

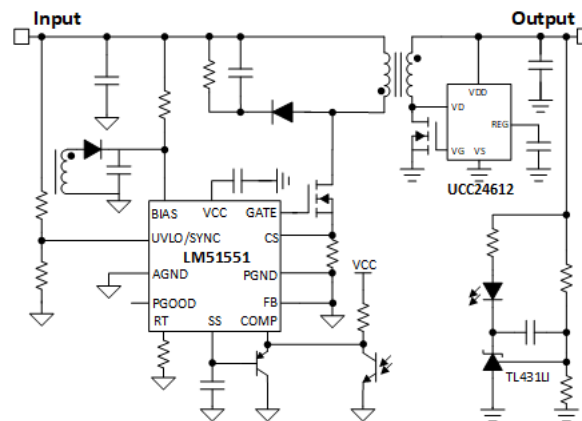
# Test Report: PMP40569

## 36~57-Vdc Input, 5-V/4-A Output Isolated Flyback With Synchronous Rectification Reference Design



### Description

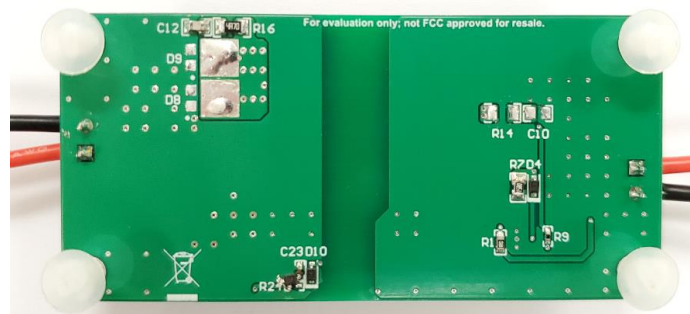
This reference design is a 36~57-Vdc input, 5-V/4-A output isolated flyback converter using LM51551 and UCC24612. The switching frequency is 250 kHz. With the synchronous rectification controller UCC24612 and a MOSFET at the secondary side, the system achieves 89.29% peak efficiency at 36-V input, which is 3.86% higher than Schottky rectification. The temperature of the rectified MOSFET is 33 degrees Celsius lower than Schottky under full load output. The load regulation in the whole input range is within  $\pm 0.5\%$ .



Top View



Bottom View



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## Test Prerequisites

### 1.1 Voltage and Current Requirements

**Table 1. Voltage and Current Requirements**

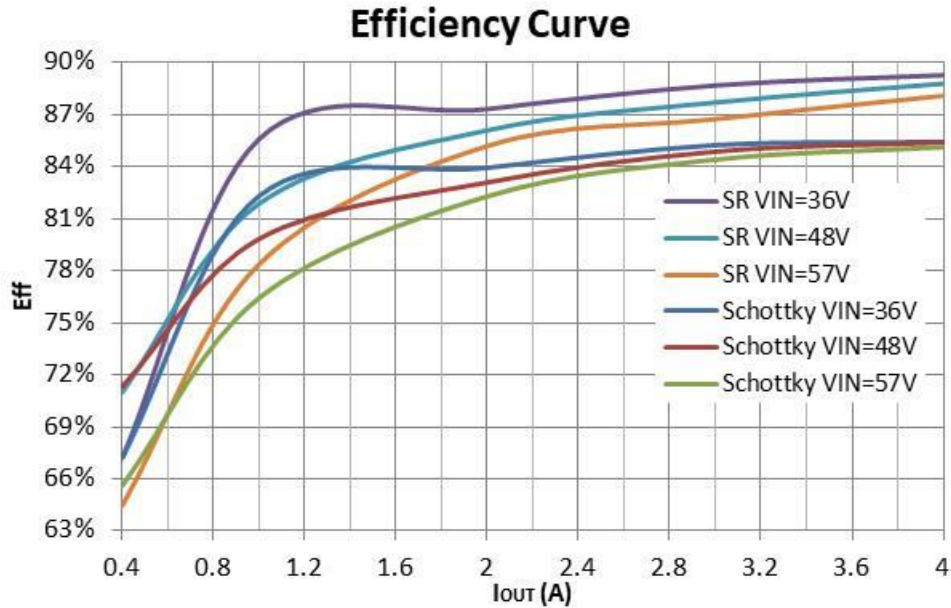
| PARAMETER            | SPECIFICATIONS |
|----------------------|----------------|
| Input Voltage        | 36–57 Vdc      |
| Output Voltage       | 5 Vdc          |
| Rated Output Current | 4 A            |

### 1.2 Required Equipment

- Multi-meter (current): Fluke 287C
- Multi-meter (voltage): Fluke 287C
- DC Source: Chroma 62006P-100-25
- E-Load: Chroma 63105A module
- Oscilloscope: Tektronix DPO3054
- Electrical Thermography: Fluke TiS65

## 2 Testing and Results

### 2.1 Efficiency Graphs



### 2.2 Efficiency Data

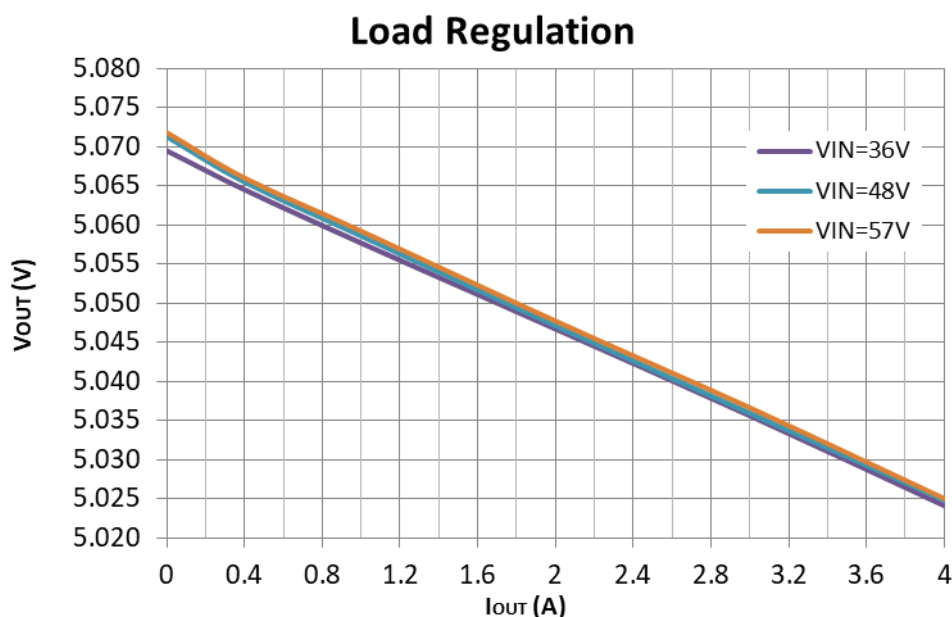
These data are based on **Synchronous Rectification**, with UCC24612+CSD18514Q5Q (40V, 6mΩ @ 4.5V, SON5x6 package).

