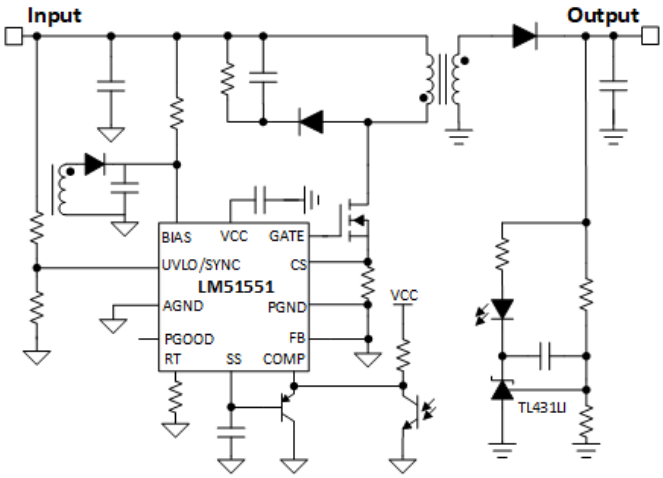
Test Report: PMP40555
9~60-Vdc Input, 12-V/2-A Output Flyback Reference Design

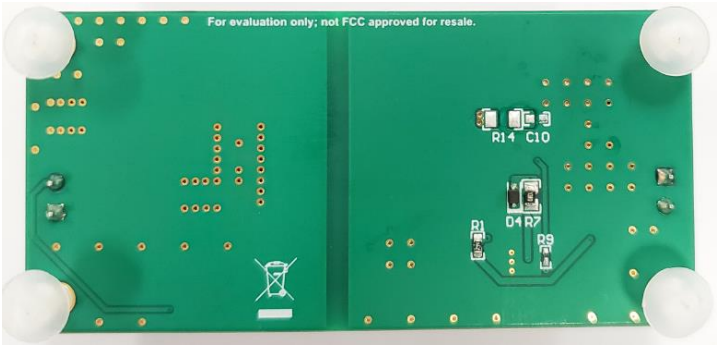
Description

This reference design is a wide input, 12-V/2-A output isolated flyback converter using LM51551. The switching frequency is 250 kHz and the peak efficiency of the system is 89.19% at 24-V input. The load regulation in the whole input range is within ±0.5%. Peak-to-peak ripple of the output is within 296 mV under load transient from 1 A to 2 A with a slew rate of 1 A/us.



Top View

Bottom View



1 Test Prerequisites

1.1 Voltage and Current Requirements

Table 1. Voltage and Current Requirements

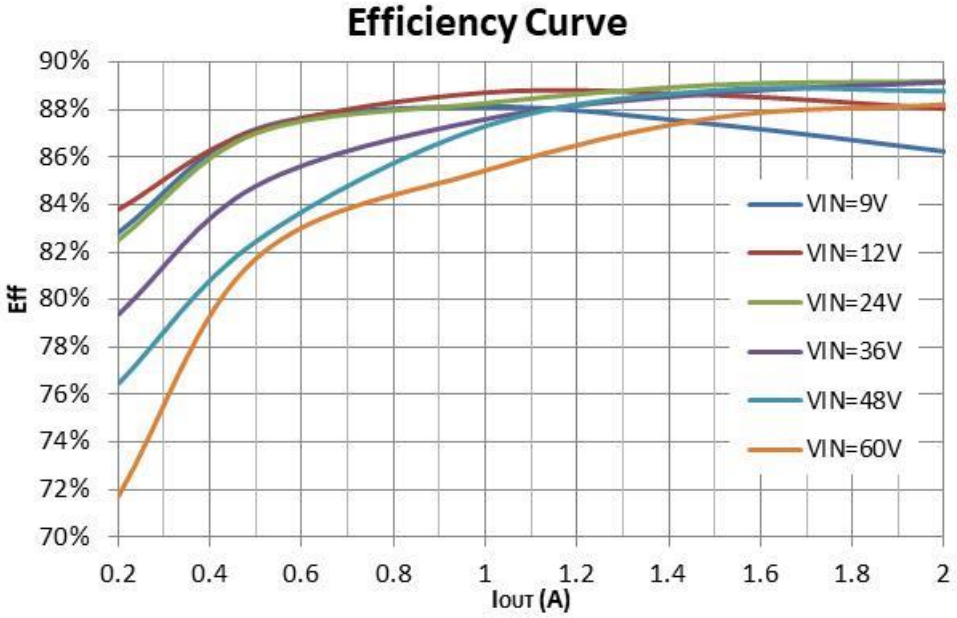
PARAMETER	SPECIFICATIONS
Input Voltage	9~60 Vdc
Output Voltage	12 Vdc
Rated Output Current	2 A

1.2 Required Equipment

- Multi-meter (current): Fluke 287C
- Multi-meter (voltage): Fluke 287C
- DC Source: Chroma 62006P-100-25
- E-Load: Chroma 63103A module
- Oscilloscope: Tektronix DPO3054
- Current Probe: Tektronix TCPA300
- Electrical Thermography: Fluke TiS65

2 Testing and Results

2.1 Efficiency Graphs

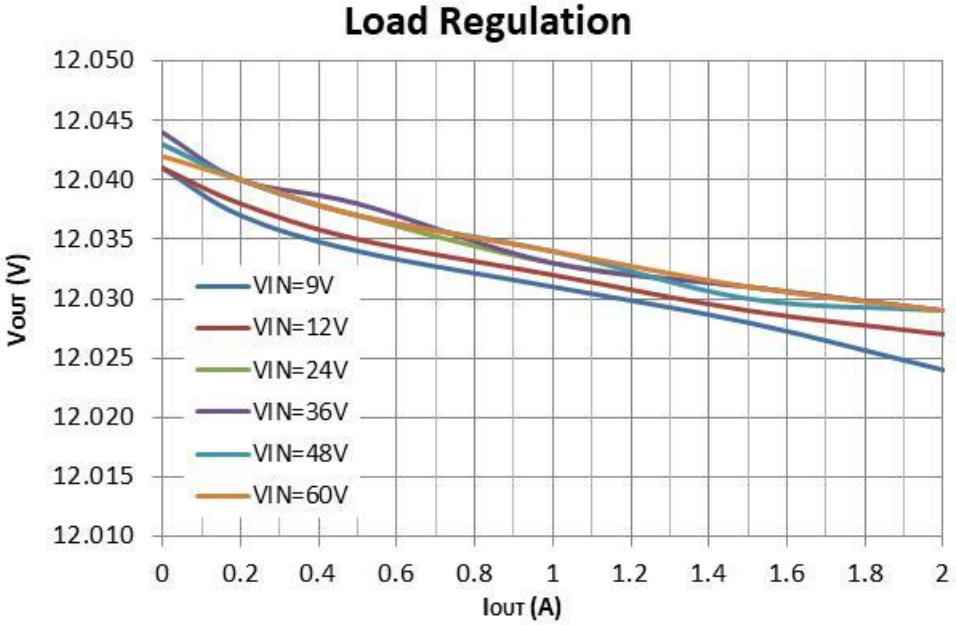


2.2 Efficiency Data

V_{IN} (V)	I_{IN} (A)	V_{OUT} (V)	I_{OUT} (A)	P_{OUT} (W)	P_{IN} (W)	Eff
8.997	3.1002	12.024	2.0006	24.0552	27.8925	**86.24%**
8.999	2.2944	12.028	1.50009	18.0431	20.6473	**87.39%**
9.000	1.5168	12.031	0.9999	12.0298	13.6512	**88.12%**
9.001	0.7678	12.034	0.5007	6.0254	6.9110	**87.19%**
8.999	0.3243	12.037	0.2008	2.4170	2.9184	**82.82%**
9.001	0.03241	12.041	0	0.0000	0.2917	
11.999	2.2777	12.027	2.0006	24.0612	27.3301	**88.04%**
12.002	1.6976	12.029	1.5009	18.0543	20.3746	**88.61%**
12.005	1.1296	12.032	0.9999	12.0308	13.5608	**88.72%**
12.006	0.5761	12.035	0.5007	6.0259	6.9167	**87.12%**
12.000	0.2404	12.038	0.2008	2.4172	2.8848	**83.79%**
12.000	0.02698	12.041	0	0.0000	0.3238	
23.998	1.1243	12.029	2.0006	24.0652	26.9810	**89.19%**
23.999	0.8450	12.031	1.5009	18.0573	20.2792	**89.04%**
24.001	0.5679	12.033	0.9999	12.0318	13.6302	**88.27%**
24.002	0.2886	12.037	0.5007	6.0269	6.9270	**87.01%**
23.998	0.1221	12.04	0.2008	2.4176	2.9302	**82.51%**
24.002	0.0132	12.043	0	0.0000	0.3156	

