Test Report: PMP30942

5-W Inverting Buck-Boost Reference Design

Description

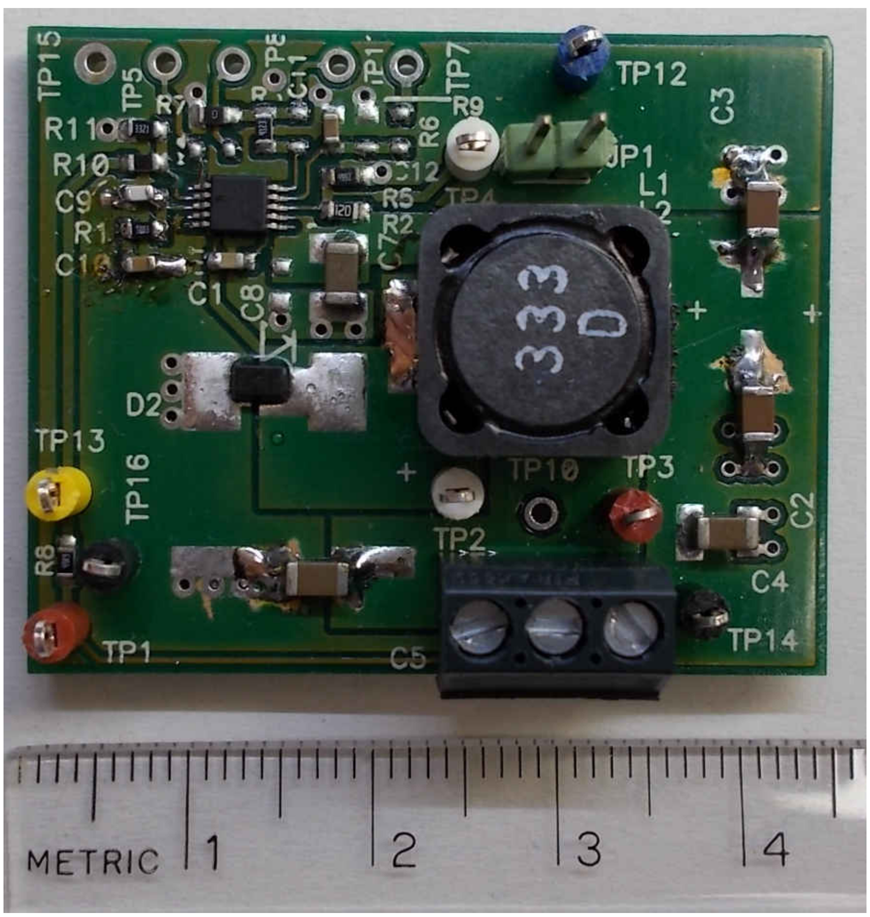
This tiny inverting buck boost provides negative voltage up to –45 V out of input voltage 5.2 V for light detection and ranging (LIDAR) applications. Maximum load current is limited here to 120 mA – for bigger loads, use the TPS54260 or TPS54360 devices. Those buck devices are well suited to cover the needed high duty cycle range and easily start up well below 5-V input.

Features

- SIMPLE SWITCHER® power converter using integrated FET in inverting buck-boost configuration
- Cost-effective inverter using just a single inductor and a standard buck device
- Sinusoidal input and output ripple reduces conducted emissions
- Clean waveforms (no ringing, no overshoot) prevents FM band noise

Applications

- Mechanically scanning LIDAR
- Robot sensing module
- Mobile robot sensing module
- Drone vision



Board Photo (Top)

1 Test Prerequisites

1.1 Voltage and Current Requirements

Table 1-1. Voltage and Current Requirements

Parameter	Specifications
IC	TPS57160-Q1
Topology	Inverting Buck Boost
Input Voltage Range	4.7 V to 5.7 V
Output Voltage	-45 V
Maximum Output Current	120 mA
Switching Frequency	300 kHz

1.2 Considerations

Remember the following considerations while working with this design:

- The measured switching frequency is around 280 kHz
- The circuit starts up at an input voltage of 4.4 V
- Unless otherwise mentioned, the test was done with a input voltage of 5.2 V and output current was adjusted to 0.12 A with a resistor
- For availability reasons, this design was tested using the Coilcraft MSS1260-333 (33 µH)
- The Coilcraft XGL6060-333 is recommended for the smallest board space

1.3 Dimensions

The PMP30942 board dimensions are 41.9 mm × 33.7 mm.