| V <sub>IN</sub> (V) | I <sub>IN</sub> (A) | V <sub>OUT</sub> (V) | I <sub>OUT</sub> (A) | P <sub>OUT</sub> (W) | P <sub>IN</sub> (W) | Eff           |
|---------------------|---------------------|----------------------|----------------------|----------------------|---------------------|---------------|
| 35.971              | 0.6259              | 5.0241               | 4.0011               | 20.102               | 22.514              | <b>89.29%</b> |
| 35.986              | 0.4736              | 5.0356               | 3.002                | 15.117               | 17.043              | <b>88.70%</b> |
| 36                  | 0.3212              | 5.0467               | 2.001                | 10.098               | 11.563              | <b>87.33%</b> |
| 36.014              | 0.1641              | 5.0577               | 1.0003               | 5.059                | 5.910               | <b>85.61%</b> |
| 36.021              | 0.0838              | 5.0645               | 0.4008               | 2.030                | 3.019               | <b>67.25%</b> |
| 36.027              | 0.021               | 5.0695               | 0                    | 0.000                | 0.757               |               |
|                     |                     |                      |                      |                      |                     |               |
| 47.986              | 0.4718              | 5.0248               | 4.0011               | 20.105               | 22.640              | <b>88.80%</b> |
| 47.996              | 0.3591              | 5.0359               | 3.002                | 15.118               | 17.235              | <b>87.71%</b> |
| 48.008              | 0.2443              | 5.0471               | 2.001                | 10.099               | 11.728              | <b>86.11%</b> |
| 48.018              | 0.1287              | 5.0586               | 1.0002               | 5.060                | 6.180               | <b>81.87%</b> |
| 48.024              | 0.0595              | 5.0655               | 0.4006               | 2.029                | 2.857               | <b>71.02%</b> |
| 48.028              | 0.0123              | 5.0713               | 0                    | 0.000                | 0.591               |               |
|                     |                     |                      |                      |                      |                     |               |
| 57.01               | 0.4003              | 5.025                | 4.0011               | 20.106               | 22.821              | <b>88.10%</b> |
| 57.01               | 0.3057              | 5.0366               | 3.002                | 15.120               | 17.428              | <b>86.76%</b> |
| 57.02               | 0.2079              | 5.0477               | 2.001                | 10.100               | 11.854              | <b>85.20%</b> |
| 57.03               | 0.1132              | 5.0592               | 1.0002               | 5.060                | 6.456               | <b>78.38%</b> |
| 57.03               | 0.0552              | 5.066                | 0.4006               | 2.029                | 3.148               | <b>64.47%</b> |
| 57.03               | 0.0106              | 5.0718               | 0                    | 0.000                | 0.605               |               |

These data are based on **Schottky Rectification**, with SS10P4-M3/87A (40V, 10A, TO-277A package).

| $V_{IN}$ (V) | $I_{IN}$ (A) | $V_{OUT}$ (V) | $I_{OUT}$ (A) | $P_{OUT}$ (W) | $P_{IN}$ (W) | Eff           |
|--------------|--------------|---------------|---------------|---------------|--------------|---------------|
| 35.966       | 0.6528       | 5.0133        | 4.0011        | 20.059        | 23.479       | <b>85.43%</b> |
| 35.982       | 0.4918       | 5.0253        | 3.002         | 15.086        | 17.696       | <b>85.25%</b> |
| 35.995       | 0.3335       | 5.036         | 2.001         | 10.077        | 12.004       | <b>83.94%</b> |
| 36.011       | 0.1703       | 5.047         | 1.0003        | 5.049         | 6.133        | <b>82.32%</b> |
| 36.02        | 0.0836       | 5.0533        | 0.4008        | 2.025         | 3.011        | <b>67.26%</b> |
| 36.026       | 0.0218       | 5.0576        | 0.000         | 0.000         | 0.785        |               |
|              |              |               |               |               |              |               |
| 47.982       | 0.4896       | 5.0142        | 4.0011        | 20.062        | 23.492       | <b>85.40%</b> |
| 47.993       | 0.3704       | 5.0266        | 3.002         | 15.090        | 17.777       | <b>84.89%</b> |
| 48.003       | 0.2527       | 5.0378        | 2.001         | 10.081        | 12.130       | <b>83.10%</b> |
| 48.015       | 0.1317       | 5.0481        | 1.0002        | 5.049         | 6.324        | <b>79.85%</b> |
| 48.022       | 0.0591       | 5.0541        | 0.4006        | 2.025         | 2.838        | <b>71.34%</b> |
| 48.026       | 0.01161      | 5.0601        | 0.000         | 0.000         | 0.558        |               |
|              |              |               |               |               |              |               |
| 57.01        | 0.4136       | 5.017         | 4.0011        | 20.074        | 23.579       | <b>85.13%</b> |
| 57.02        | 0.3138       | 5.0317        | 3.002         | 15.105        | 17.893       | <b>84.42%</b> |
| 57.03        | 0.2149       | 5.0406        | 2.001         | 10.086        | 12.256       | <b>82.30%</b> |
| 57.04        | 0.1158       | 5.048         | 1.0002        | 5.049         | 6.605        | <b>76.44%</b> |
| 57.04        | 0.0541       | 5.0548        | 0.4006        | 2.025         | 3.086        | <b>65.62%</b> |
| 57.04        | 0.00995      | 5.0586        | 0.000         | 0.000         | 0.568        |               |

