PMP10610
Test Report
05/01/2015

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I. Overview

The PMP10610 is a 12W SEPIC power supply reference design for automotive applications. It takes 12V nominal input voltage, and generates a 12V @ 1A output with 92% peak efficiency. The SEPIC converter topology allows voltage step-up and step-down conversion. The design covers a wide input range of 4.5V to 20V. When using it in the 12V car battery system, the design can operate uninterrupted during vehicle start-stop. The reference design features the LM3481 as the SEPIC controller, and it is available in automotive grade AEC-Q100 Grade 1. The design uses single coupled inductor to achieve compact solution size. The component area of the SEPIC is about 24 x 30 mm (1.2 x 0.95 inch). The reference board is layout-optimized for improved EMI performance, and there is an optional input EMI filter section on the board. The board is tested under the automotive EMC standard, CISPR 25, and its conducted emissions are in compliance with the CISPR 25 Class 5 limits.

II. Power Specification

Input Voltage:	12V nominal, 4.5V – 20V
	(Minimum Vin is 5V with the EMI filter)
Output:	12V @ 1A
Total output power:	12W
Switching frequency:	500 kHz

III. Reference Board

The board size is 76 x 76 mm (3 x 3 inch). The SEPIC component area is 24 x 30 mm (1.2 x 0.95 inch).

Figure 1 Reference board top view

Figure 2 Reference board bottom view

IV. Efficiency and Regulation

The efficiency and output regulation was measured without the EMI filter section at different input voltage condition.

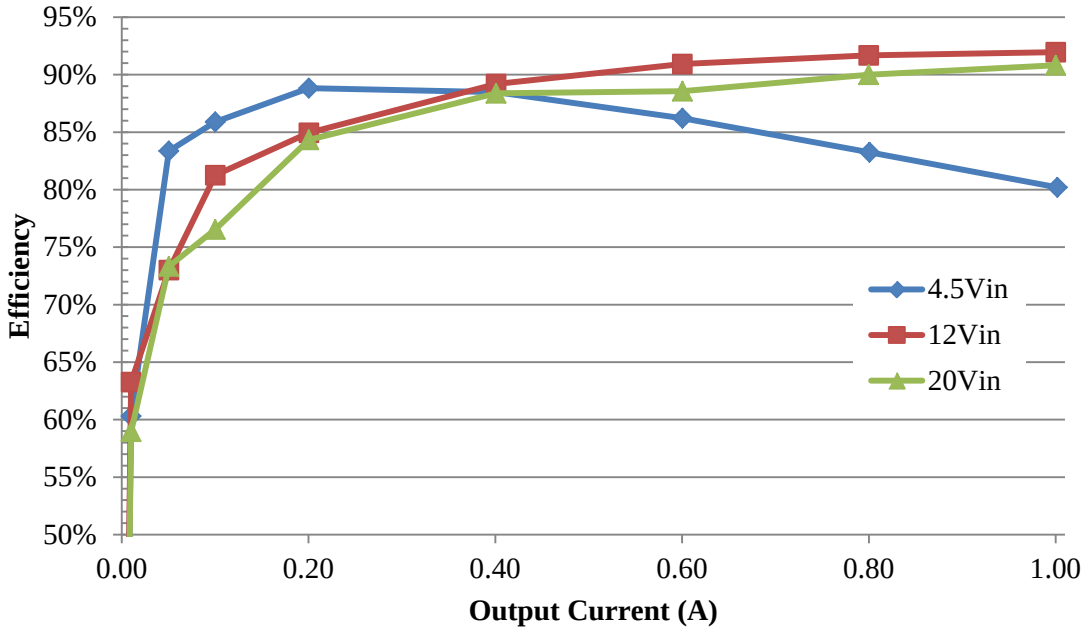

Figure 3 Power efficiency

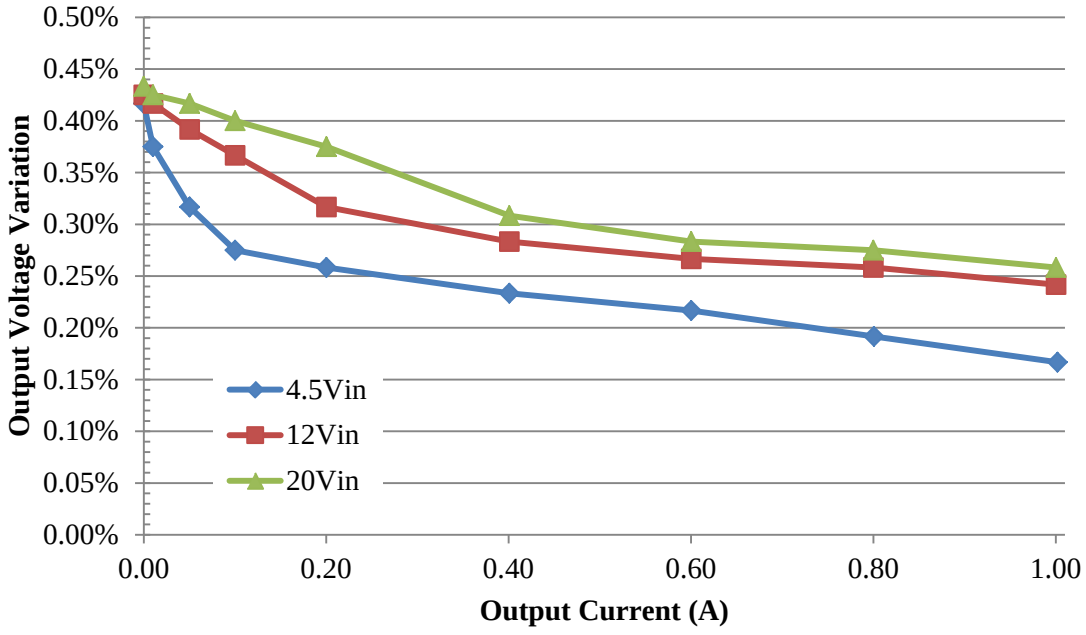

Figure 4 Output regulation

V. Thermal

The thermal image was taken at 23°C room temperature, no air flow. The board was operating at 12V input, full load.

