

10.5-W Nonsynchronous SEPIC Reference Design With Non-coupled Inductors



Description

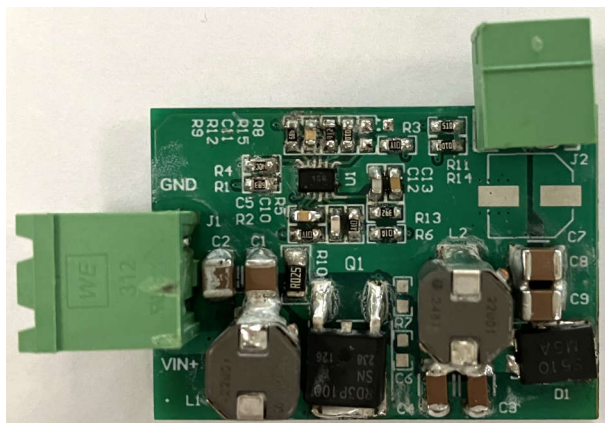
This reference design showcases a nonsynchronous single-ended primary-inductor converter (SEPIC) with non-coupled inductors using the LM51561-Q1 device. The design covers an input voltage range of 6.0 V to 28 V. The output voltage is 21.0 V with a maximum load current of 0.5 A. The design has compact form factor and low cost.

Features

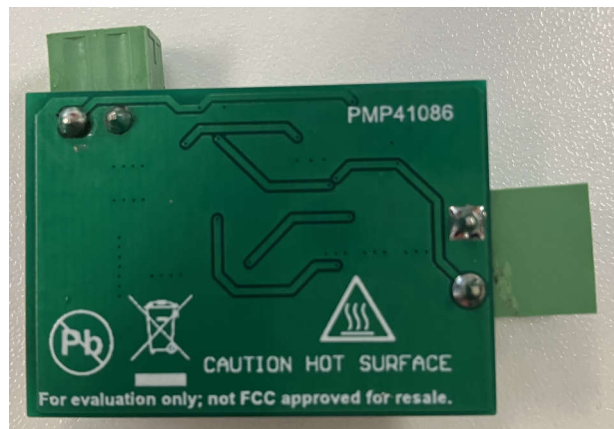
- Nonsynchronous SEPIC design with non-coupled inductors
- Wide input voltage range from 6 V to 28 V
- Compact form factor and low-cost design

Applications

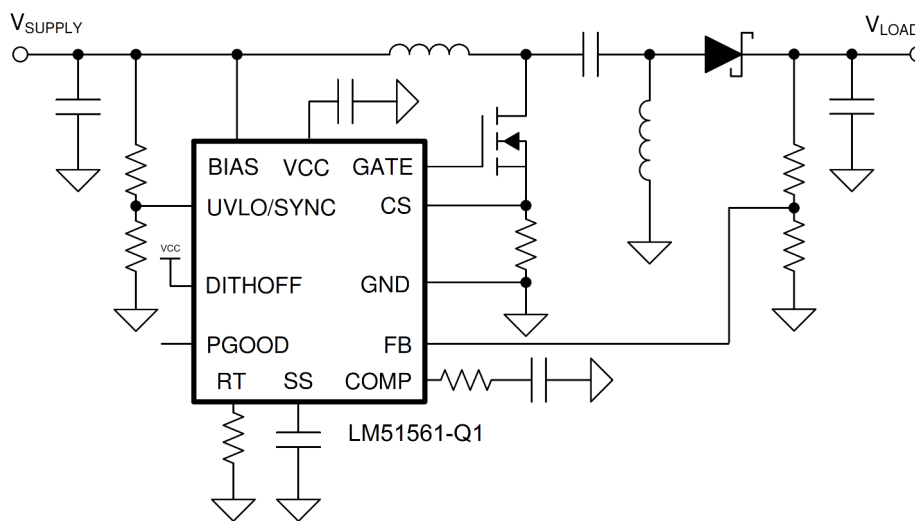
- [Traction inverter-low voltage](#)