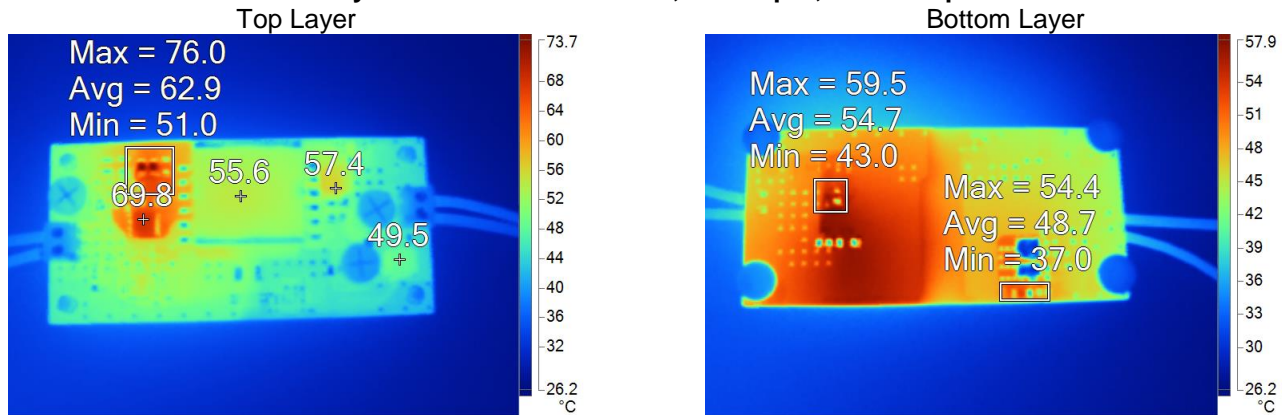
### 2.3 Load Regulation



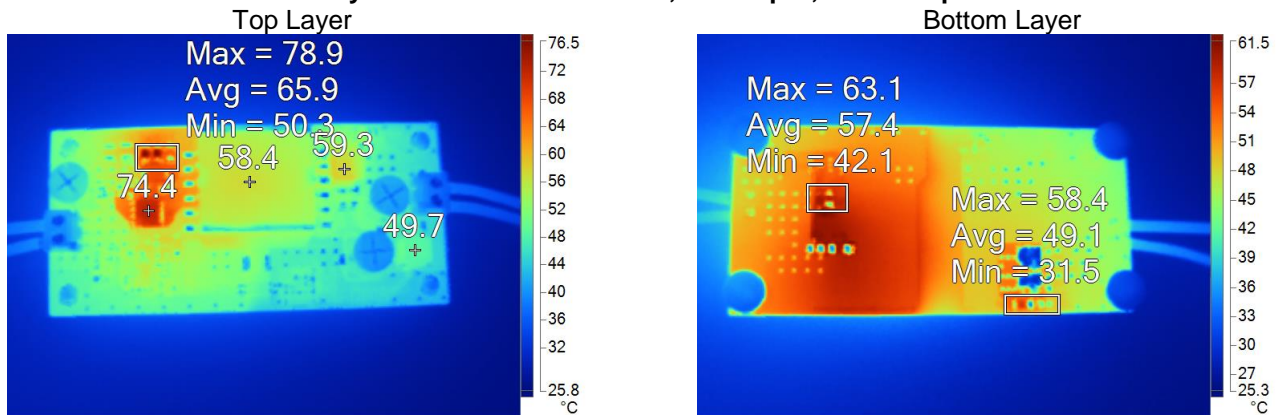
## 2.4 Thermal Images

Test is done under  $T_a=25.0^{\circ}\text{C}$ , Two-layer PCB, 1-oz Copper.

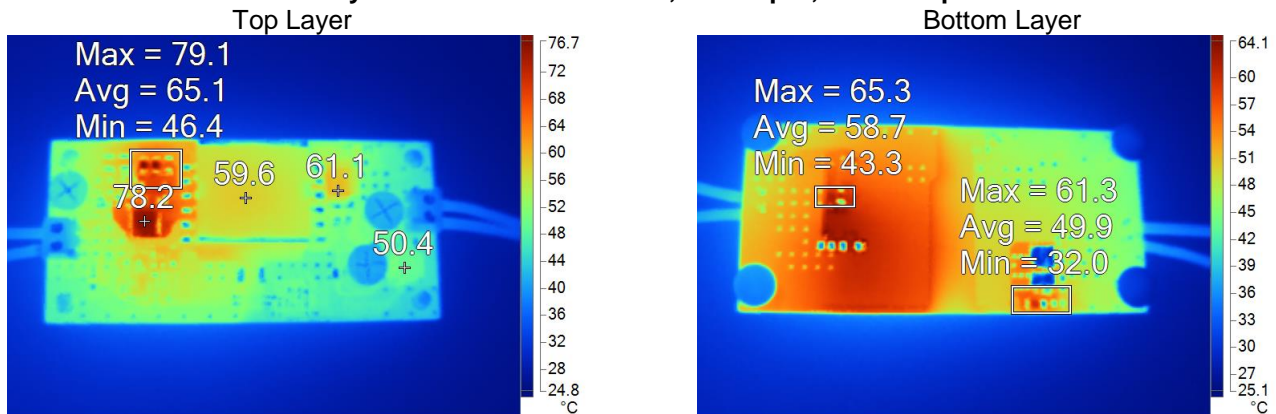
### Synchronous Rectification, 36 V input, 5V4A output