35.999	0.7498	12.029	2.0007	24.0664	26.9921	**89.16%**
35.997	0.5656	12.031	1.5009	18.0573	20.3599	**88.69%**
36.004	0.3815	12.033	0.9999	12.0318	13.7355	**87.60%**
36.001	0.1975	12.038	0.5008	6.0286	7.1102	**84.79%**
36.006	0.0846	12.04	0.2008	2.4176	3.0461	**79.37%**
35.998	0.00742	12.044	0	0.0000	0.2671	
47.999	0.5648	12.029	2.0007	24.0664	27.1098	**88.77%**
48.004	0.4235	12.03	1.5009	18.0558	20.3297	**88.82%**
47.999	0.2869	12.034	0.999	12.0220	13.7709	**87.30%**
48.004	0.1523	12.037	0.5008	6.0281	7.3110	**82.45%**
48.007	0.0659	12.04	0.2009	2.4188	3.1637	**76.46%**
48.009	0.00514	12.043	0	0.0000	0.2468	
60.00	0.4547	12.029	2.0007	24.06642	27.282	**88.21%**
60.00	0.3433	12.031	1.5009	18.05733	20.598	**87.67%**
60.01	0.2347	12.034	0.9999	12.0328	14.08435	**85.43%**
60.01	0.1229	12.037	0.5008	6.02813	7.375229	**81.73%**
60.01	0.0562	12.04	0.2009	2.418836	3.372562	**71.72%**
60.01	0.00404	12.042	0	0	0.24244	