Top Photo



Bottom Photo



Block Diagram

1 Test Prerequisites

1.1 Voltage and Current Requirements

Table 1-1. Voltage and Current Requirements

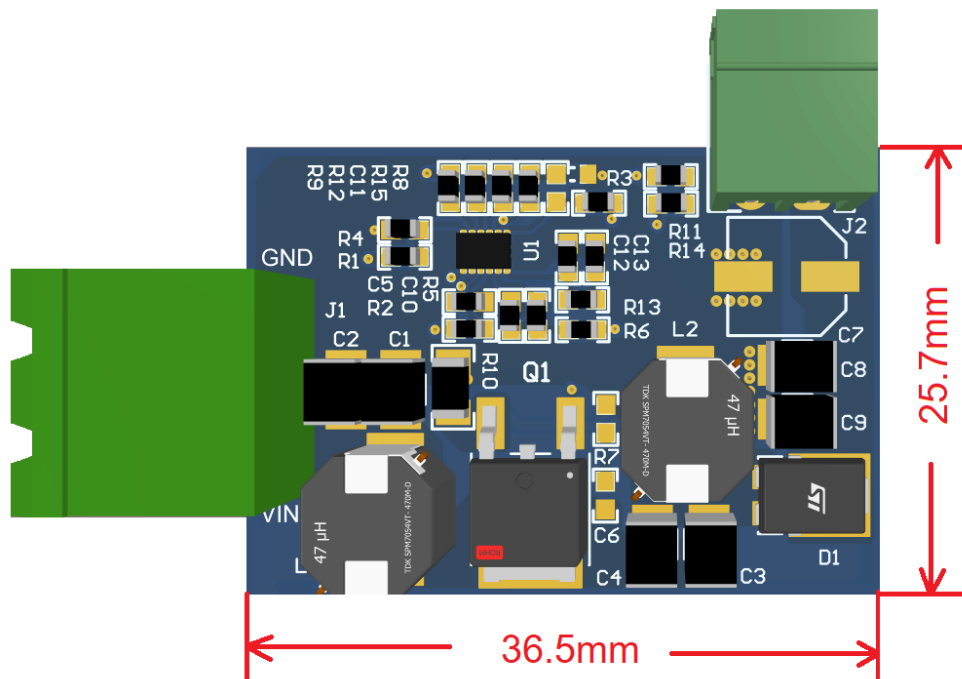
| Parameter | Specifications |
|-----------------------------|----------------|
| Input voltage range | 6 V–28 V DC |
| Output voltage | 21 V |
| Maximum output current | 0.5 A |
| Nominal switching frequency | 400 kHz |

1.2 Required Equipment

- Chroma DC Source 62024P-600-8
- Chroma DC E-load Model 6314A
- Tektronix DPO 3054
- Multimeter: Fluke 287C
- Thermal Camera: Fluke TiS55
- Bode plot measurement: Bode 100

1.3 Dimensions

The board dimensions are 36.5 mm (length) × 25.7 mm (width) × 6 mm (height).



2 Testing and Results

2.1 Efficiency Graphs

Efficiency is shown in the following figure.