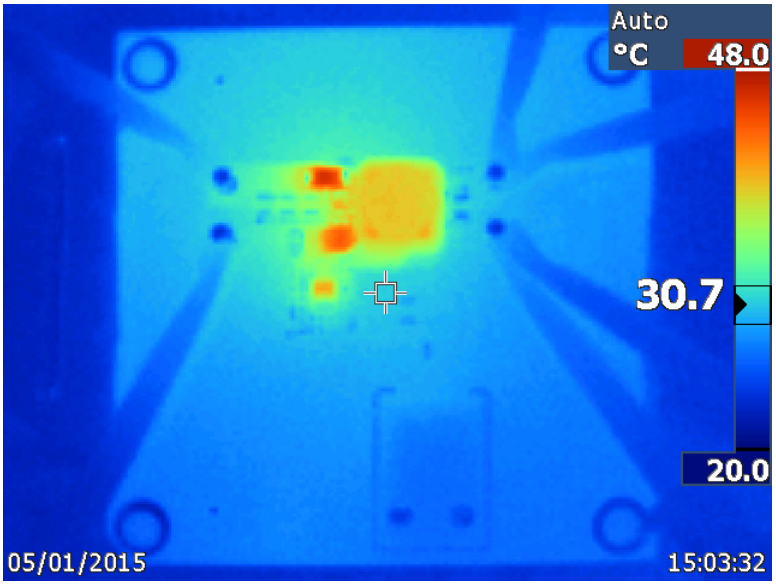

Figure 5 Thermal image from top view

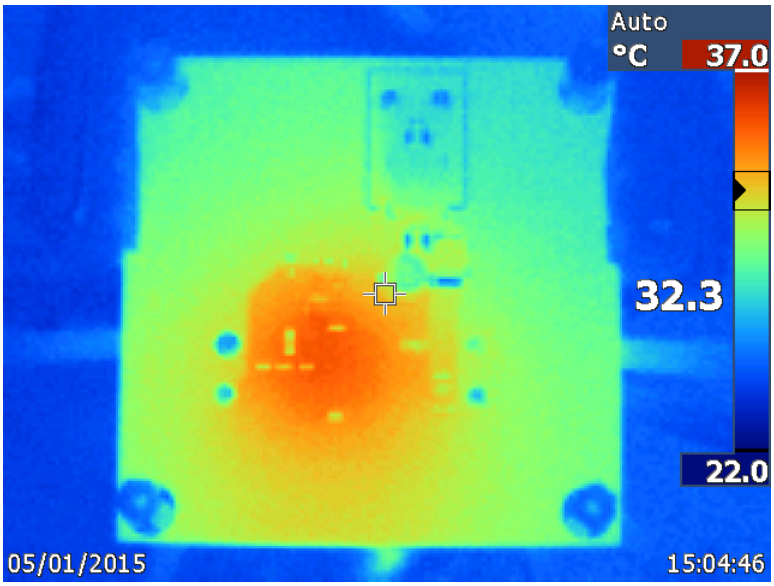

Figure 6 Thermal image from bottom view

VI. Conducted EMI

The conducted emissions were tested under the CISPR 25 standards. The test setup is shown in Figure 7. The input voltage was set at 13V and supplied to the reference board through two CISPR 25 compliant LISNs (Line Impedance Stabilization Networks). The input supply cables was connected to the filter input terminals, IN+ and IN-, and one 12Ω power resistors were soldered on the output terminals of the test board as the 1A load.

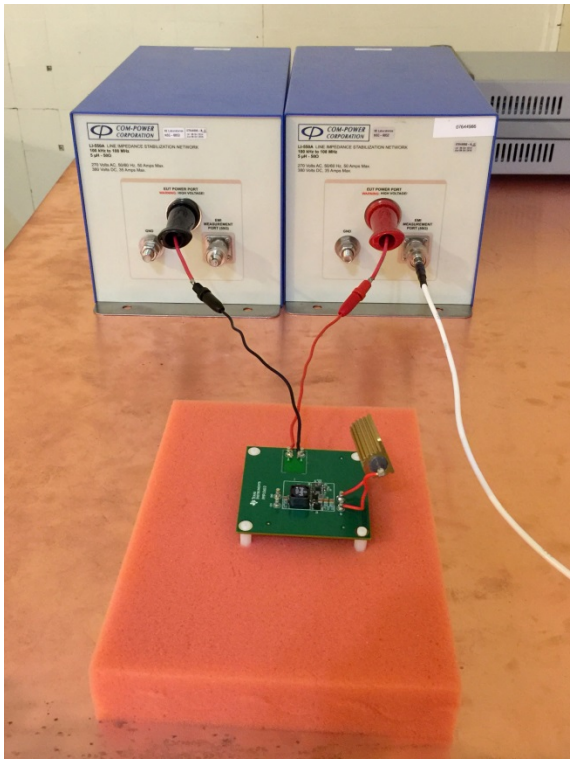

Figure 7 Conducted EMI Test Setup

The frequency band examined spans from 150 kHz to 108 MHz covering the AM, FM radio bands, VHF band, and TV band specified in the CISPR 25. The scan results (Figure 8, Figure 9,) show the EMI noise using peak detector (yellow) and average detector (blue) in the spectrum analyzer. The limit lines in red are the Class 5 limits for conducted disturbances at different frequency bands specified in the standard, and the peak limits are the higher ones than the average limits. It can be seen that, with the EMI filter, the peak/average noise is lower than the corresponding peak/average limits in the scan results. Therefore, the SEPIC power supply board is in compliance with the CISPR 25 Class 5 conducted emissions standard.