### Synchronous Rectification, 48 V input, 5V4A output

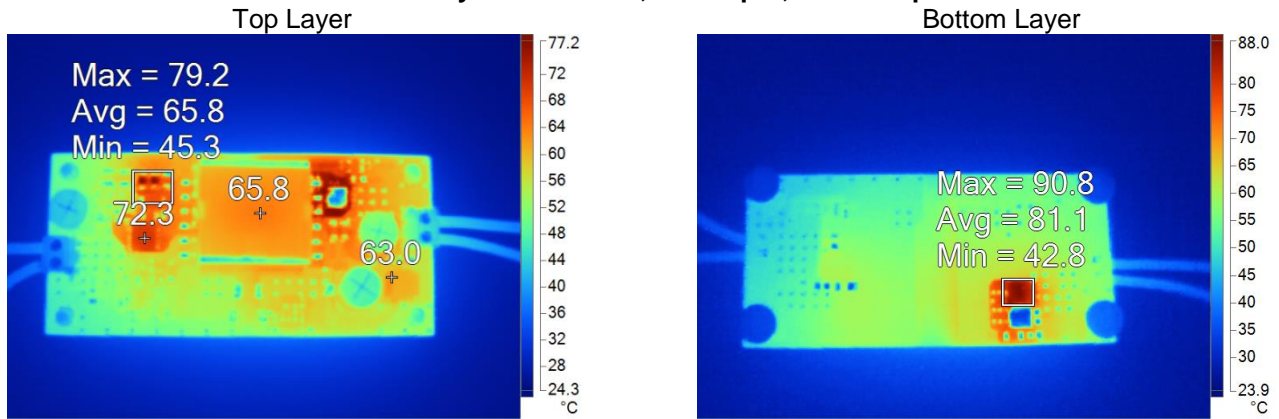


### Synchronous Rectification, 57 V input, 5V4A output

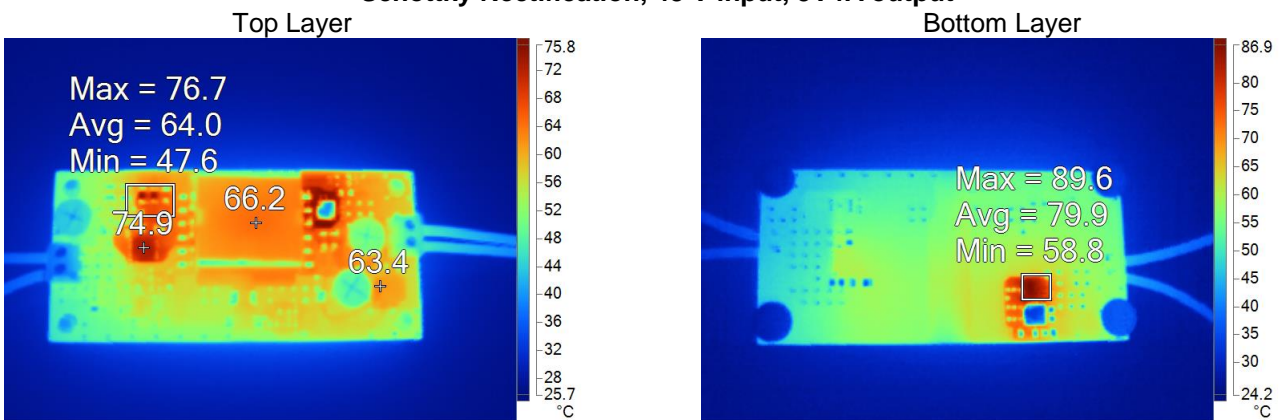




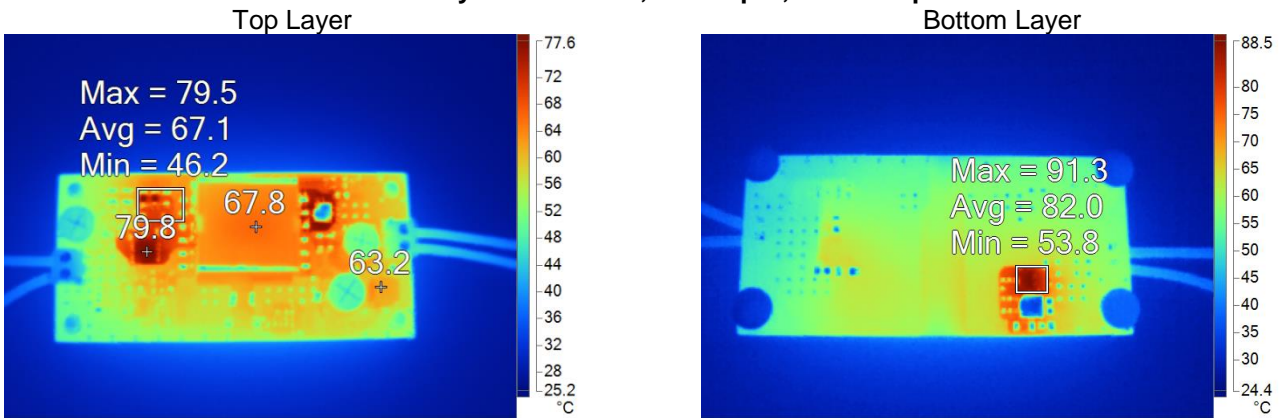
**Schottky Rectification, 36 V input, 5V4A output**



**Schottky Rectification, 48 V input, 5V4A output**

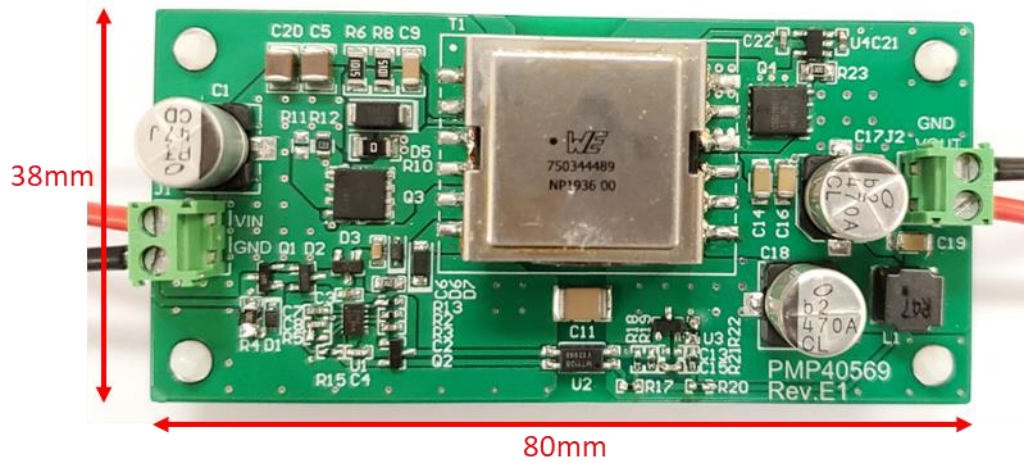


**Schottky Rectification, 57 V input, 5V4A output**



## 2.5 Dimensions

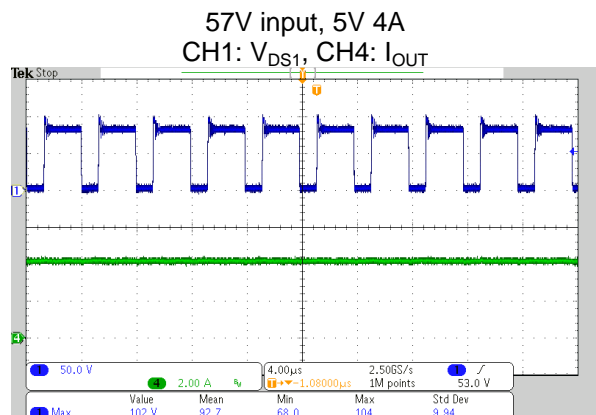
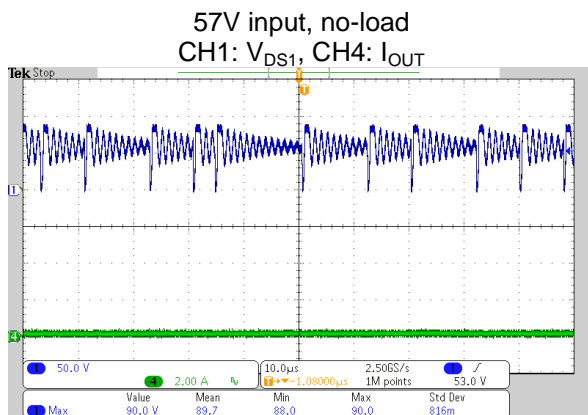
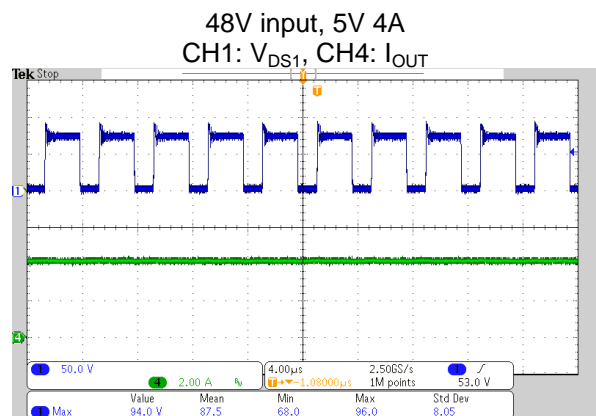
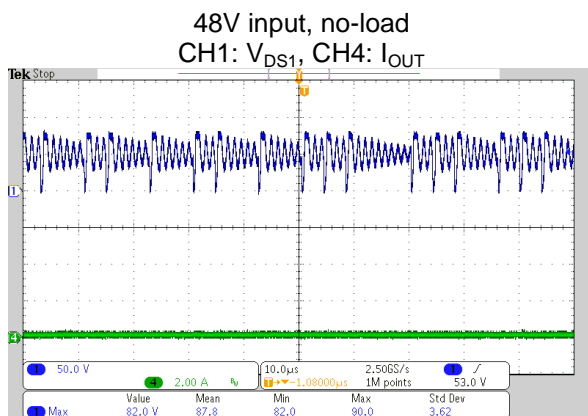
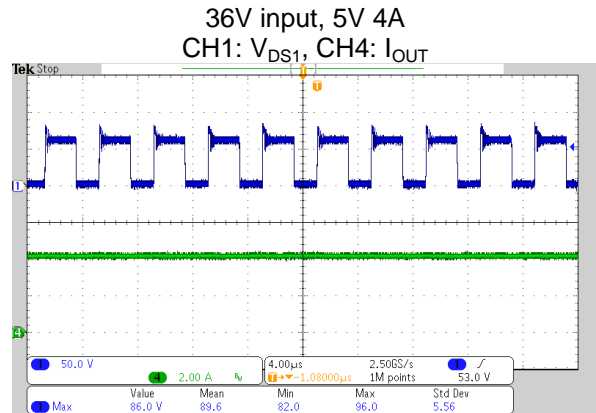
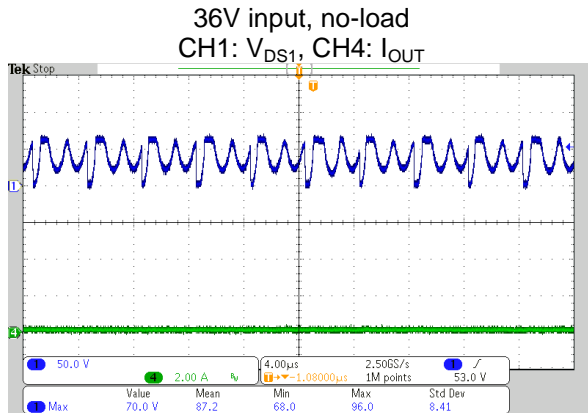
The dimension of this board is 80mm (length)\*38mm (width)\*11mm (height).