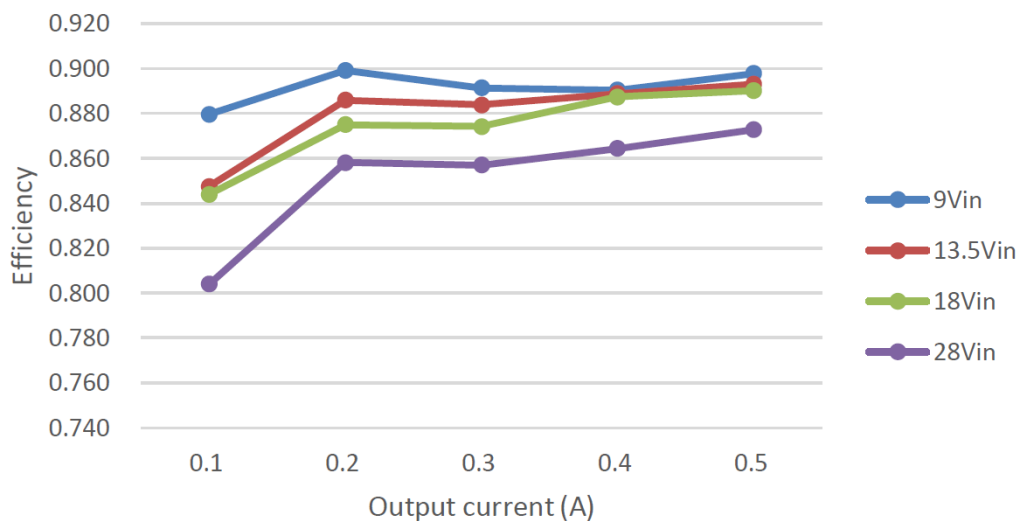


Figure 2-1. Efficiency Graph

2.2 Efficiency Data

Efficiency data is shown in the following table.

| V _{IN} (V) | I _{IN} (A) | V _O (V) | I _O (A) | P _{loss} (W) | Efficiency % |
|---------------------|---------------------|--------------------|--------------------|-----------------------|--------------|
| 9.013 | 0.287 | 21.098 | 0.108 | 0.31 | 0.880 |
| 8.958 | 0.521 | 21.096 | 0.199 | 0.47 | 0.899 |
| 9.053 | 0.789 | 21.099 | 0.302 | 0.78 | 0.891 |
| 8.993 | 1.031 | 21.11 | 0.391 | 1.02 | 0.890 |
| 8.914 | 1.311 | 21.11 | 0.497 | 1.19 | 0.898 |
| 13.482 | 0.170 | 21.103 | 0.092 | 0.35 | 0.848 |
| 13.422 | 0.353 | 21.101 | 0.199 | 0.54 | 0.886 |
| 13.499 | 0.534 | 21.103 | 0.302 | 0.84 | 0.884 |
| 13.549 | 0.687 | 21.109 | 0.392 | 1.04 | 0.889 |
| 13.499 | 0.870 | 21.109 | 0.497 | 1.26 | 0.893 |
| 18.048 | 0.129 | 21.109 | 0.093 | 0.36 | 0.844 |
| 18.012 | 0.266 | 21.11 | 0.199 | 0.60 | 0.875 |
| 17.975 | 0.404 | 21.106 | 0.301 | 0.91 | 0.874 |
| 17.942 | 0.520 | 21.109 | 0.392 | 1.05 | 0.887 |
| 17.904 | 0.661 | 21.109 | 0.499 | 1.30 | 0.890 |
| 28.009 | 0.087 | 21.11 | 0.093 | 0.48 | 0.804 |
| 27.786 | 0.176 | 21.11 | 0.199 | 0.69 | 0.858 |
| 27.99 | 0.264 | 21.11 | 0.300 | 1.06 | 0.857 |
| 27.889 | 0.344 | 21.11 | 0.393 | 1.30 | 0.864 |
| 27.951 | 0.430 | 21.11 | 0.497 | 1.53 | 0.873 |

2.3 Thermal Images

The thermal images are shown in the following figures.