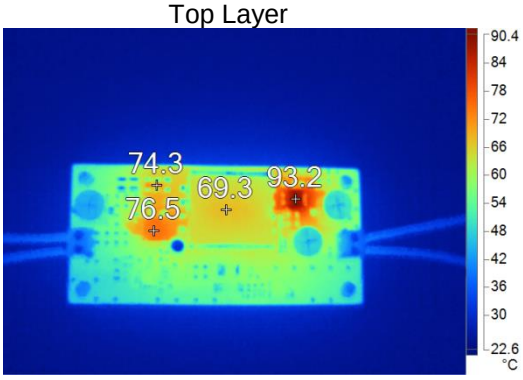
2.3 Load Regulation



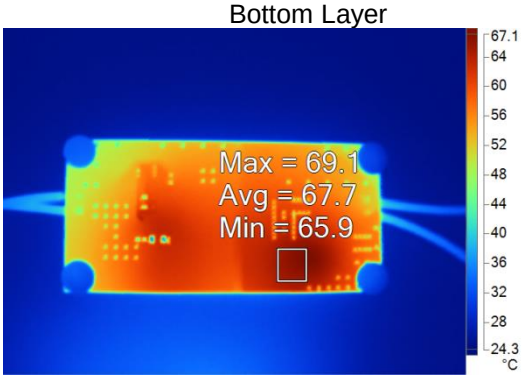
2.4 Thermal Images

Ta=25.0°C, 9 V input, 12V2A output

Top Layer

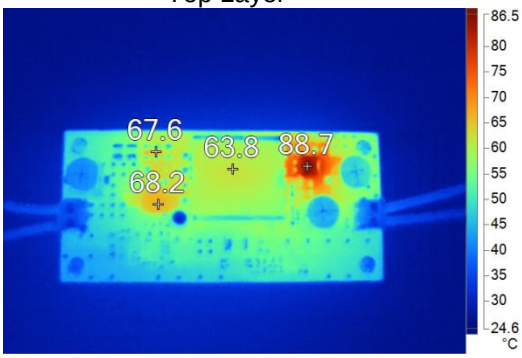


Bottom Layer

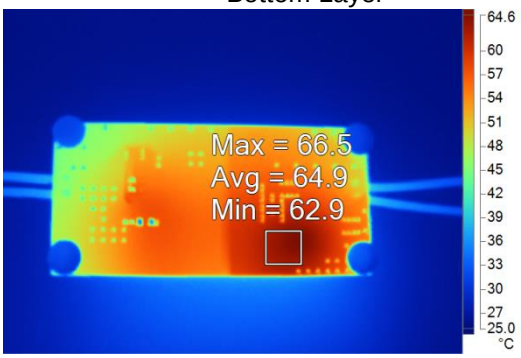


Ta=25.0°C, 12 V input, 12V2A output

Top Layer

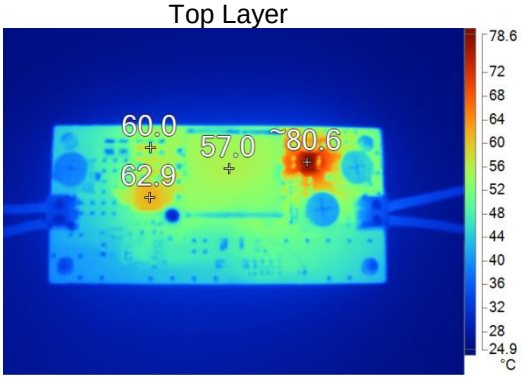


Bottom Layer

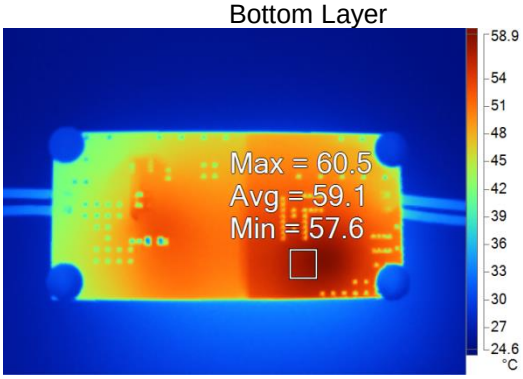


Ta=25.0°C, 36 V input, 12V2A output

Top Layer

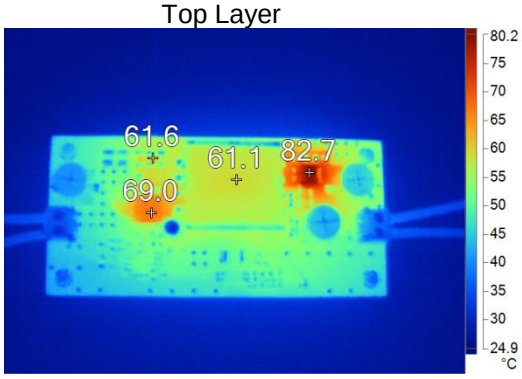


Bottom Layer

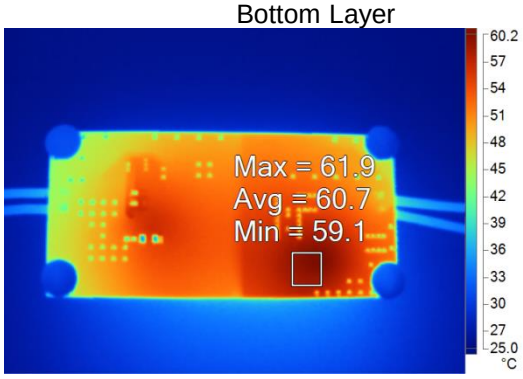


Ta=25.0°C, 60 V input, 12V2A output

Top Layer

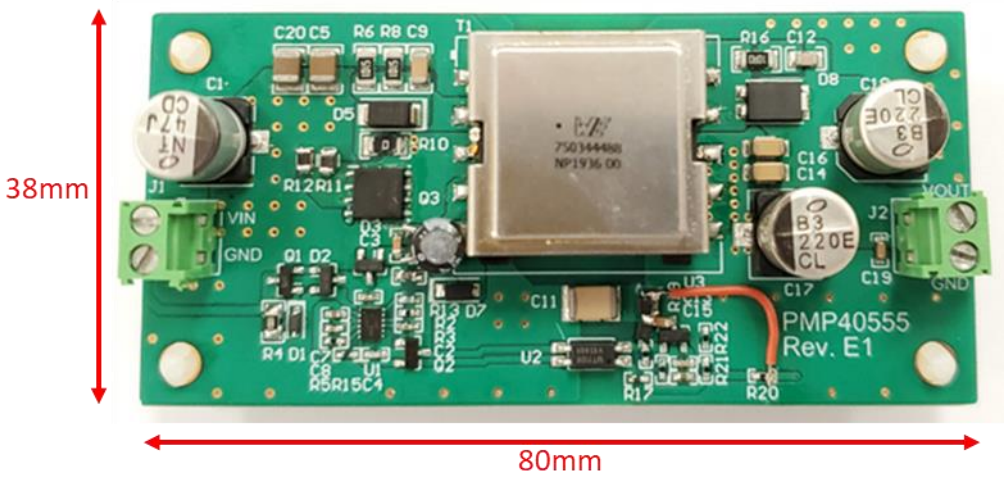


Bottom Layer



2.5 Dimensions

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

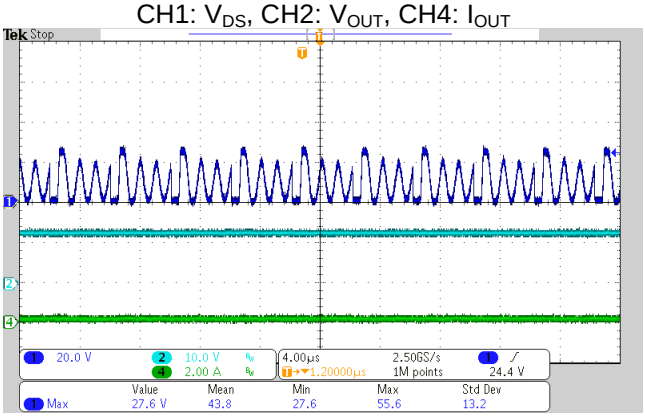


3 Waveforms

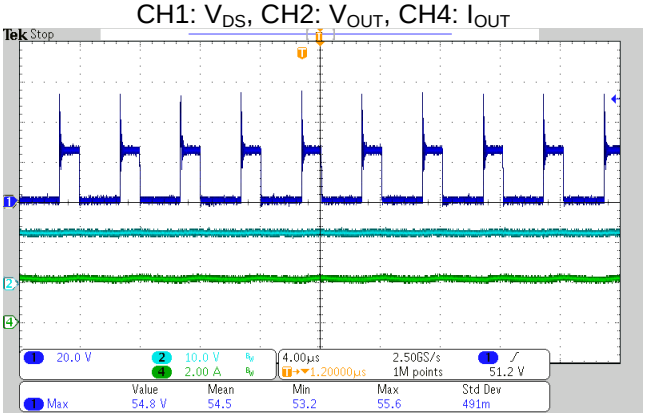
3.1 Switching

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

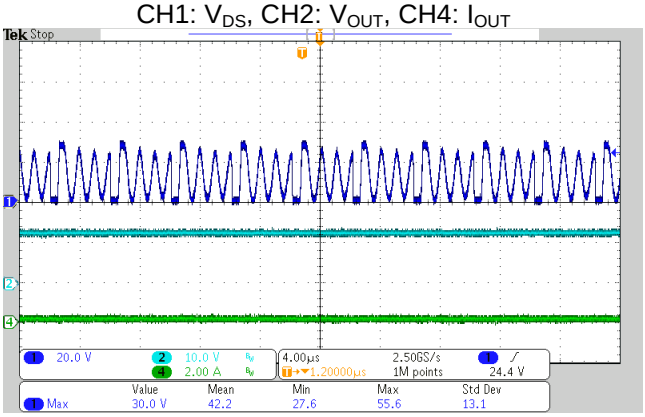
9V input, no-load
CH1: V_{DS}, CH2: V_{OUT}, CH4: I_{OUT}



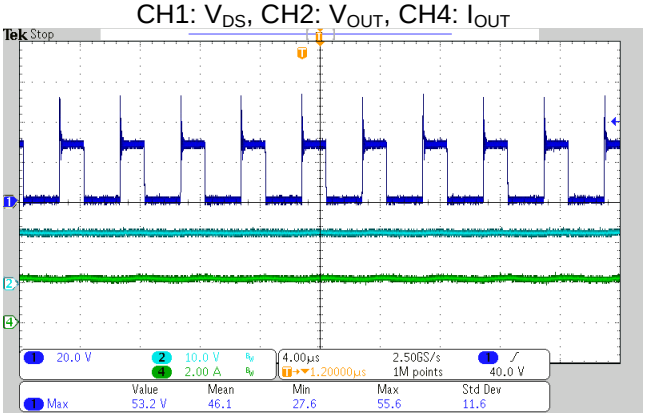
9V input, 12V 2A
CH1: V_{DS}, CH2: V_{OUT}, CH4: I_{OUT}



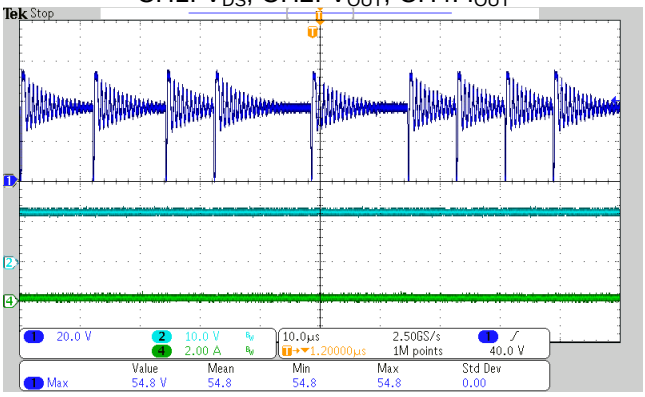
12V input, no-load
CH1: V_{DS}, CH2: V_{OUT}, CH4: I_{OUT}



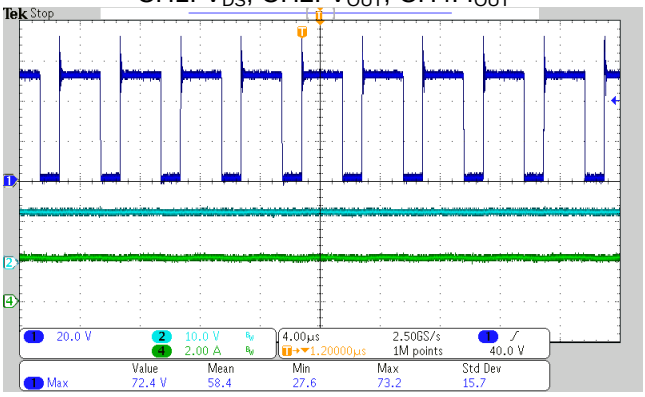
12V input, 12V 2A
CH1: V_{DS}, CH2: V_{OUT}, CH4: I_{OUT}