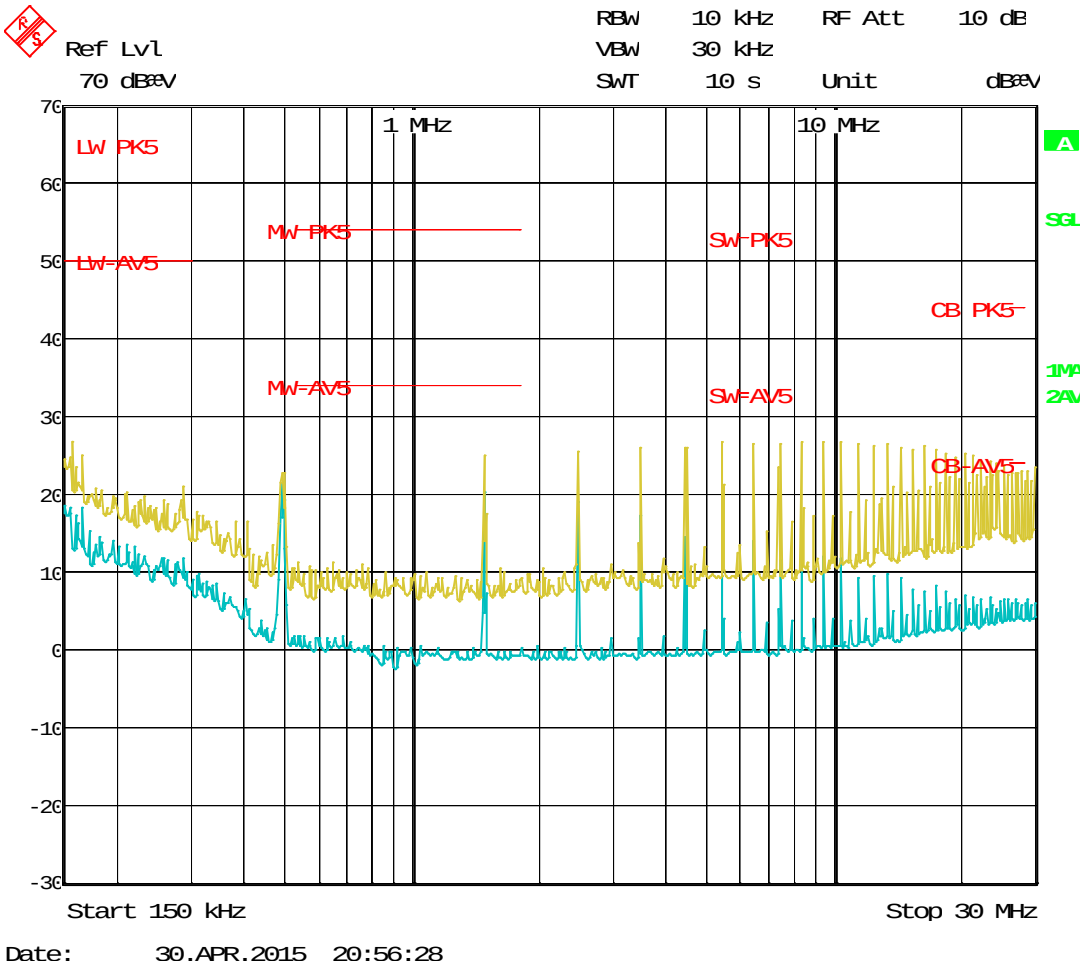

Figure 8 Conducted EMI scan, 150 kHz – 30 MHz, with the EMI filter

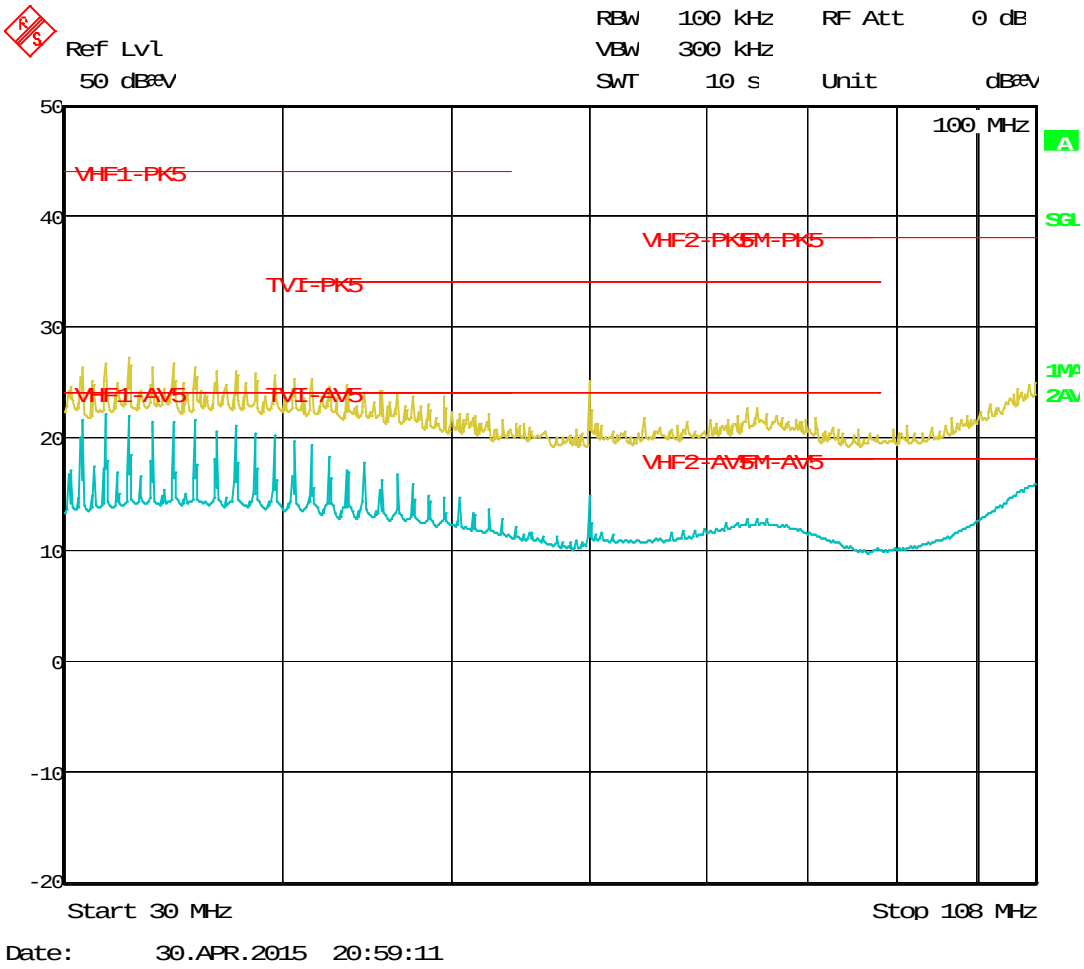

Figure 9 Conducted EMI scan, 30 MHz – 108 MHz, with the EMI filter

VII. Power Up

The reference board was tested under no load and full load at 12V input. Ch1 (yellow) is the input voltage, and Ch2 (green) is the output voltage.