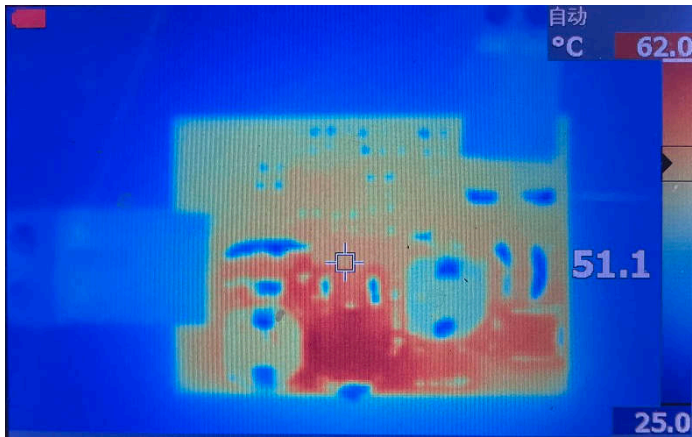


Figure 2-2. Thermal Image, $V_{IN} = 9\text{ V}$, $I_{OUT} = 0.5\text{ A}$

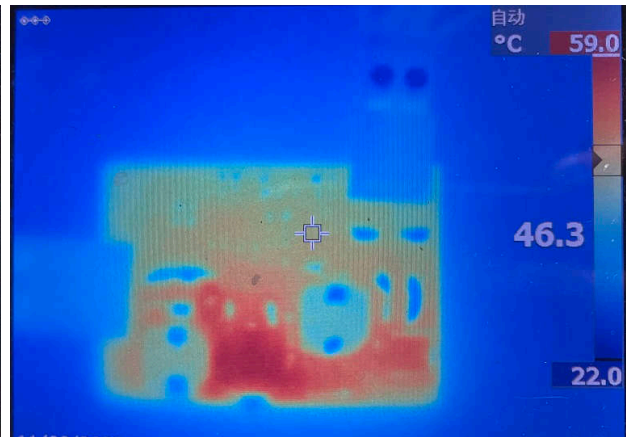


Figure 2-3. Thermal Image, $V_{IN} = 13.5\text{ V}$, $I_{OUT} = 0.5\text{ A}$

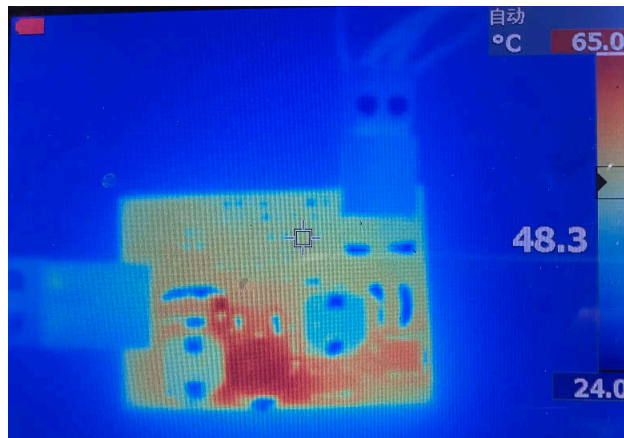
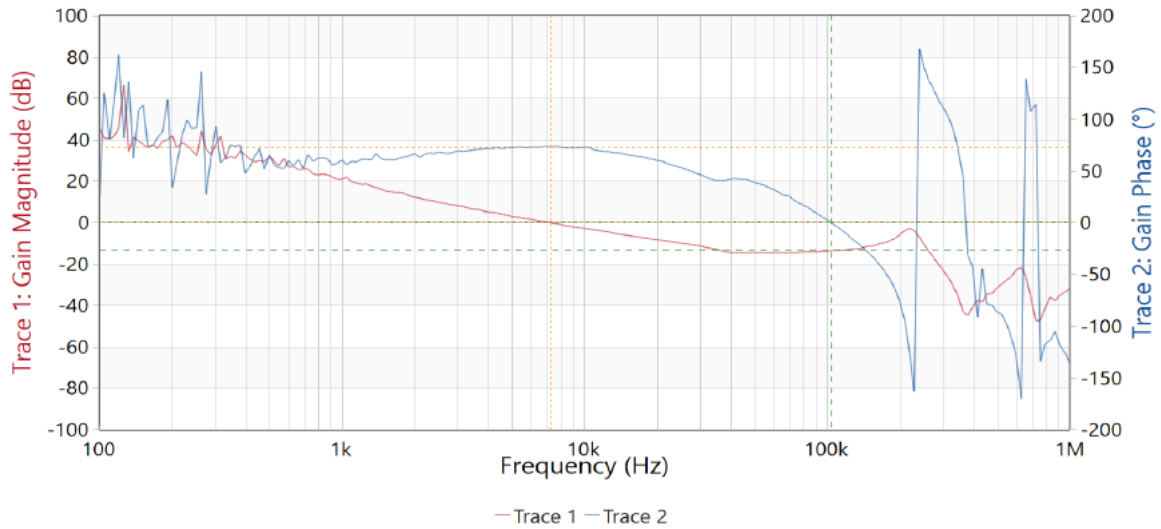