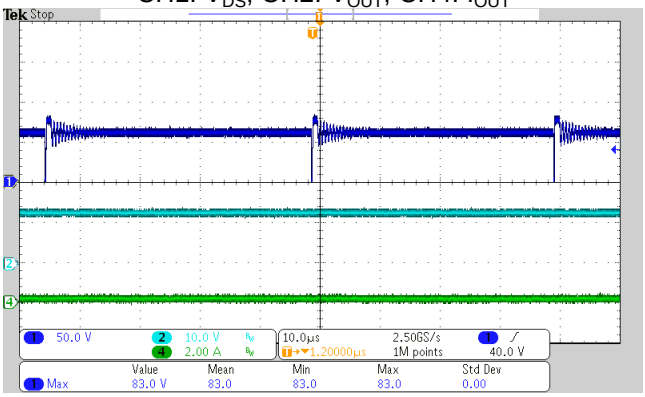
36V input, no-load
CH1: V_{DS}, CH2: V_{OUT}, CH4: I_{OUT}



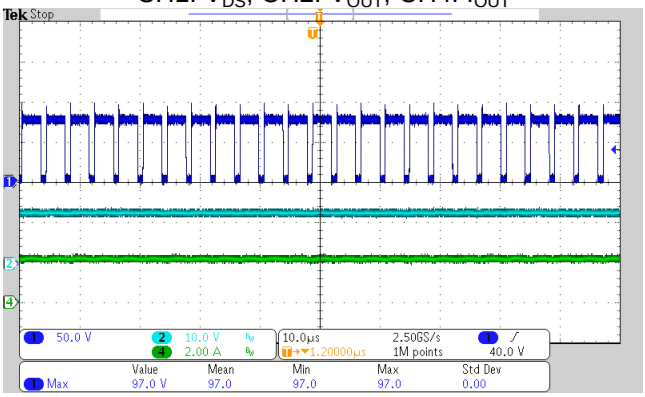
36V input, 12V 2A
CH1: V_{DS}, CH2: V_{OUT}, CH4: I_{OUT}



60V input, no-load
CH1: V_{DS}, CH2: V_{OUT}, CH4: I_{OUT}



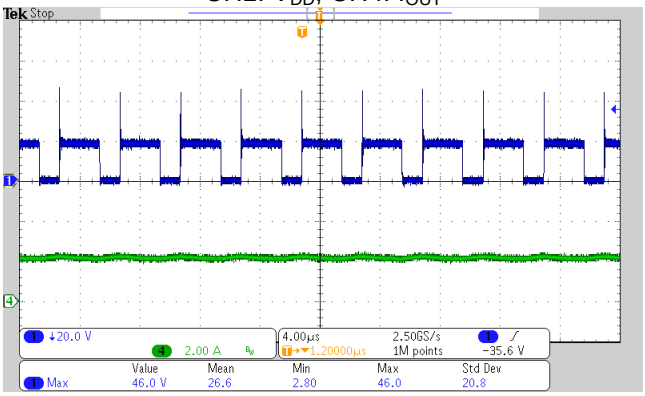
60V input, 12V 2A
CH1: V_{DS}, CH2: V_{OUT}, CH4: I_{OUT}



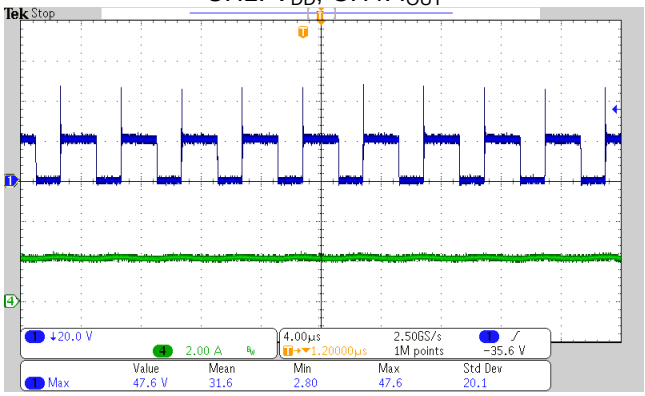
3.2 Rectified Diode Waveform

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

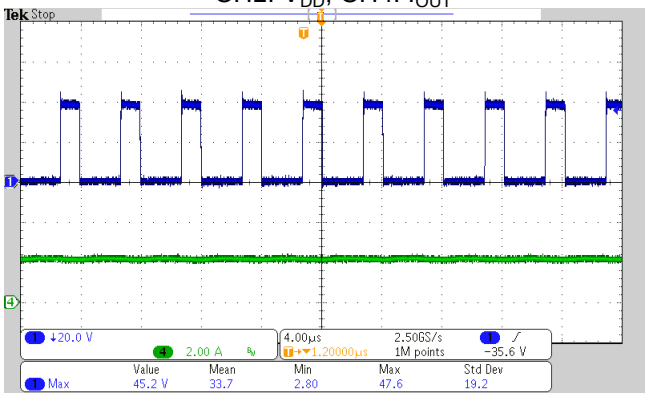
9V input, 12V2A
CH1: V_{DD}, CH4: I_{OUT}



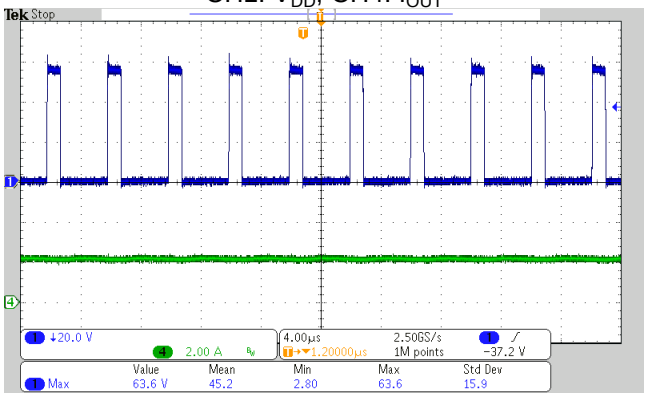
12V input, 12V2A
CH1: V_{DD}, CH4: I_{OUT}



36V input, 12V2A
CH1: V_{DD}, CH4: I_{OUT}



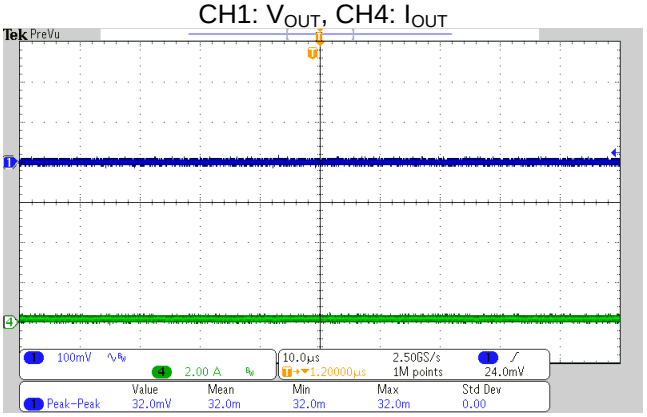
60V input, 12V2A
CH1: V_{DD}, CH4: I_{OUT}