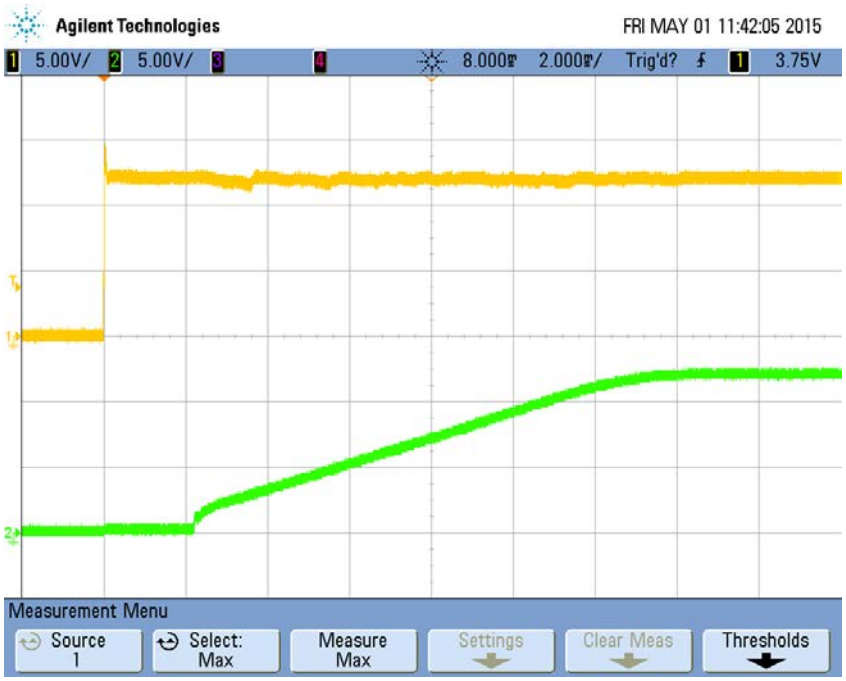

Figure 10 Power up into no load at 12V input

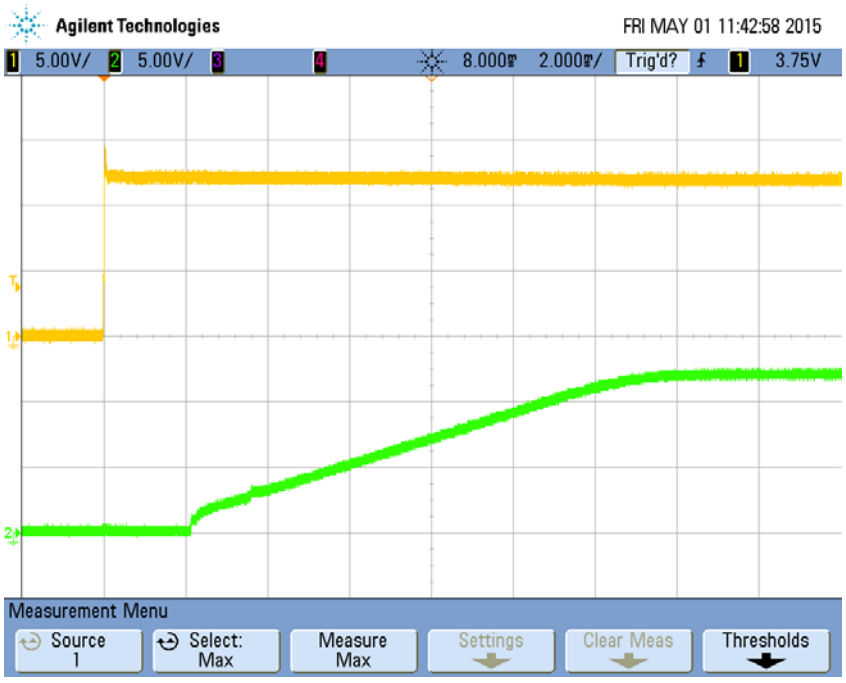

Figure 11 Power up into full load at 12V input

VIII. Switching Waveforms

The switch node voltage was measured at the drain terminal of the Q1 FET. Ch1 (yellow) is the switch node voltage.