Figure 2-4. Thermal Image, $V_{IN} = 28\text{ V}$, $I_{OUT} = 0.5\text{ A}$

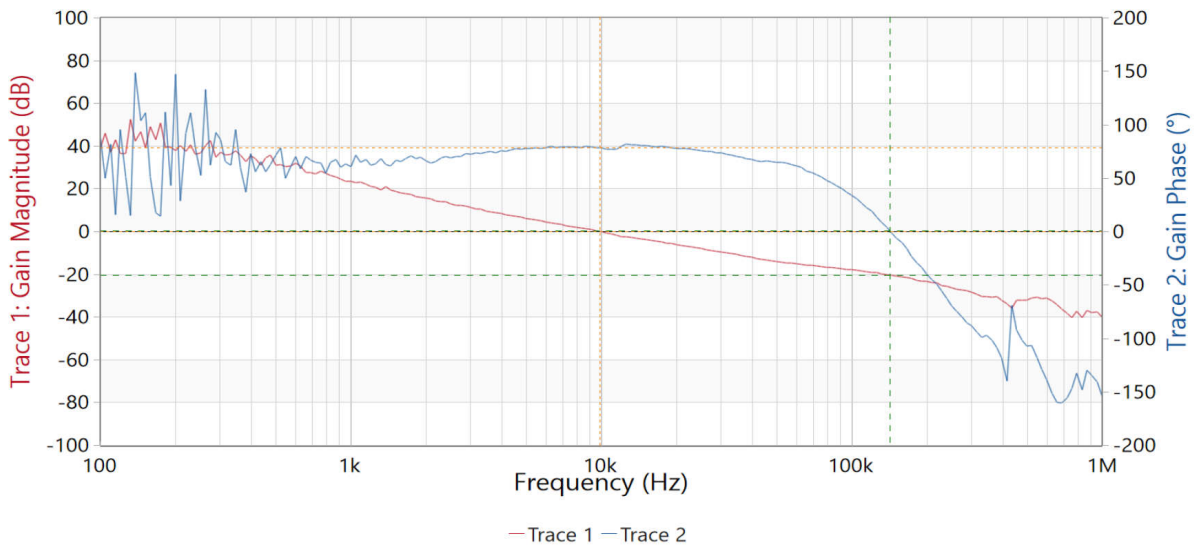
2.4 Bode Plots

Bode plots are shown in the following figures.



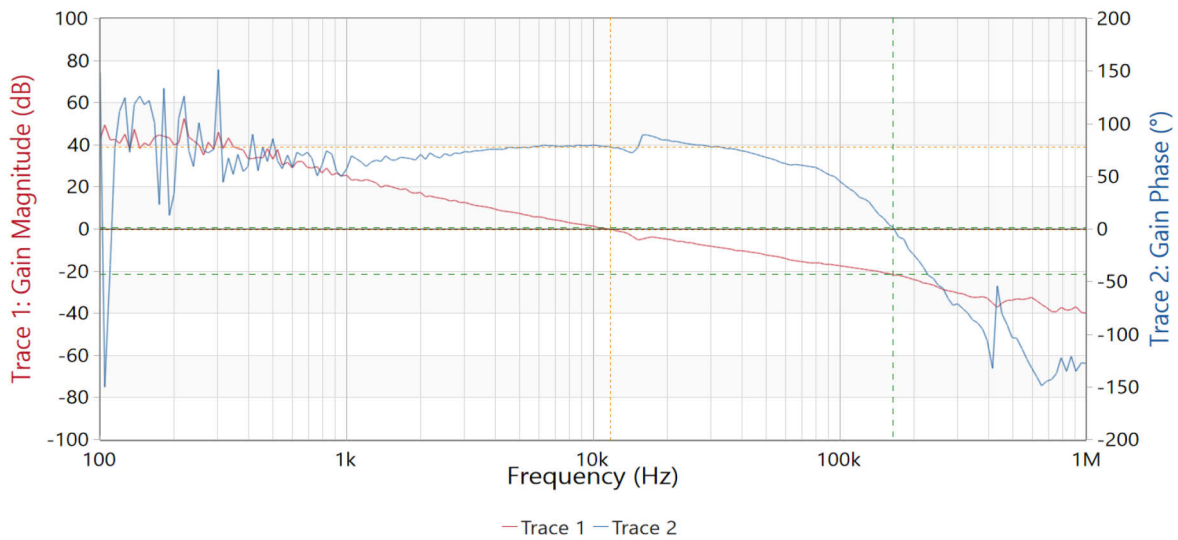
| | Cursor 1 | Cursor 2 | Delta C2-C1 |
|----------------|-----------------------|-----------------------|-----------------------|
| Frequency | 103.896 kHz | 7.226 kHz | -96.669 kHz |
| Trace 1 | Magnitude (dB) | Magnitude (dB) | Magnitude (dB) |
| Measurement | -13.417 dB | -123.03 mdB | 13.294 dB |
| Trace 2 | Phase (°) | Phase (°) | Phase (°) |
| Measurement | 19.358 m° | 73.241 ° | 73.222 ° |