### 3 Waveforms

#### 3.1 Switching

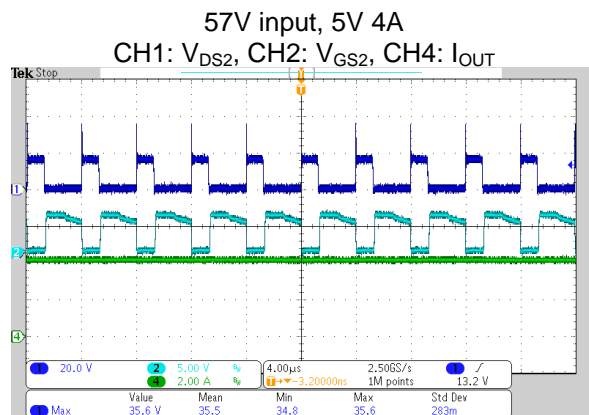
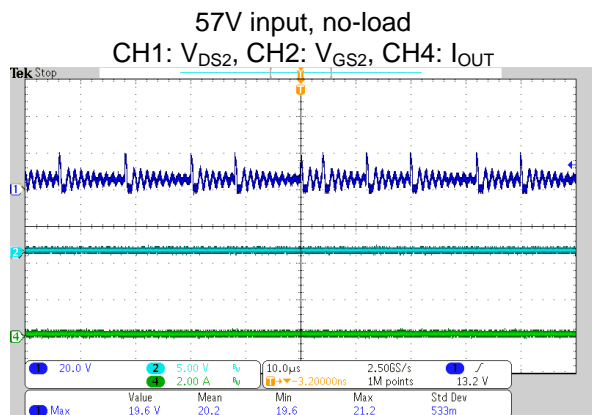
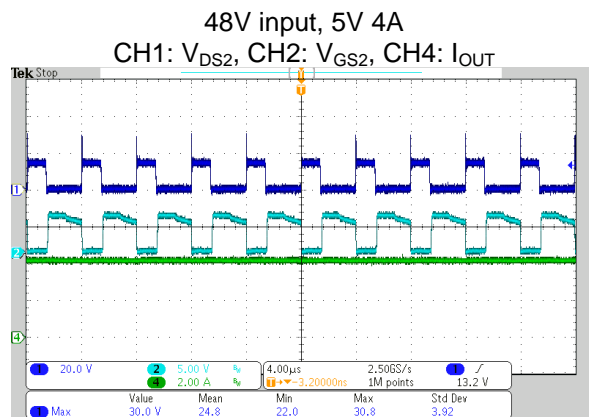
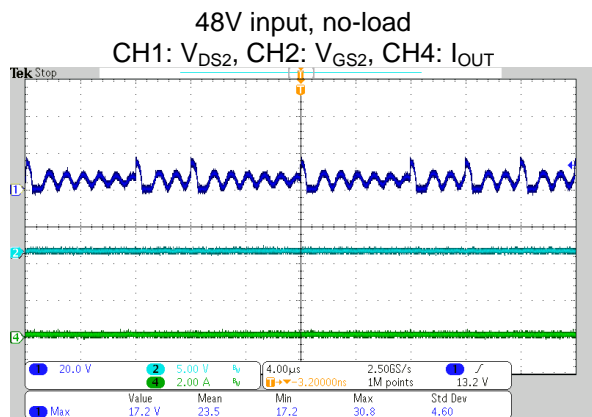
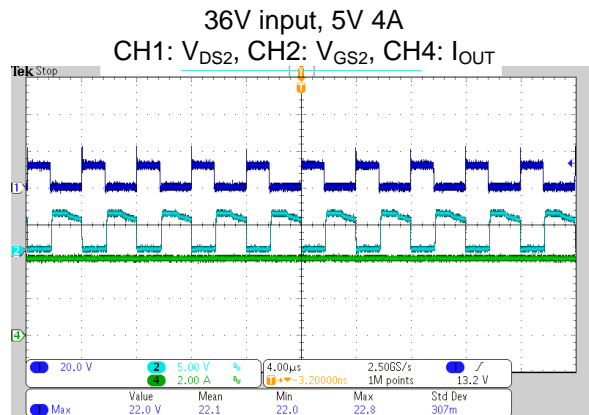
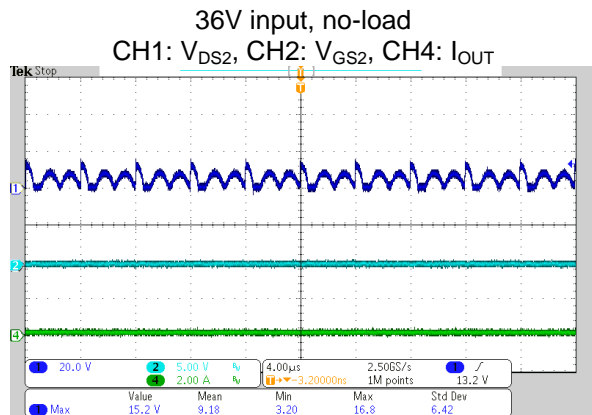
The waveforms of switching nodes at no load and full load condition are shown in following pictures.