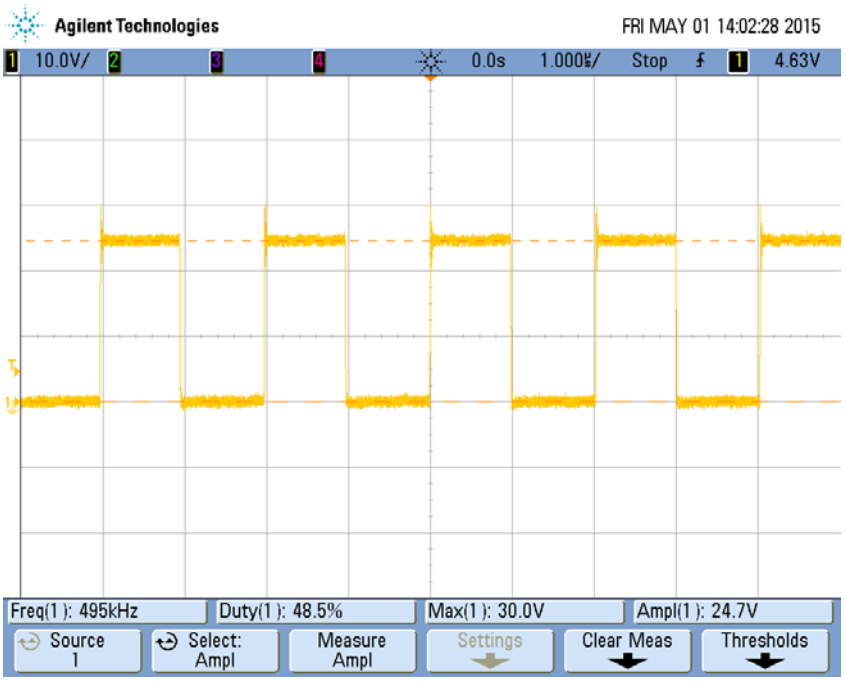

Figure 12 Switch node voltage at full load, 12V input

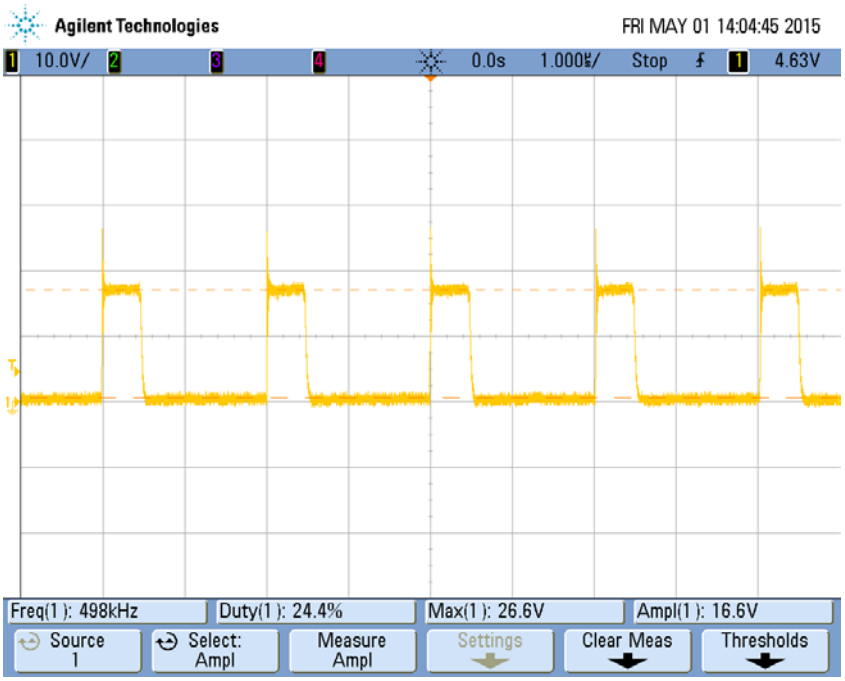

Figure 13 Switch node voltage at full load, 4.5V input

The voltages across the output diode D2 was measured at full load and 20V input, where the diode had the highest voltage pulses. The result shows that the max voltage across the diode is lower than its 40V rating. Ch1 (yellow) shows the voltage across the diode.

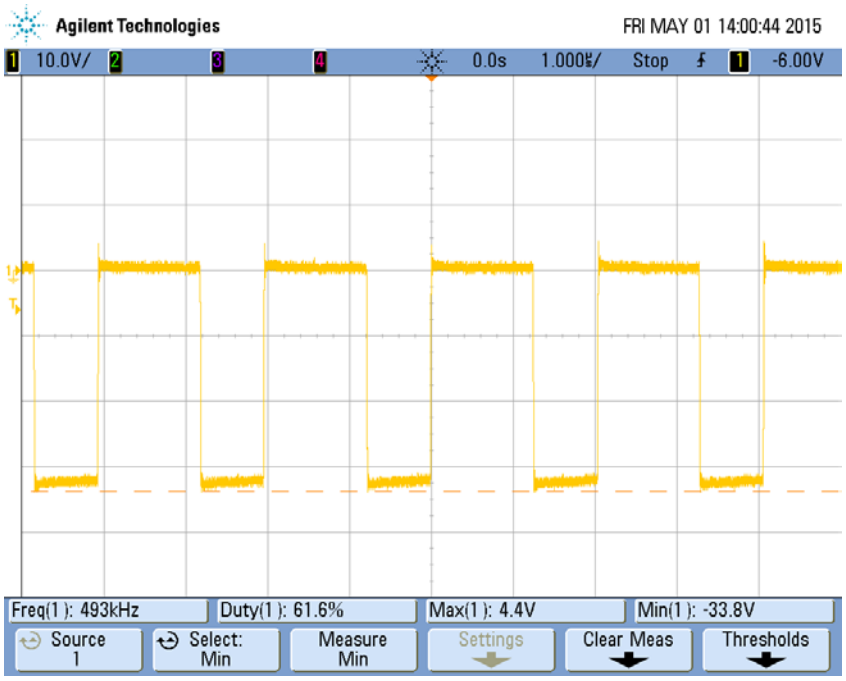

Figure 14 Output diode anode (+) to cathode (-) voltage at full load, 20V input

IX. Load Transients

The load transient responses were tested by applying output load steps from 50% to 100% at different input voltages. Ch1 (yellow) is the output voltage in AC mode, and Ch4 (magenta) is the output current.