Figure 2-5. Bode Plot, $V_{IN} = 6\text{ V}$, $I_{OUT} = 0.5\text{ A}$



| | Cursor 1 | Cursor 2 | Delta C2-C1 |
|----------------|-----------------------|-----------------------|-----------------------|
| Frequency | 142.406 kHz | 9.905 kHz | -132.501 kHz |
| Trace 1 | Magnitude (dB) | Magnitude (dB) | Magnitude (dB) |
| Measurement | -20.311 dB | 90.467 mdB | 20.402 dB |
| Trace 2 | Phase (°) | Phase (°) | Phase (°) |
| Measurement | 411.678 m° | 78.329 ° | 77.917 ° |

Figure 2-6. Bode Plot, $V_{IN} = 13.5\text{ V}$, $I_{OUT} = 0.5\text{ A}$



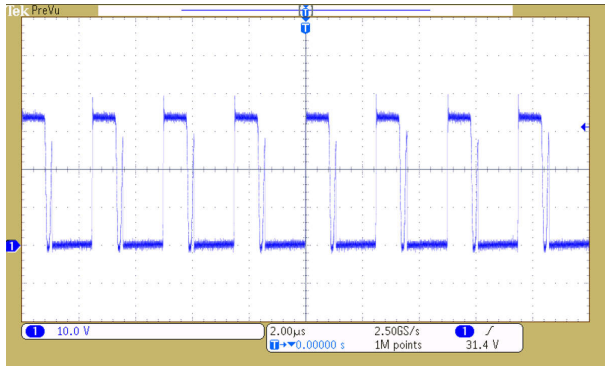
| | Cursor 1 | Cursor 2 | Delta C2-C1 |
|----------------|-----------------------|-----------------------|-----------------------|
| Frequency | 164.349 kHz | 11.764 kHz | -152.586 kHz |
| Trace 1 | Magnitude (dB) | Magnitude (dB) | Magnitude (dB) |
| Measurement | -21.574 dB | -257.348 mdB | 21.317 dB |
| Trace 2 | Phase (°) | Phase (°) | Phase (°) |
| Measurement | 1.206 ° | 77.645 ° | 76.439 ° |

Figure 2-7. Bode Plot, $V_{IN} = 28\text{ V}$, $I_{OUT} = 0.5\text{ A}$

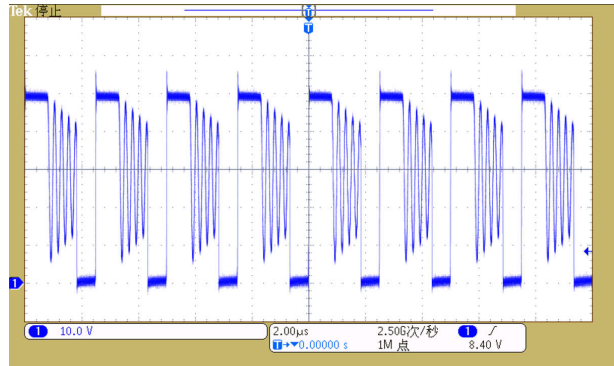
3 Waveforms

3.1 Switching

Switching behavior is shown in the following figures.



**Figure 3-1. Switch-Node Voltage, $V_{IN} = 13.5\text{ V}$,
 $I_{OUT} = 0.5\text{ A}$**



**Figure 3-2. Switch-node voltage, $V_{IN} = 28\text{ V}$,
 $I_{OUT} = 0.5\text{ A}$**

3.2 Output Voltage Ripple

Output voltage ripple is shown in the following figures.