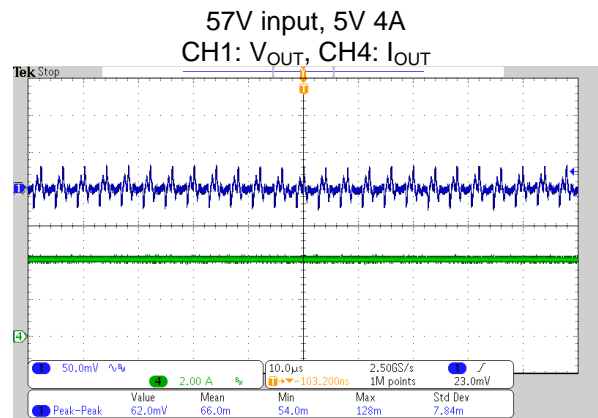
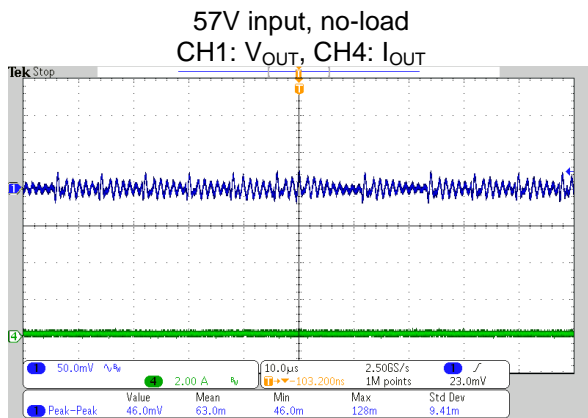
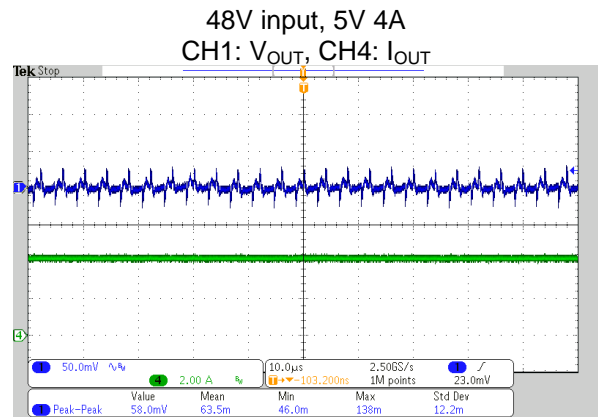
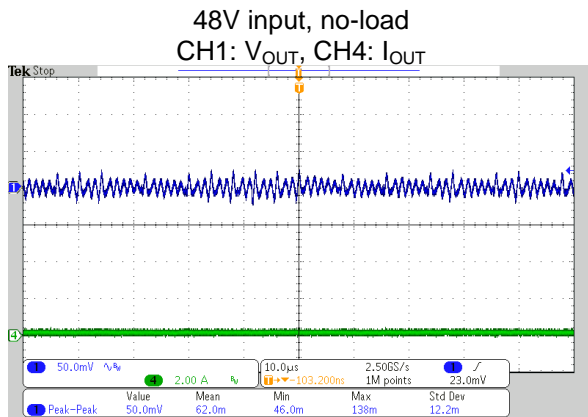
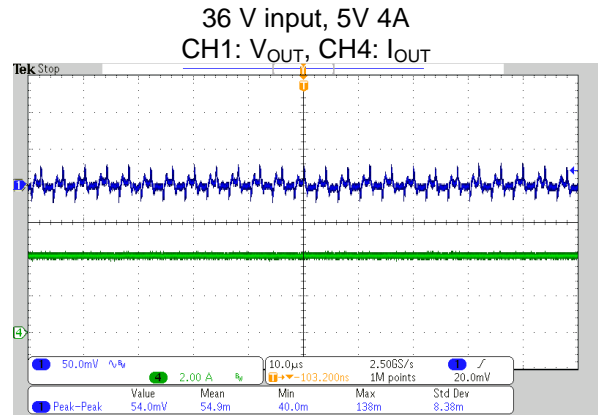
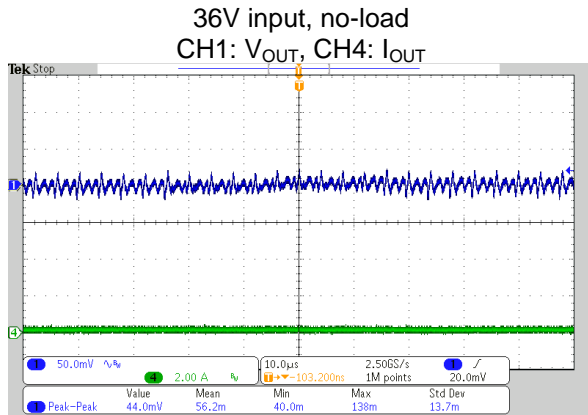
### 3.2 Rectified MOSFET Waveform

The waveforms of secondary rectified diode at full load condition are shown in following pictures.



### 3.3 Output Voltage Ripple

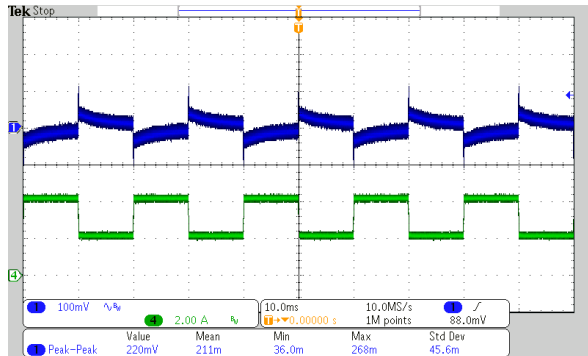
The waveforms of output AC ripples at no load and full load condition are shown in following pictures.



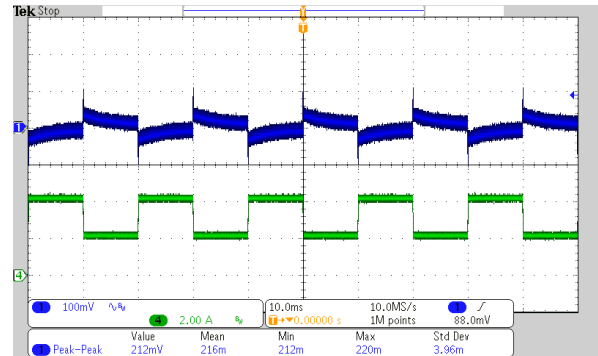
### 3.4 Load Transient

The waveforms of output AC ripples at load transient are shown in following pictures. The high current level is 2A for 10ms; the low current level is 4A for 10ms, with a slew rate of 0.1A/us.