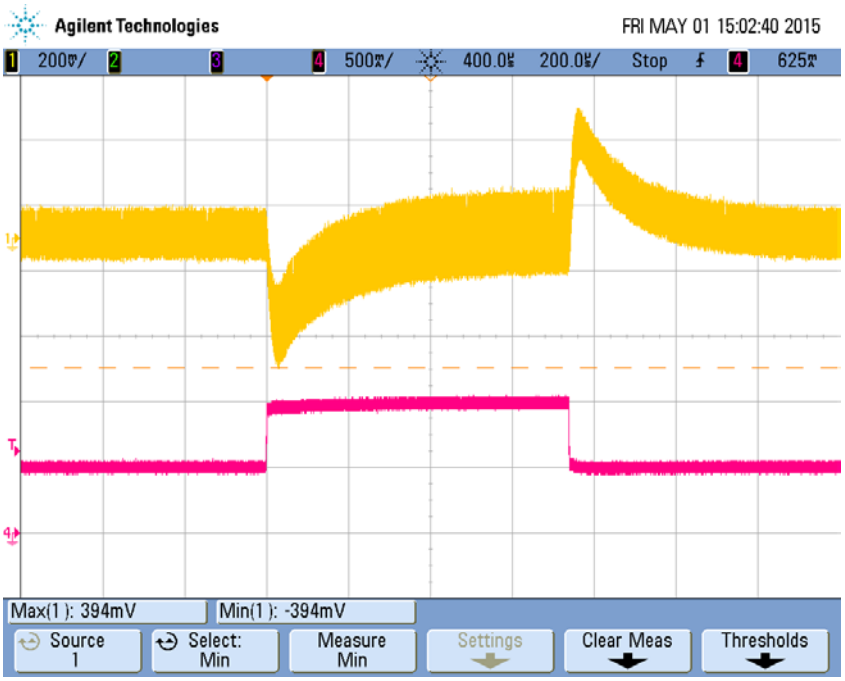

Figure 15 Output load transient response at 12V input

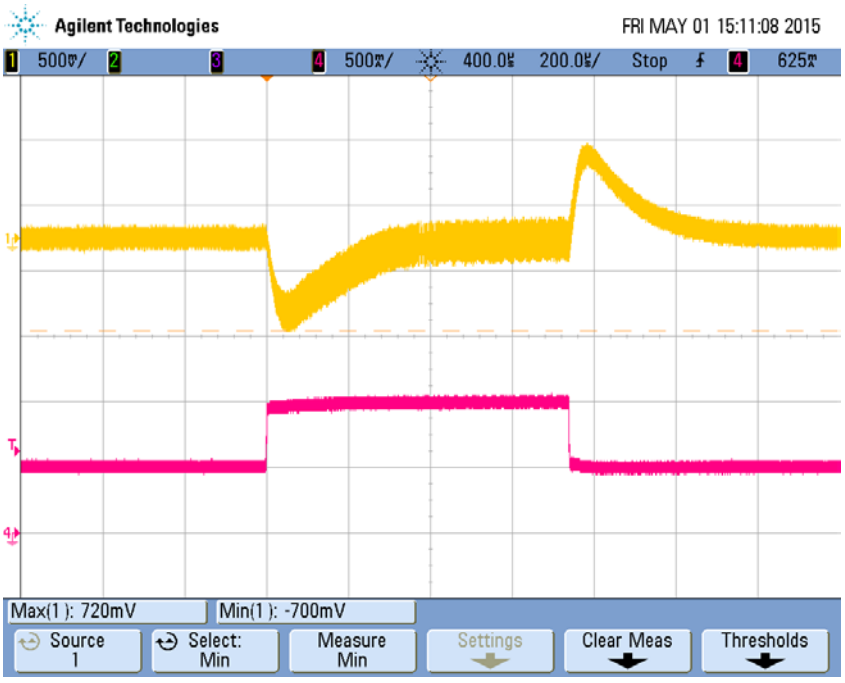

Figure 16 Output load transient response at 4.5V input

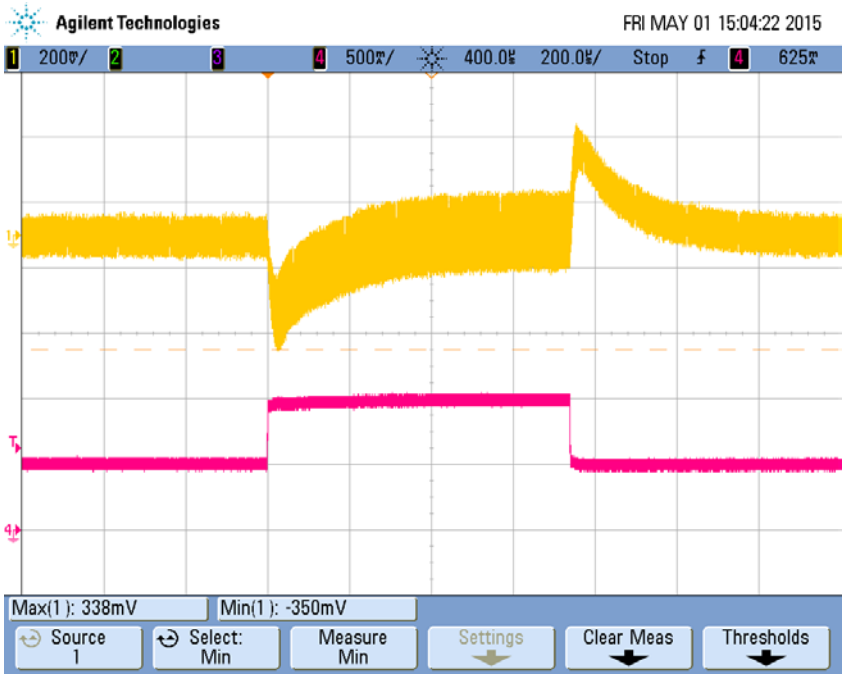

Figure 17 Output load transient response at 20V input

X. Output Voltage Ripples

The output ripples were measured directly at the output capacitors at full load condition. Ch1 (yellow) is the output voltage ripple in AC mode.