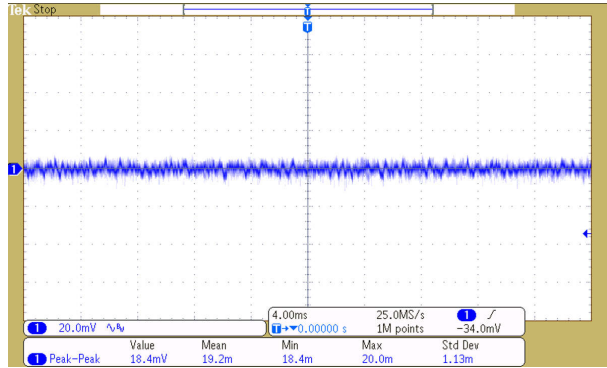


Figure 3-3. Output Voltage Ripple, $V_{IN} = 9\text{ V}$, No Load

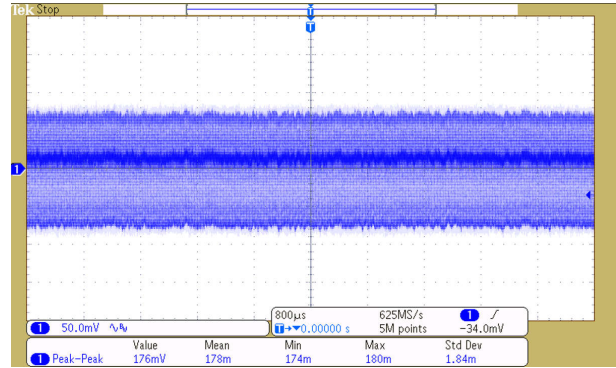


Figure 3-4. Output Voltage Ripple, $V_{IN} = 9\text{ V}$, $I_{OUT} = 0.5\text{ A}$

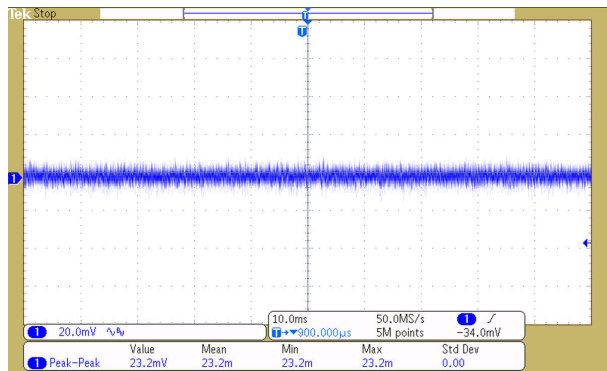


Figure 3-5. Output Voltage Ripple, $V_{IN} = 13.5\text{ V}$, No Load

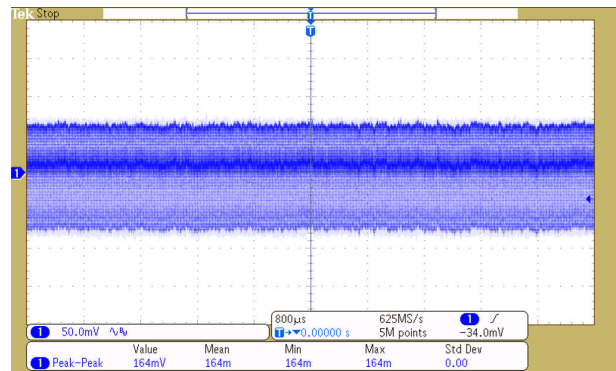


Figure 3-6. Output Voltage Ripple, $V_{IN} = 13.5\text{ V}$, $I_{OUT} = 0.5\text{ A}$