2 Testing and Results

2.1 Efficiency Graphs

Efficiency is shown in the following figure.

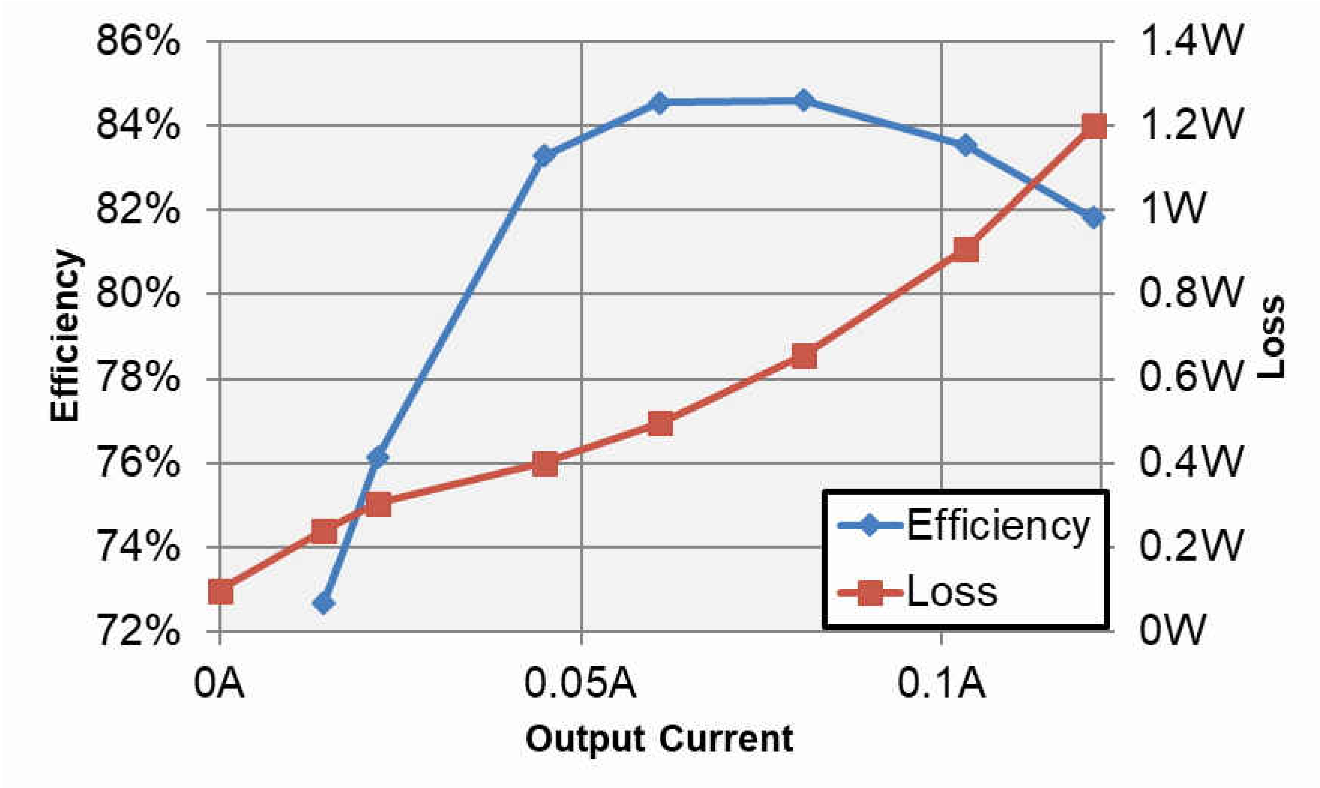


Figure 2-1. Efficiency and Loss vs Output Current

2.2 Load Regulation

The load regulation is shown in the following curve.