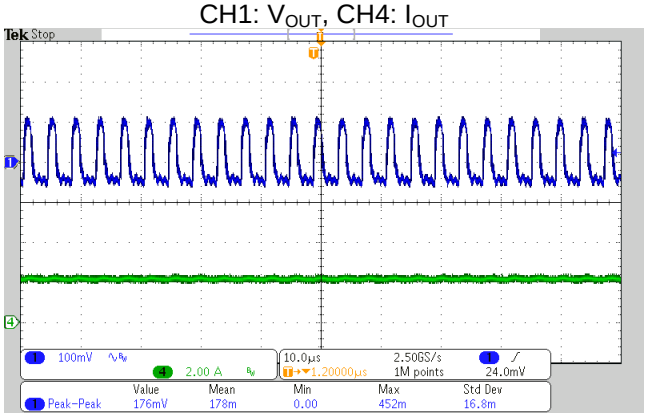
3.3 Output Voltage Ripple

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

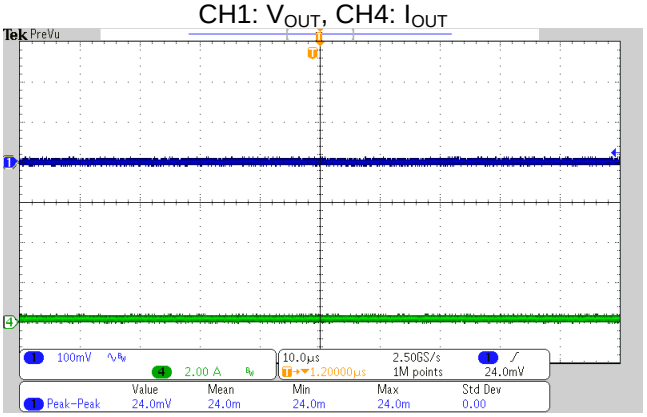
9V input, no-load
CH1: V_{OUT}, CH4: I_{OUT}



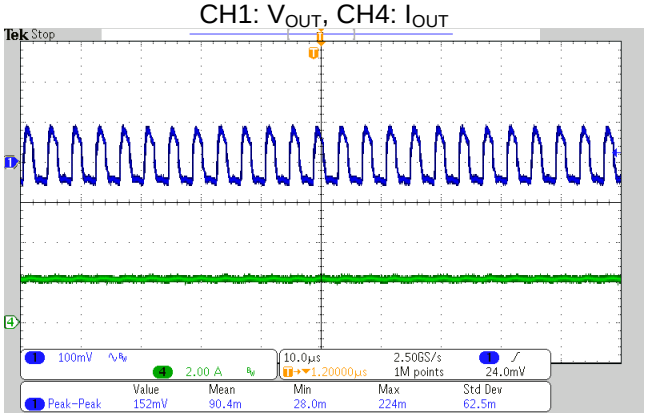
9 V input, 12V 2A
CH1: V_{OUT}, CH4: I_{OUT}



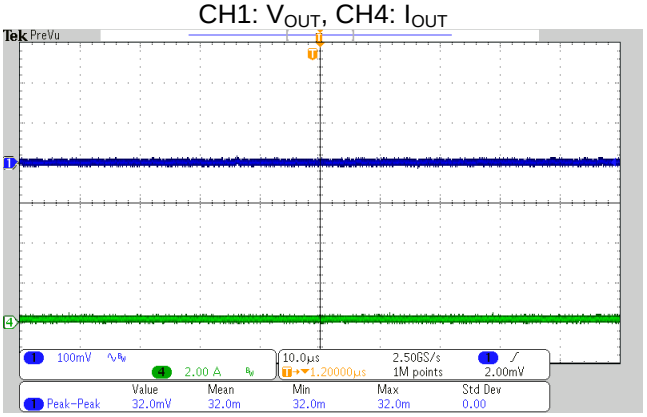
12V input, no-load
CH1: V_{OUT}, CH4: I_{OUT}



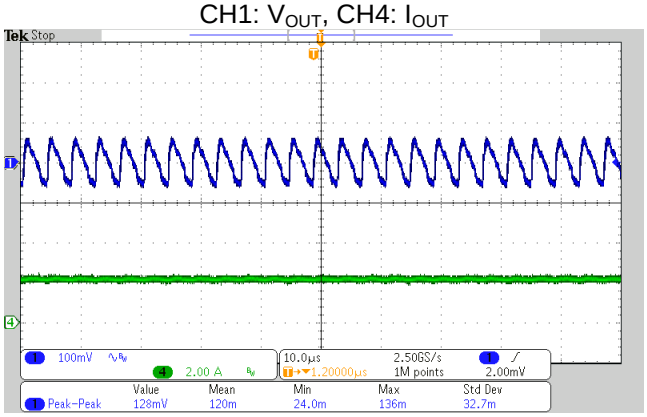
12V input, 12V 2A
CH1: V_{OUT}, CH4: I_{OUT}



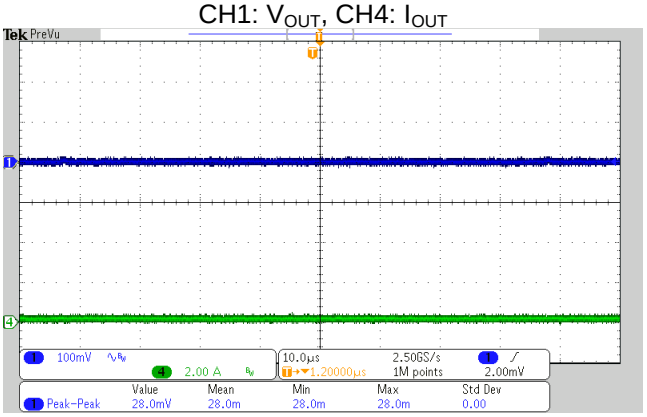
36V input, no-load
CH1: V_{OUT}, CH4: I_{OUT}



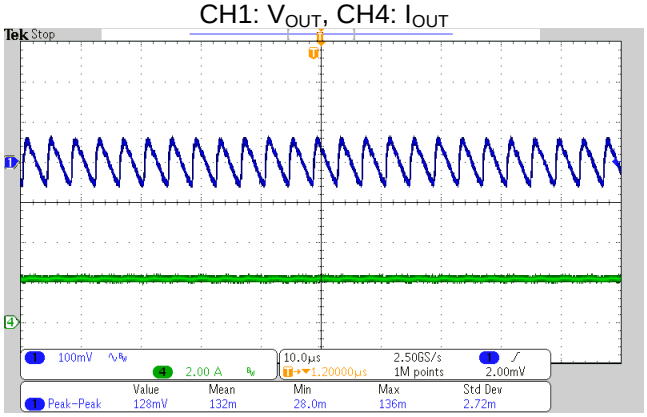
36V input, 12V 2A
CH1: V_{OUT}, CH4: I_{OUT}



60V input, no-load
CH1: V_{OUT}, CH4: I_{OUT}



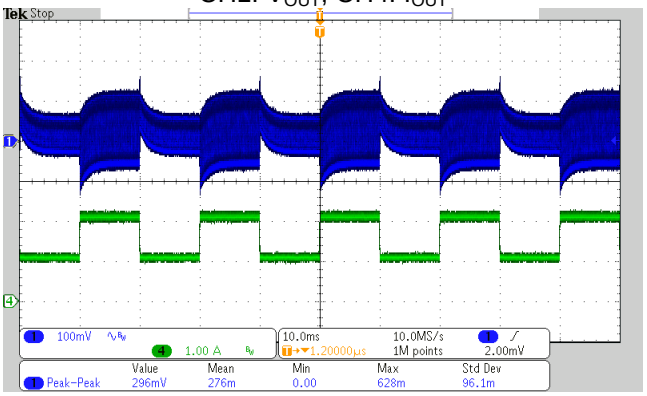
60V input, 12V 2A
CH1: V_{OUT}, CH4: I_{OUT}



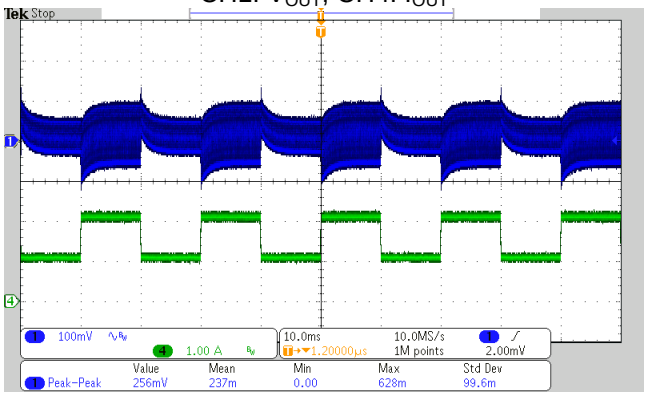
3.4 Load Transient

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 1A for 10ms, with a slew rate of 1A/us.