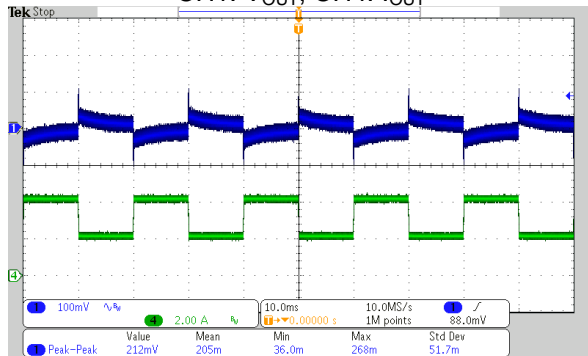
36V input, 2A->4A  
CH1: V<sub>OUT</sub>, CH4: I<sub>OUT</sub>



48V input, 2A->4A  
CH1: V<sub>OUT</sub>, CH4: I<sub>OUT</sub>



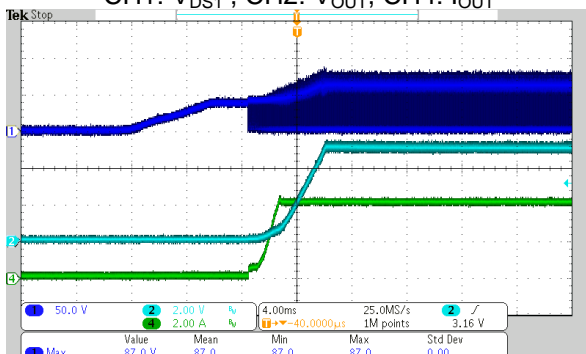
57V input, 2A->4A  
CH1: V<sub>OUT</sub>, CH4: I<sub>OUT</sub>



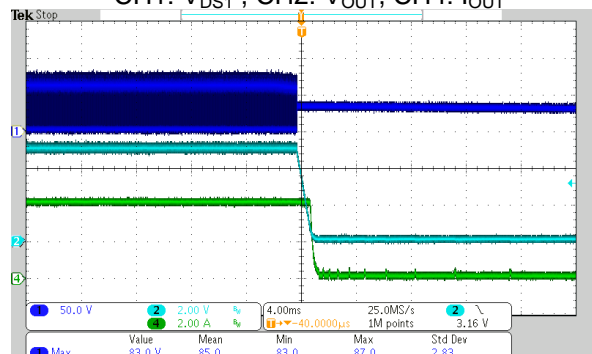
### 3.5 Power on/off

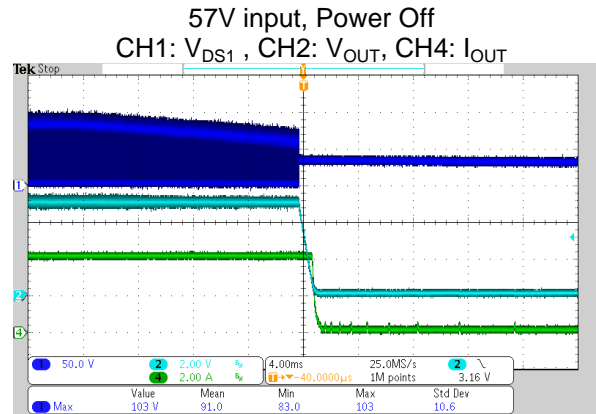
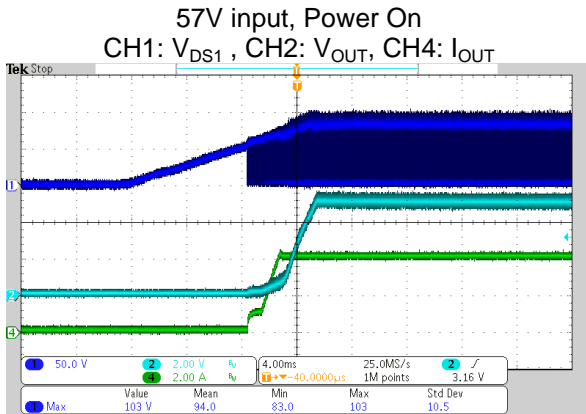
The waveforms of Power on and off with full load output are shown in following pictures.

36V input, Power On  
CH1: V<sub>DS1</sub>, CH2: V<sub>OUT</sub>, CH4: I<sub>OUT</sub>



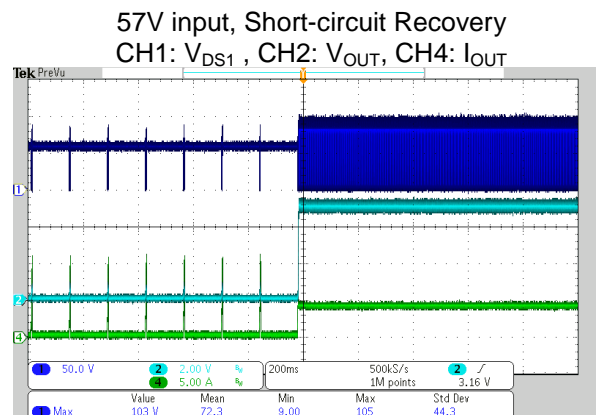
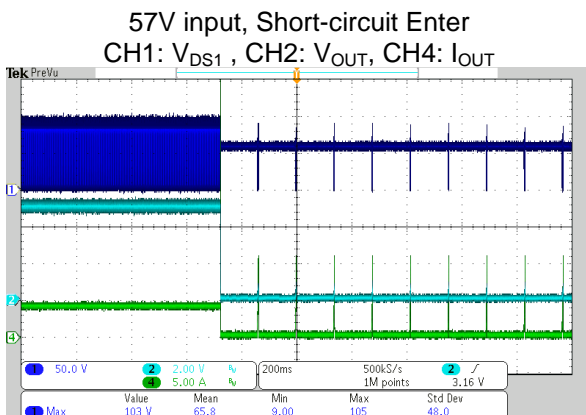
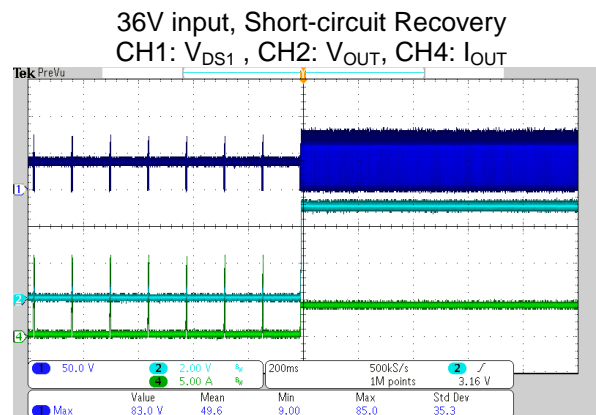
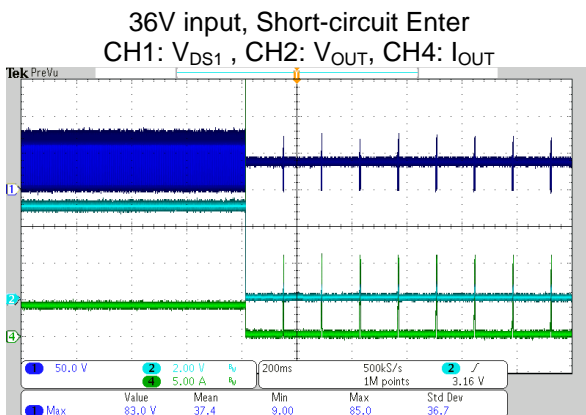
36V input, Power Off  
CH1: V<sub>DS1</sub>, CH2: V<sub>OUT</sub>, CH4: I<sub>OUT</sub>