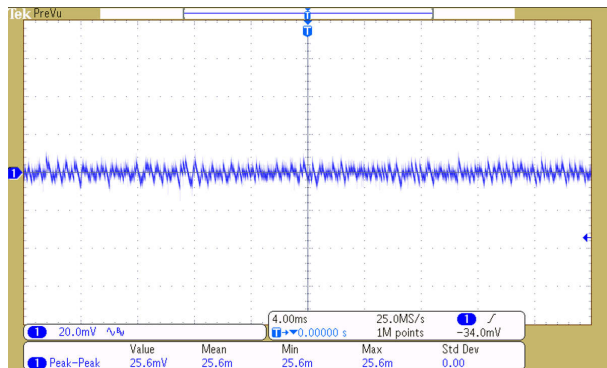


Figure 3-7. Output Voltage Ripple, $V_{IN} = 28\text{ V}$, No Load

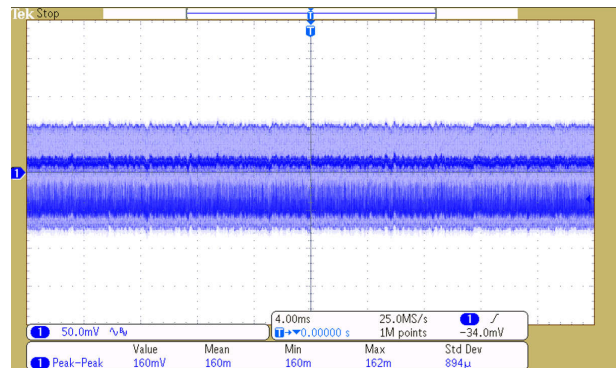


Figure 3-8. Output Voltage Ripple, $V_{IN} = 28\text{ V}$, $I_{OUT} = 0.5\text{ A}$

3.3 Load Transients

Load transient response is shown in the following figures.

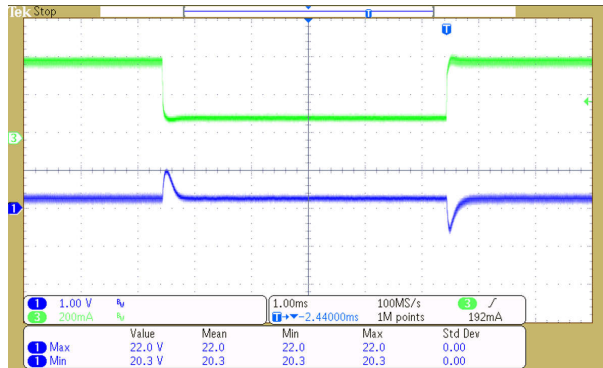


Figure 3-9. 13.5-V Input, 0.1-A to 0.4-A Load Transient, 0.1 A/ μ s

3.4 Start-Up Sequence

Start-up behavior is shown in the following figures.

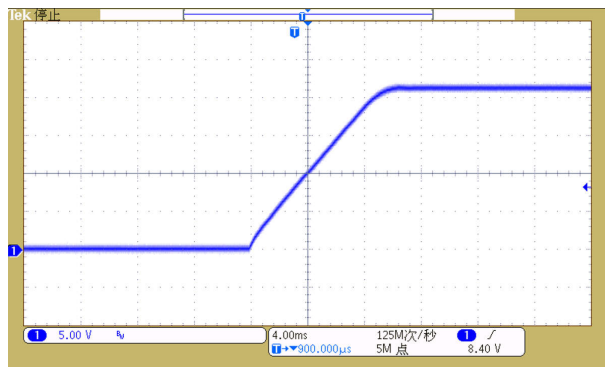


Figure 3-10. Start-Up Waveform, $V_{IN} = 13.5$ V, No Load

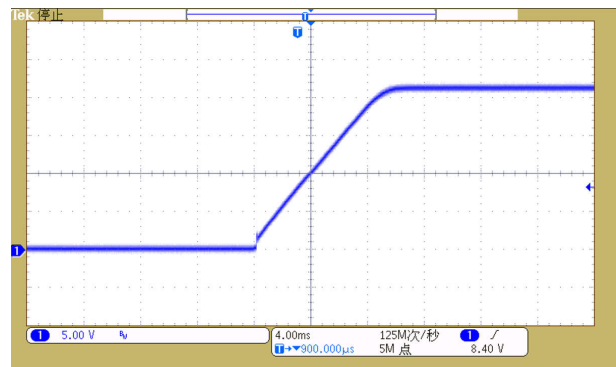


Figure 3-11. Start-Up Waveform, $V_{IN} = 13.5$ V, $I_{OUT} = 0.5$ A

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