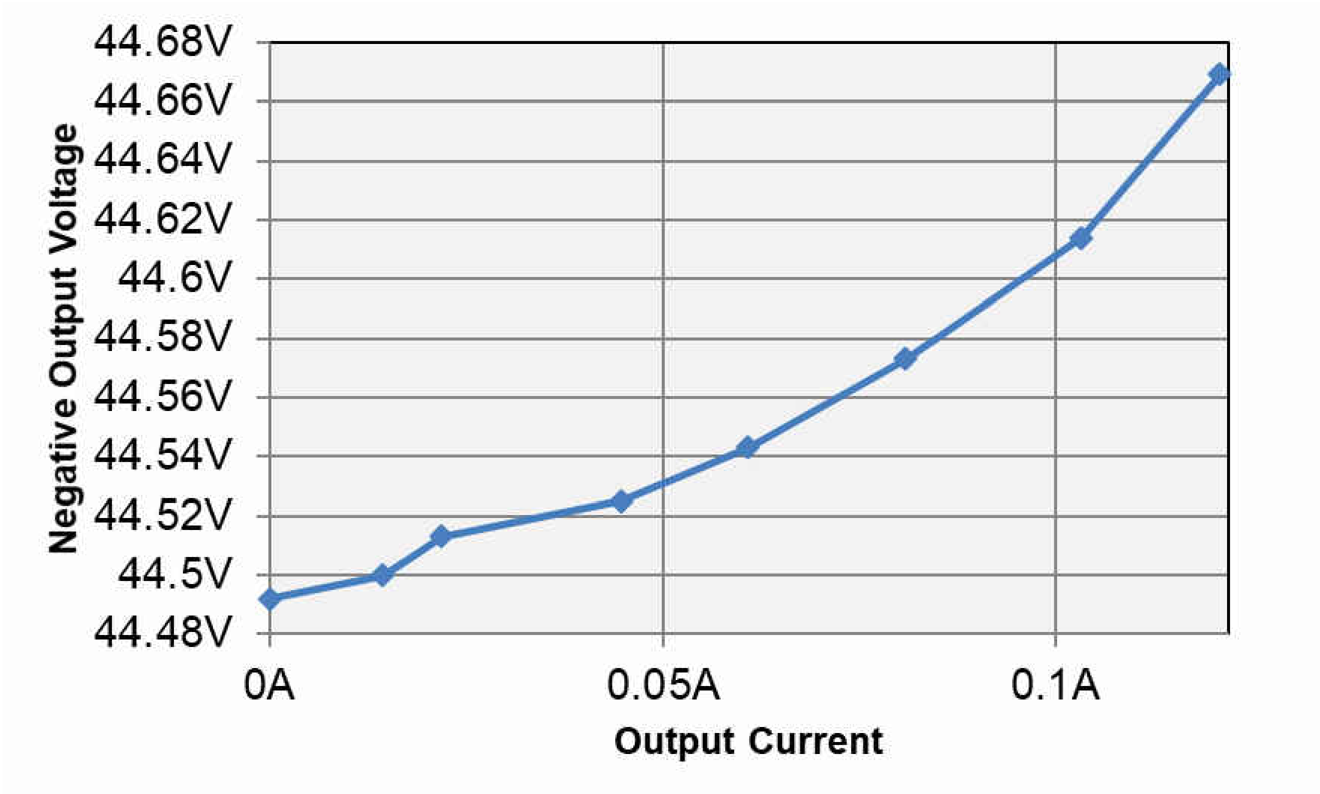


Figure 2-2. Output Voltage vs Output Current

2.3 Thermal Images

The thermal image is shown in the following figure.

Figure 2-3. Thermal Image

Name	Temperature
D2	50.6°C
L1	50.1°C
U1	81.6°C

2.4 Bode Plots

The bode plot is shown in the following figure.