### 3.6 Output Short-circuit Protection

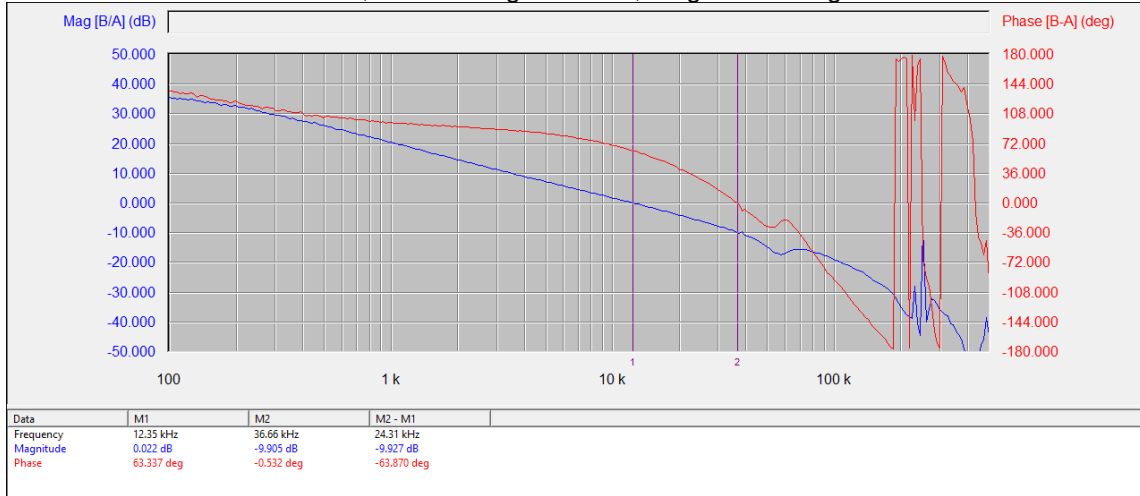
The waveforms of output short-circuit enter and recovery are shown in following pictures.



### 3.7 Loop Response

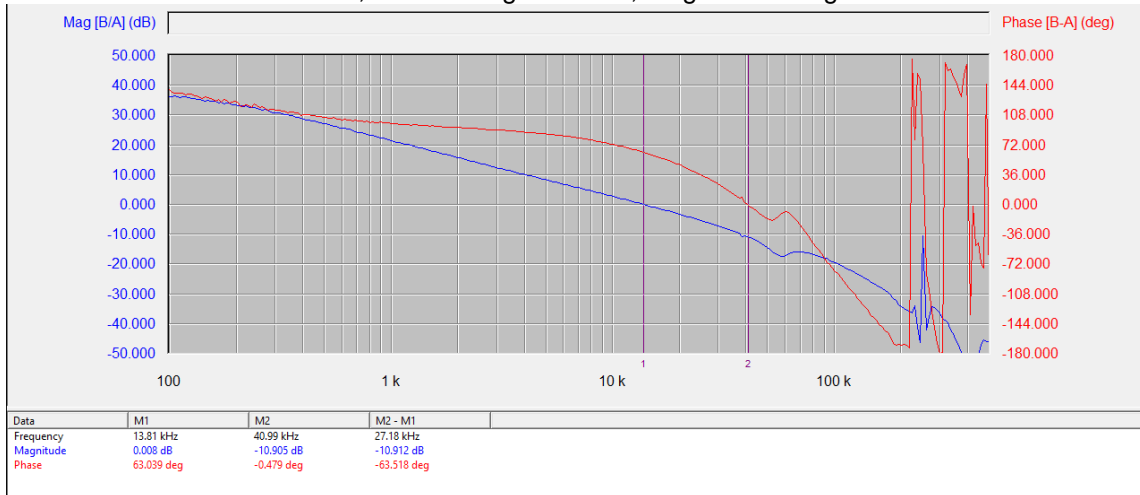
#### 36V input

BW=12.35 kHz, Phase Margin=63.34°, Magnitude Margin=9.90 dB



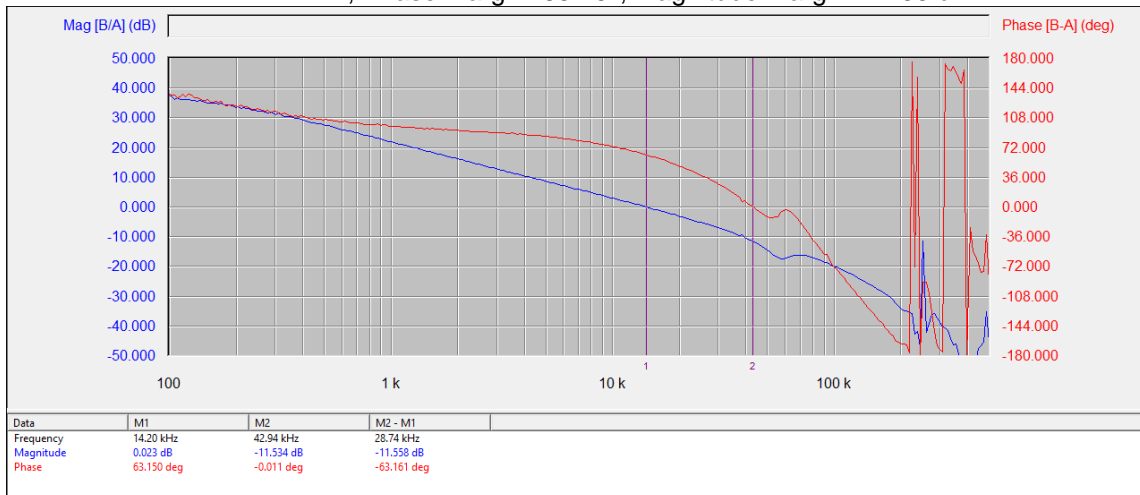
#### 48V input

BW=13.81 kHz, Phase Margin=63.04°, Magnitude Margin=10.90dB



#### 57V input

BW=14.2 kHz, Phase Margin=63.15°, Magnitude Margin=11.53 dB





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