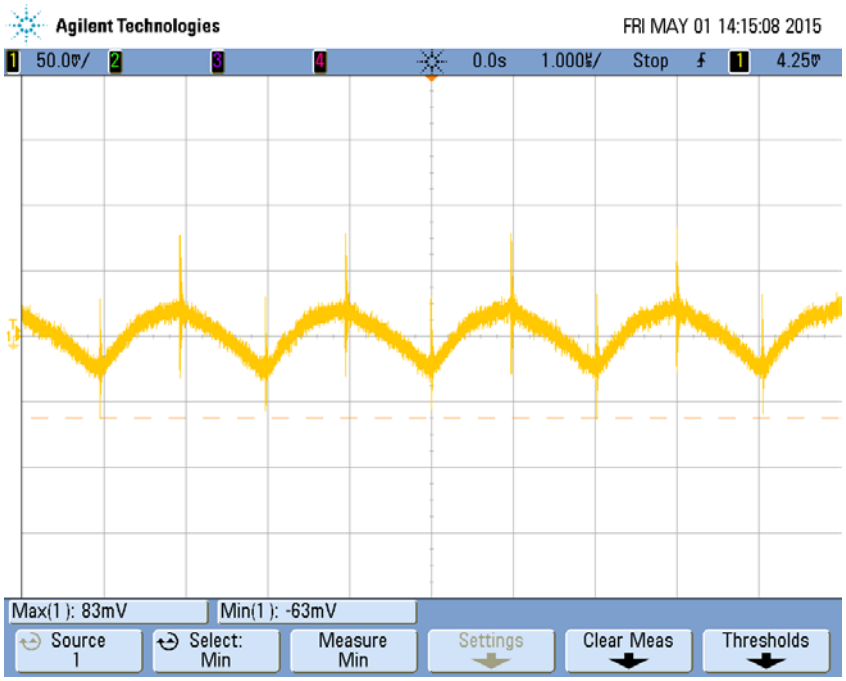

Figure 18 Output ripple at full load, 12Vin

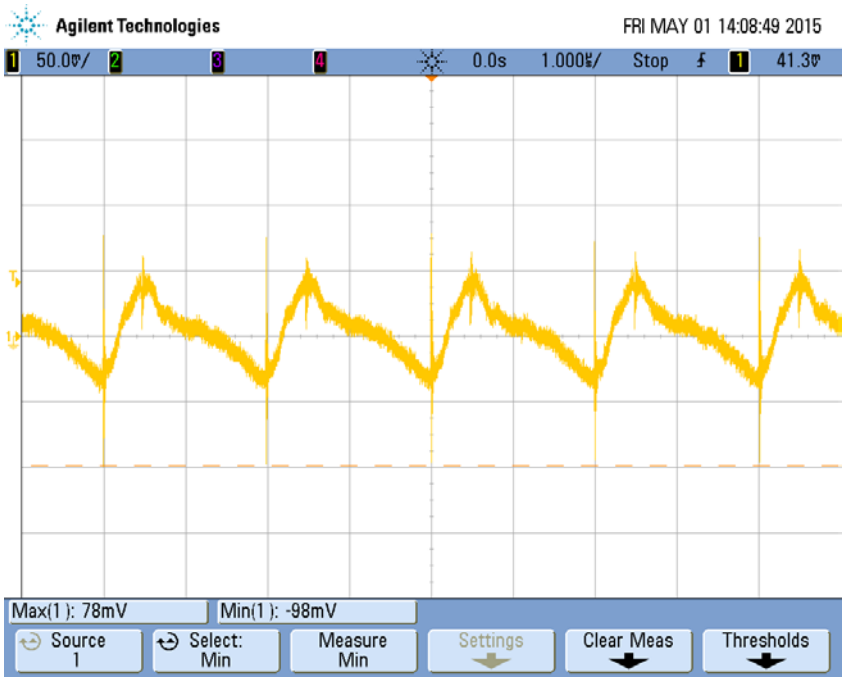

Figure 19 Output ripple at full load, 4.5Vin

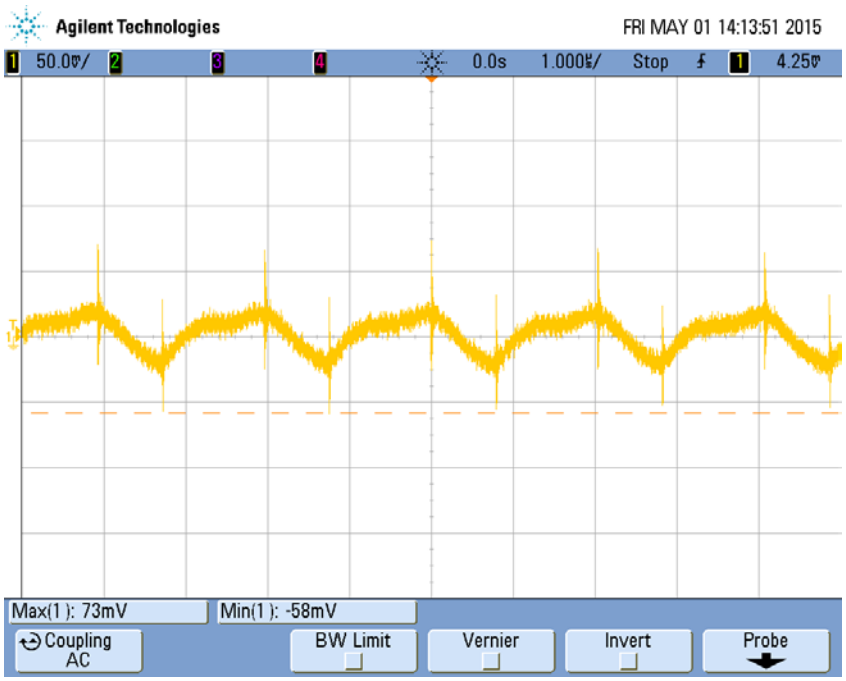

Figure 20 Output ripple at full load, 20Vin

XI. Closed Loop Response

The closed loop gain was measured by injecting a small AC signal across the 24.9Ohm resistor, R5, in series with the feedback loop. The Bode plots were obtained by using an AP200 network analyzer. The result shows the design has good phase margin for the entire input range.