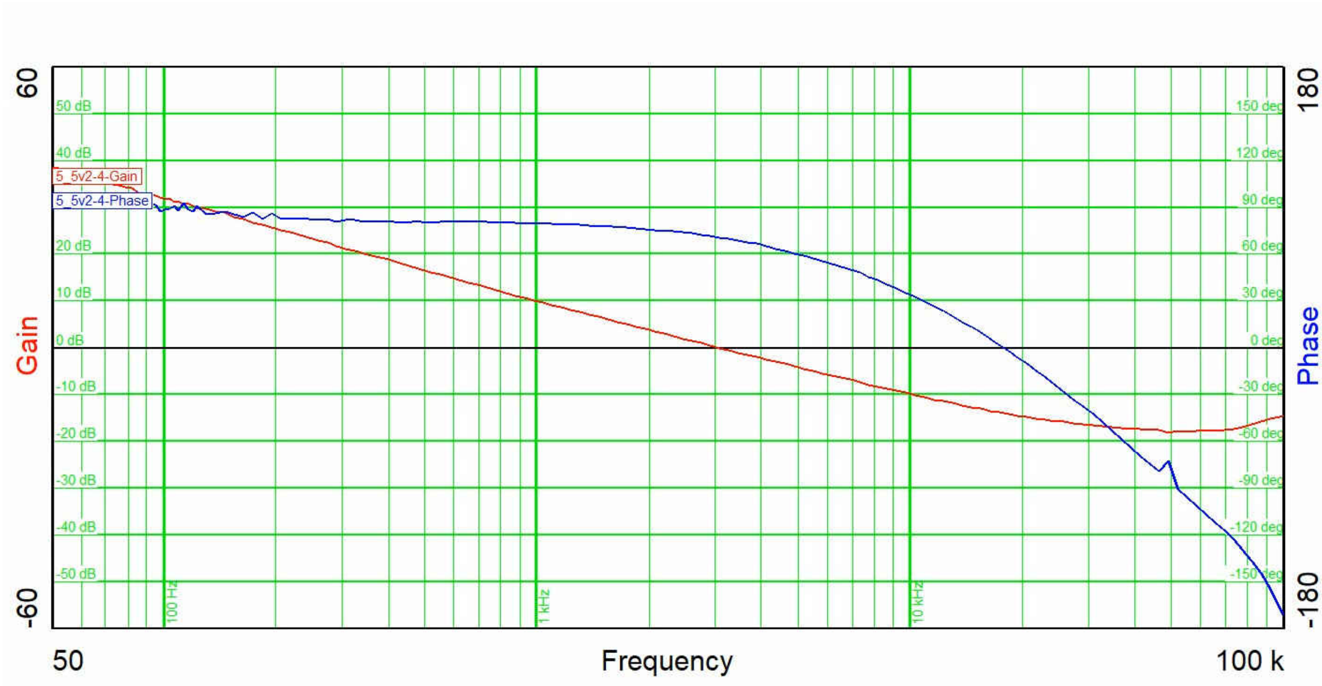


Figure 2-4. Control Loop Frequency Response

V_{IN}	**5.2 V**
Bandwidth (kHz)	3
Phase Margin	70.7°
Slope (20 dB / decade)	–0.95
Gain Margin (dB)	–14
Slope (20 dB / decade)	–0.73
Freq (kHz)	17.8