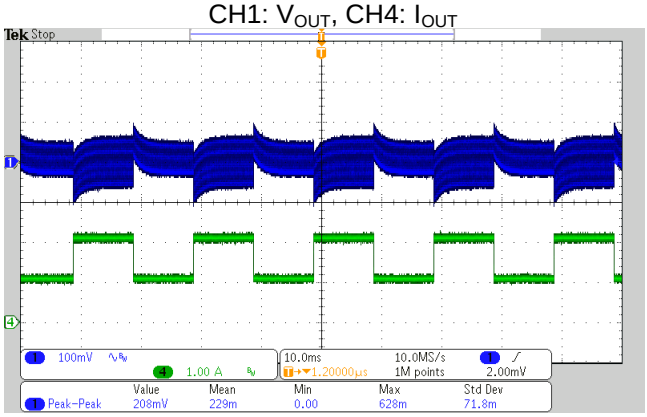
9V input, 1A->2A
CH1: V_{OUT}, CH4: I_{OUT}



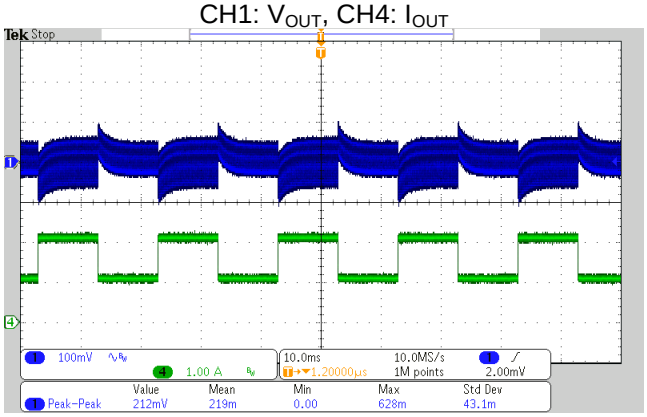
12V input, 1A->2A
CH1: V_{OUT}, CH4: I_{OUT}



36V input, 1A->2A
CH1: V_{OUT}, CH4: I_{OUT}



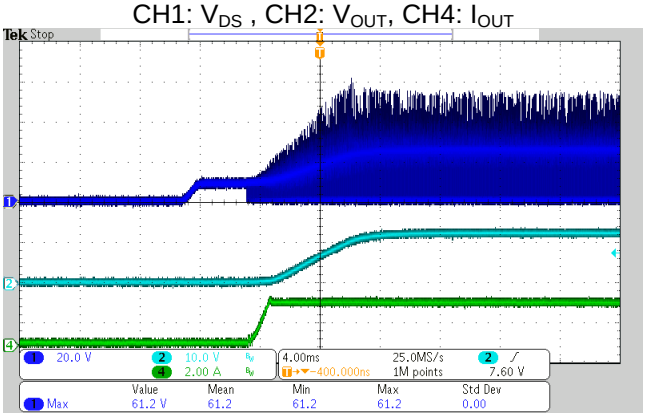
60V input, 1A->2A
CH1: V_{OUT}, CH4: I_{OUT}



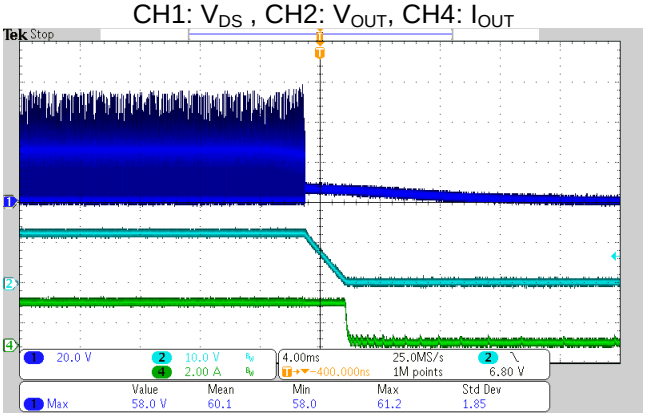
3.5 Power on/off

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

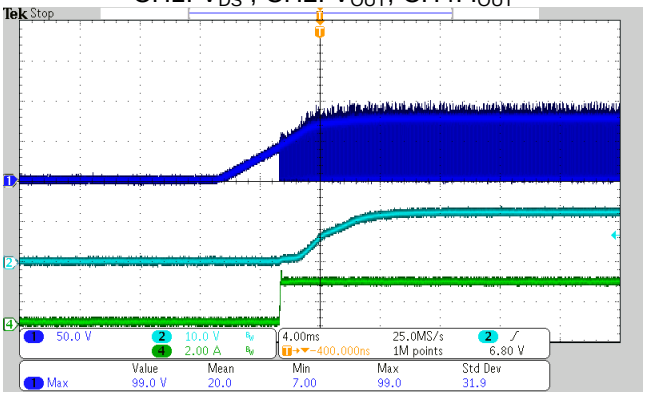
9V input, Power On
CH1: V_{DS} , CH2: V_{OUT}, CH4: I_{OUT}



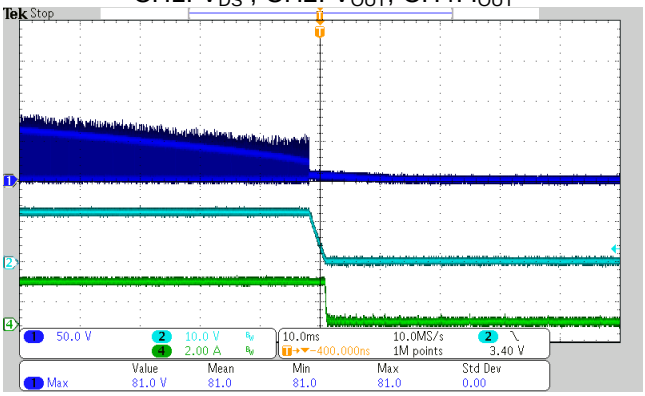
9V input, Power Off
CH1: V_{DS} , CH2: V_{OUT}, CH4: I_{OUT}



60V input, Power On
CH1: V_{DS} , CH2: V_{OUT}, CH4: I_{OUT}



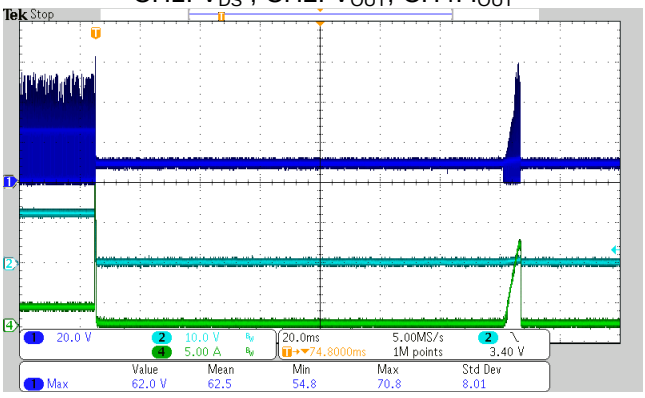
60V input, Power Off
CH1: V_{DS} , CH2: V_{OUT}, CH4: I_{OUT}