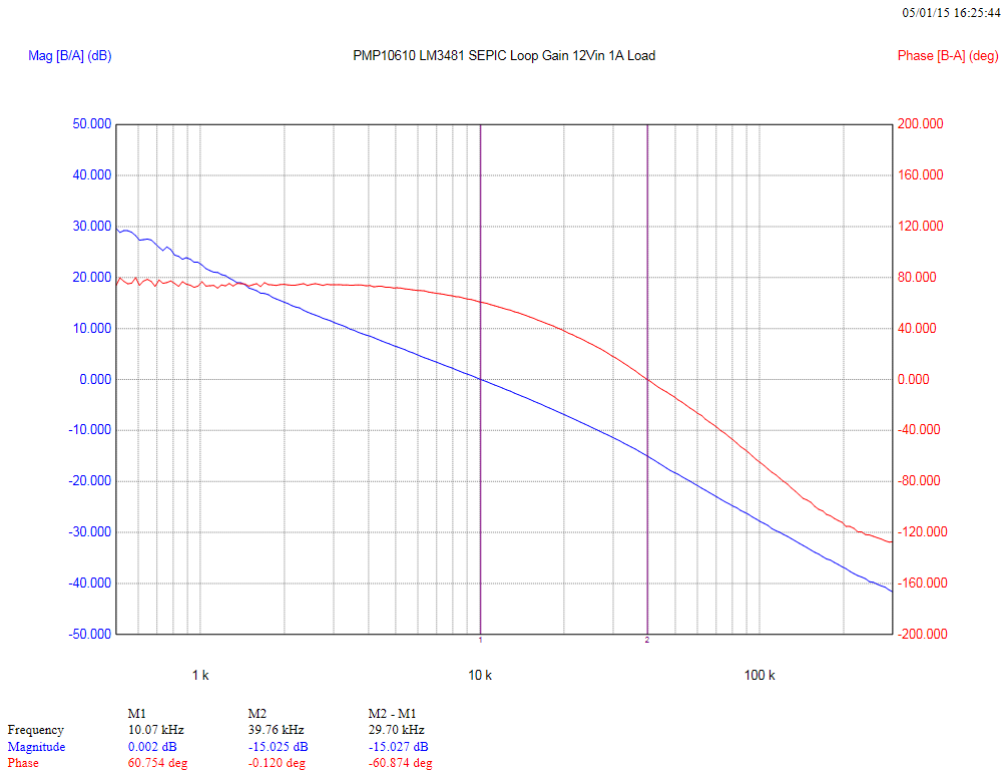

Figure 21 Closed loop response at full load, 12Vin

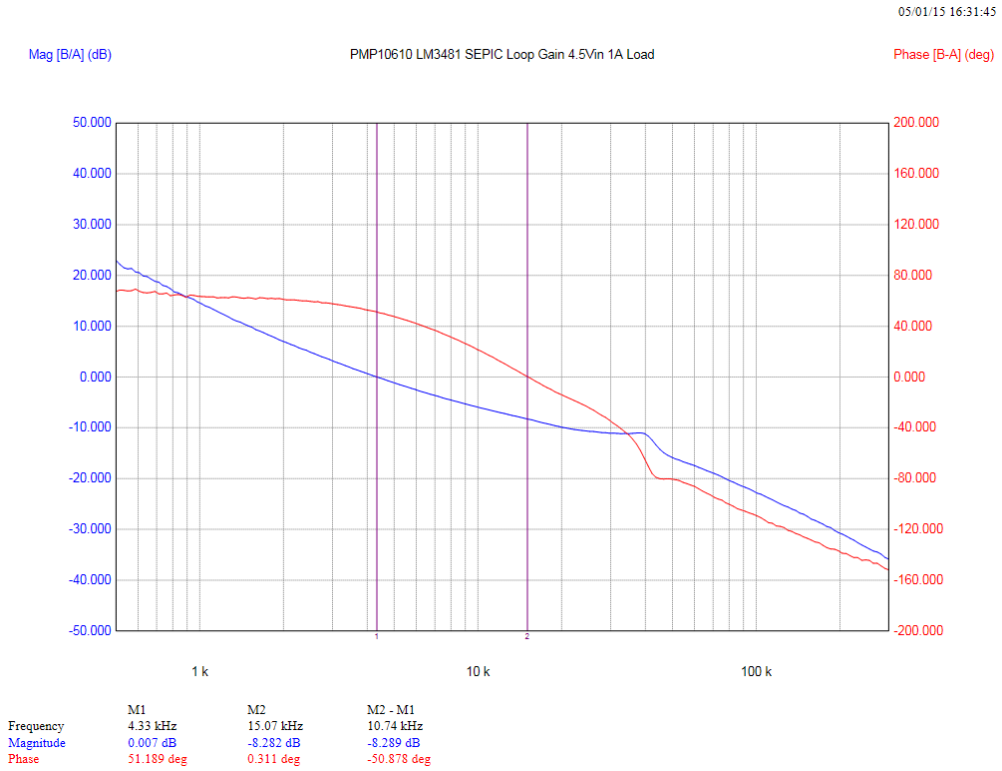

Figure 22 Closed loop response at full load, 4.5Vin

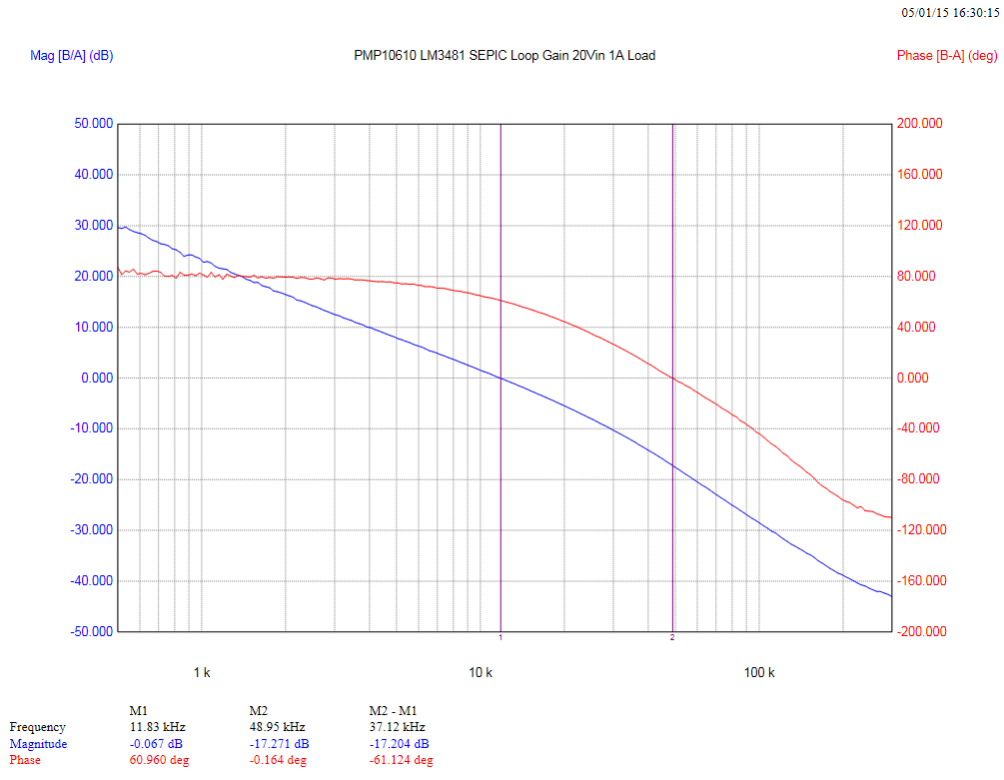

Figure 23 Closed loop response at full load, 20Vin

Appendix: Efficiency and Regulation Test Data

4.5V input

Vin(V)	Iin(A)	Vout(V)	Iout(A)	Efficiency (%)
4.508	0.004	12.050	0.000	0.0%
4.502	0.045	12.045	0.010	60.3%
4.503	0.162	12.038	0.050	83.4%
4.500	0.312	12.033	0.100	85.9%
4.504	0.603	12.031	0.200	88.8%
4.509	1.208	12.028	0.401	88.5%
4.505	1.859	12.026	0.600	86.2%
4.502	2.569	12.023	0.801	83.2%
4.513	3.327	12.020	1.002	80.2%

12V input

Vin(V)	Iin(A)	Vout(V)	Iout(A)	Efficiency (%)
12.010	0.003	12.051	0.000	0.0%
12.007	0.016	12.050	0.010	63.3%
11.999	0.069	12.047	0.050	73.0%
12.000	0.124	12.044	0.100	81.3%
12.038	0.236	12.038	0.200	84.9%
12.000	0.451	12.034	0.401	89.2%
12.001	0.662	12.032	0.600	90.9%
12.008	0.874	12.031	0.800	91.7%
12.005	1.090	12.029	1.000	92.0%

20V input

Vin(V)	Iin(A)	Vout(V)	Iout(A)	Efficiency (%)
20.010	0.003	12.052	0.000	0.0%
20.008	0.010	12.051	0.010	59.0%
20.004	0.041	12.050	0.050	73.3%
20.008	0.079	12.048	0.100	76.5%
19.998	0.143	12.045	0.200	84.3%
20.028	0.273	12.037	0.401	88.4%
20.007	0.408	12.034	0.600	88.6%
20.061	0.533	12.033	0.800	90.0%
20.041	0.661	12.031	1.000	90.8%

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