3 Waveforms

3.1 Switching

3.1.1 Switchnode to GND

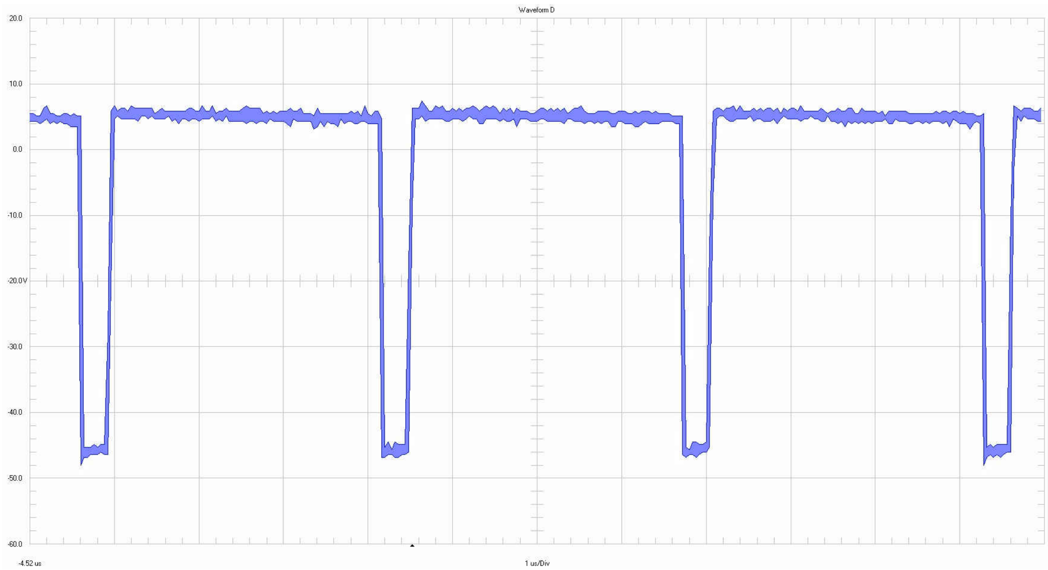
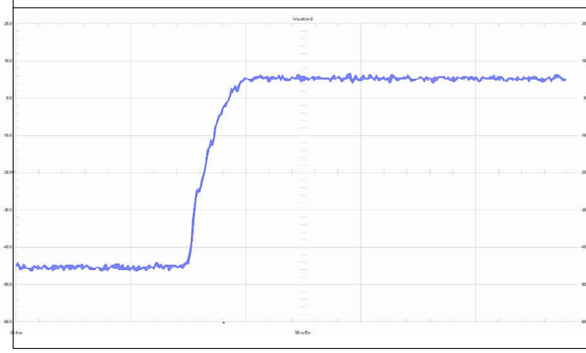
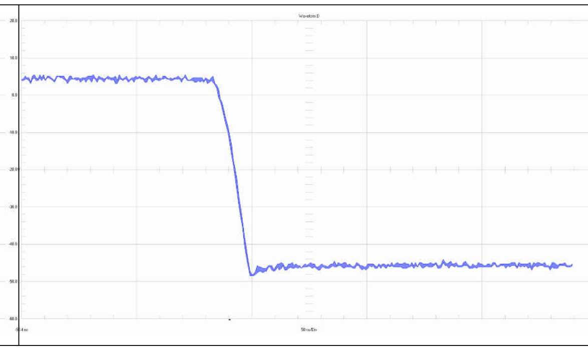
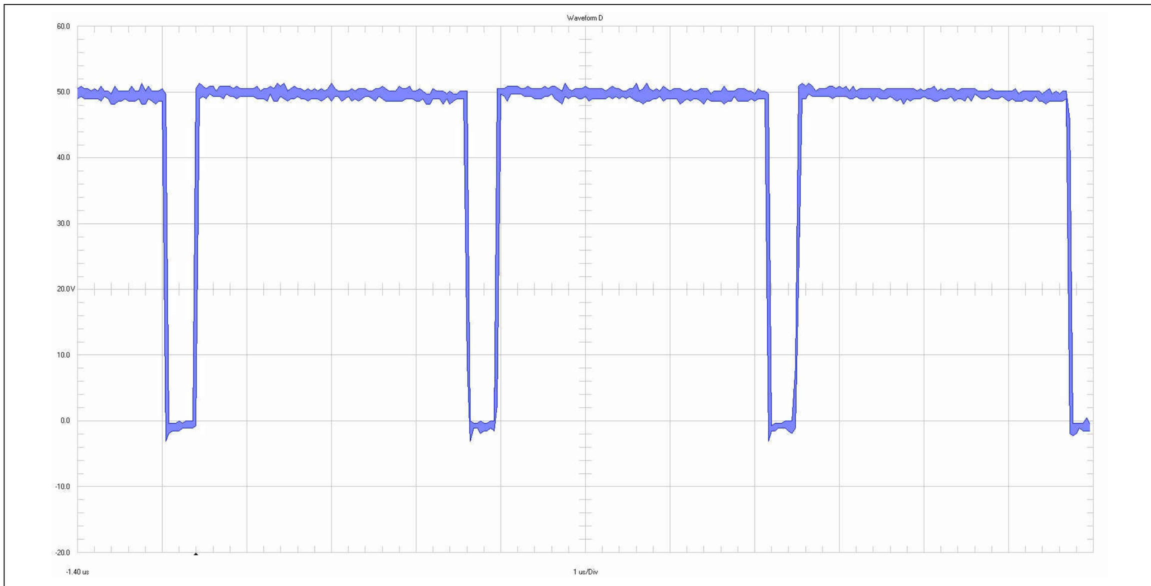
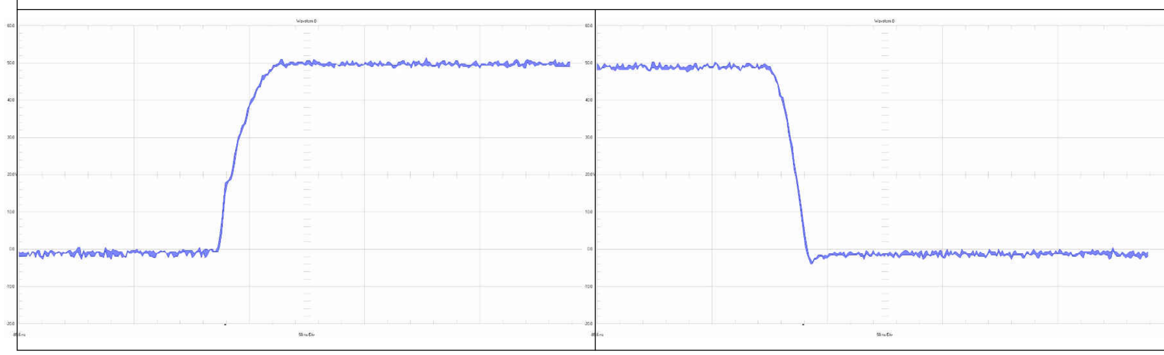
	10 V / div 1 µs / div full bandwidth
 	10 V / div 50 ns / major div full bandwidth