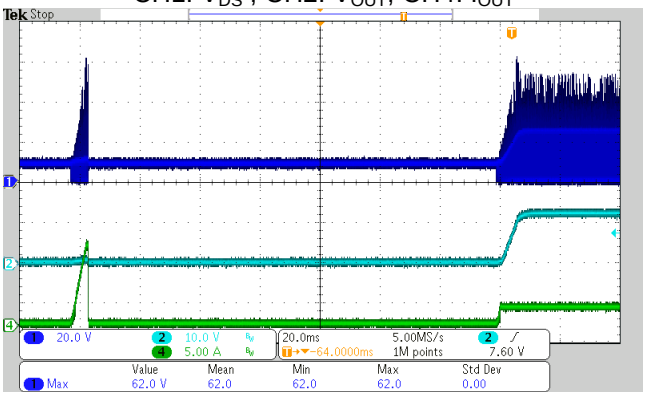
3.6 Output Short-circuit Protection

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

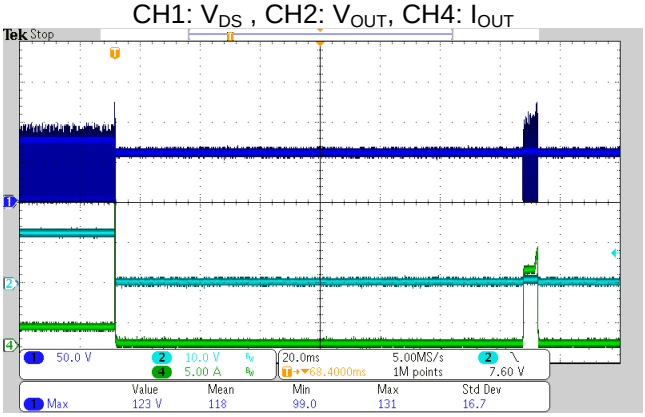
9V input, Short-circuit Enter
CH1: V_{DS} , CH2: V_{OUT}, CH4: I_{OUT}



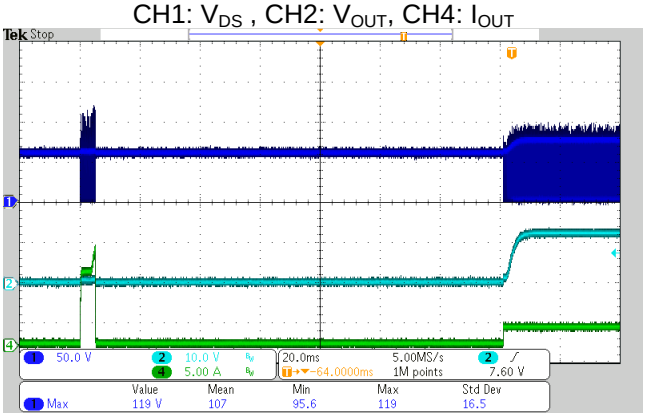
9V input, Short-circuit Recovery
CH1: V_{DS} , CH2: V_{OUT}, CH4: I_{OUT}



60V input, Short-circuit Enter
CH1: V_{DS} , CH2: V_{OUT}, CH4: I_{OUT}



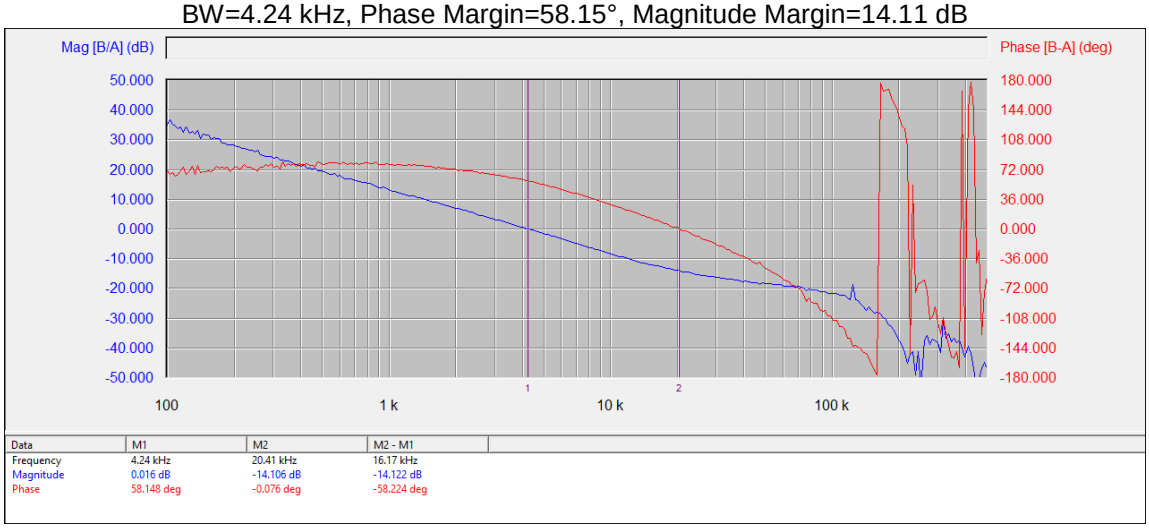
60V input, Short-circuit Recovery
CH1: V_{DS} , CH2: V_{OUT}, CH4: I_{OUT}



