>in</sub>, Full Load, Top Side**

Component	Max Temperature (°C)
Primary MOSFETs (Q3, Q7)	49.8°C
Transformer (T1)	78.6°C



**Figure 2-16. 385V<sub>in</sub>, Full Load, Bottom Side, 20 Minute Soak**

**Table 2-3. Component Temperature, 385V<sub>in</sub>, Full Load, Bottom Side**

Component	Max Temperature (°C)
LLC controller (U4)	44.4°C
LDO to SR controllers (U100)	72.3°C
SR controllers (U1, U2)	78.2°C
Synchronous rectifier MOSFETs (Q1, Q2, Q5, Q6)	77.1°C

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