3.7 Loop Response

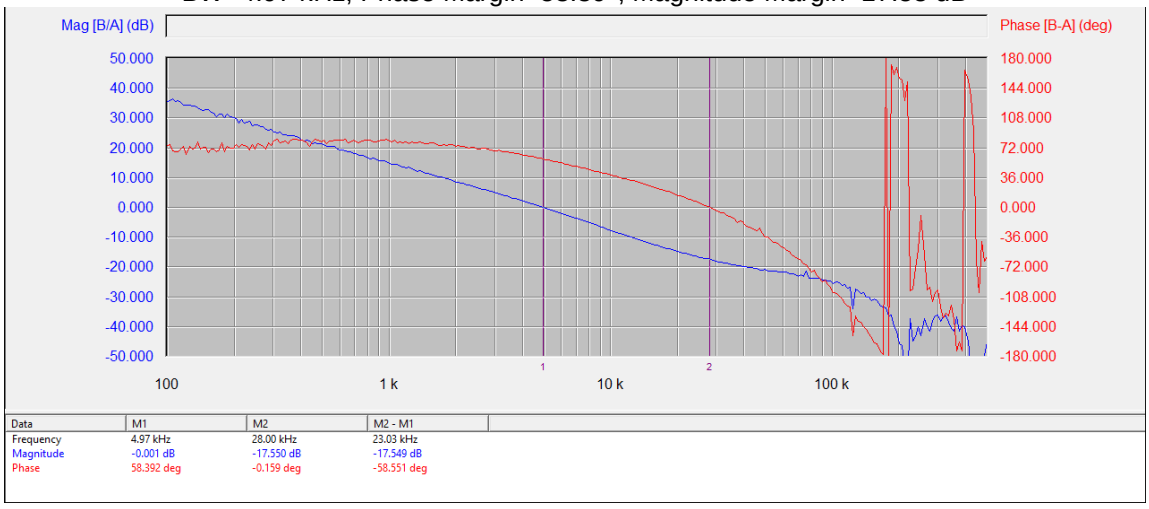
9V input

BW=4.24 kHz, Phase Margin=58.15°, Magnitude Margin=14.11 dB



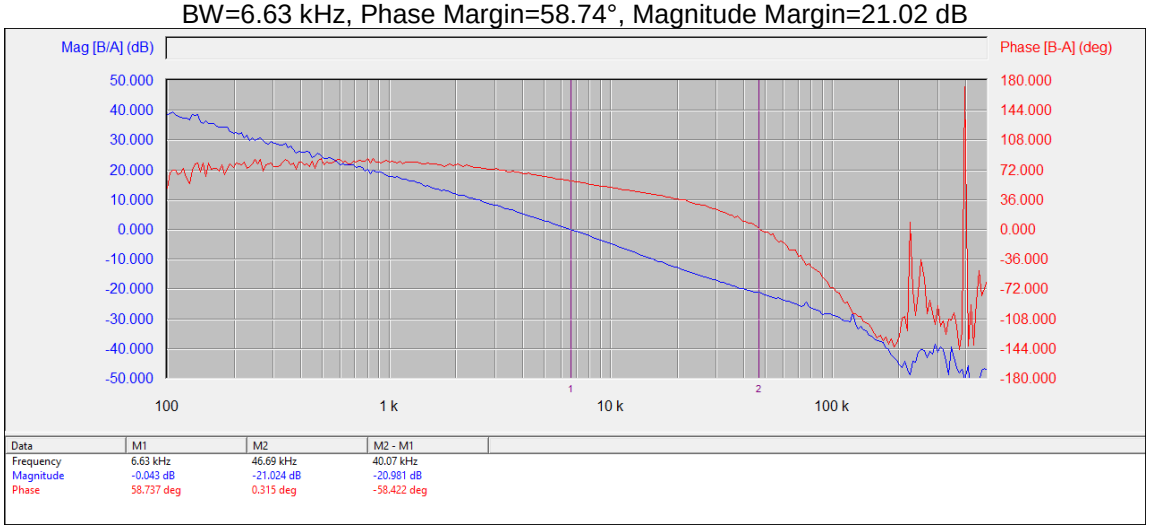
12V input

BW=4.97 kHz, Phase Margin=58.39°, Magnitude Margin=17.55 dB



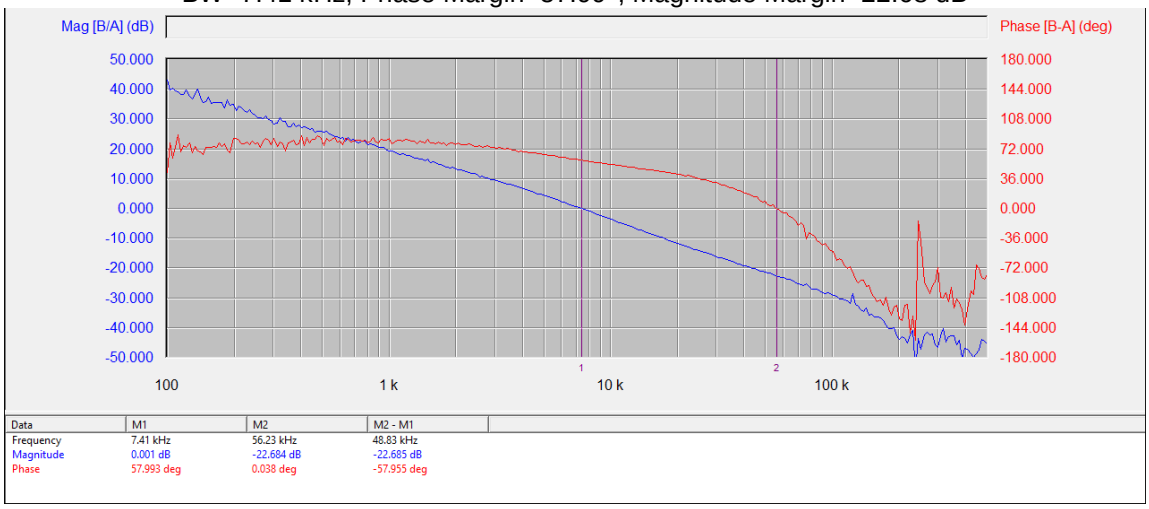
24V input

BW=6.63 kHz, Phase Margin=58.74°, Magnitude Margin=21.02 dB



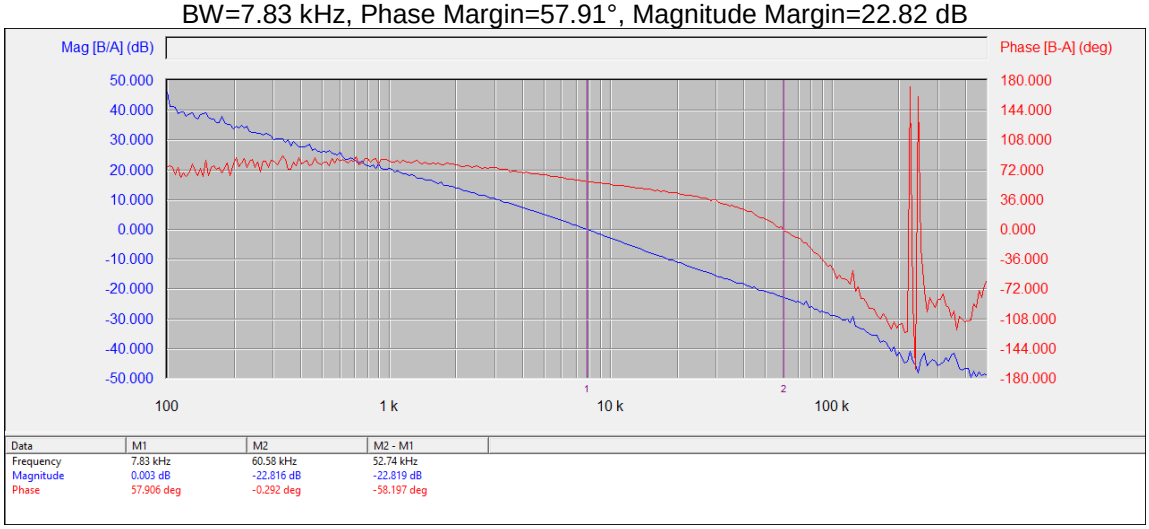
36V input

BW=7.41 kHz, Phase Margin=57.99°, Magnitude Margin=22.68 dB



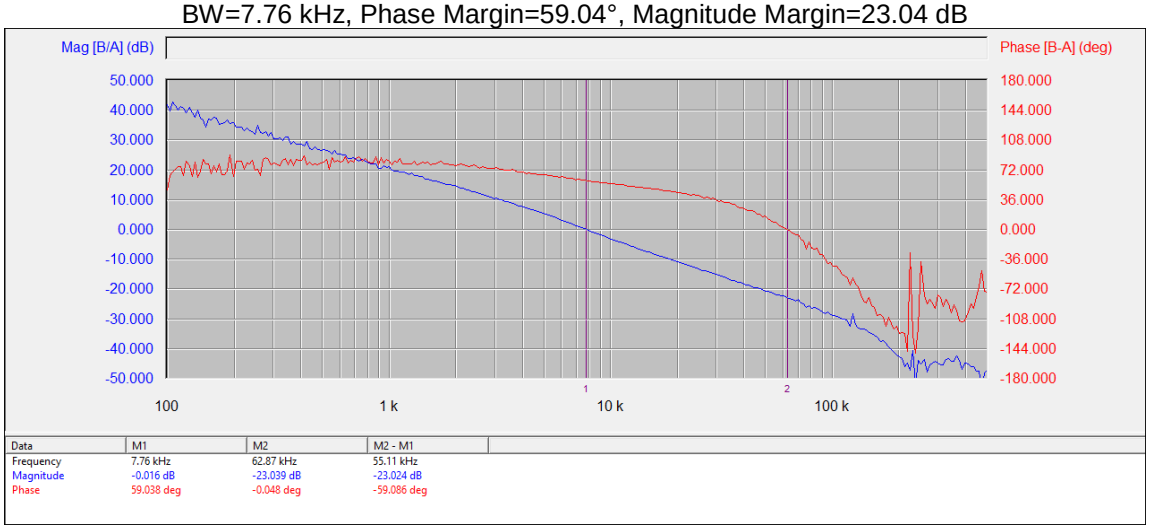
48V input

BW=7.83 kHz, Phase Margin=57.91°, Magnitude Margin=22.82 dB



60V input

BW=7.76 kHz, Phase Margin=59.04°, Magnitude Margin=23.04 dB



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