Figure 3-1. Switchnode to GND

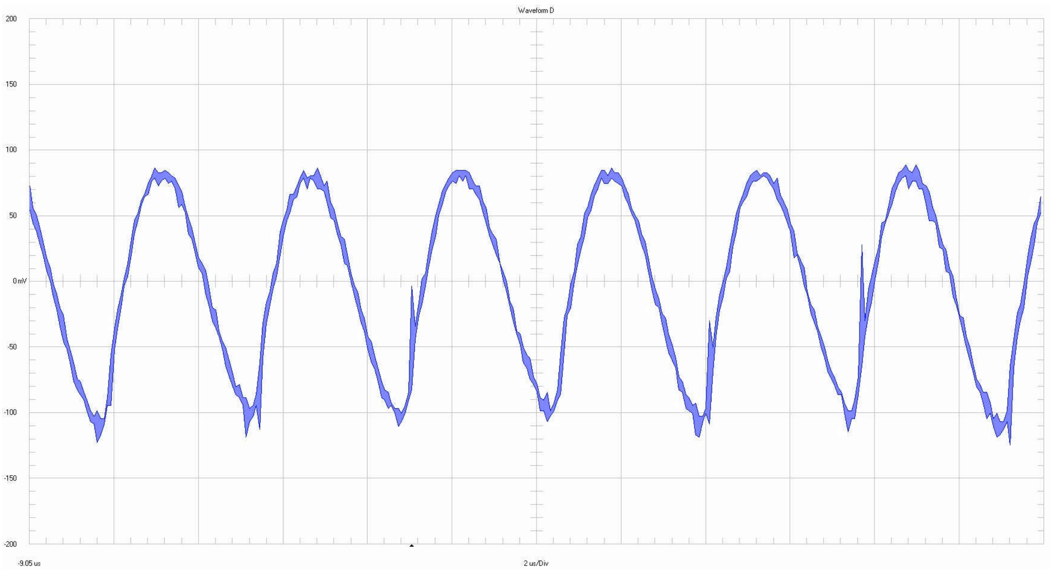
3.1.2 Switchnode to $–V_{OUT}$

	10 V / div 1 µs / div full bandwidth
	10 V / div 50 ns / major div full bandwidth

The waveforms do not show any ringing and no overshoot.

Figure 3-2. Switchnode to –VOUT

3.2 Input Voltage Ripple

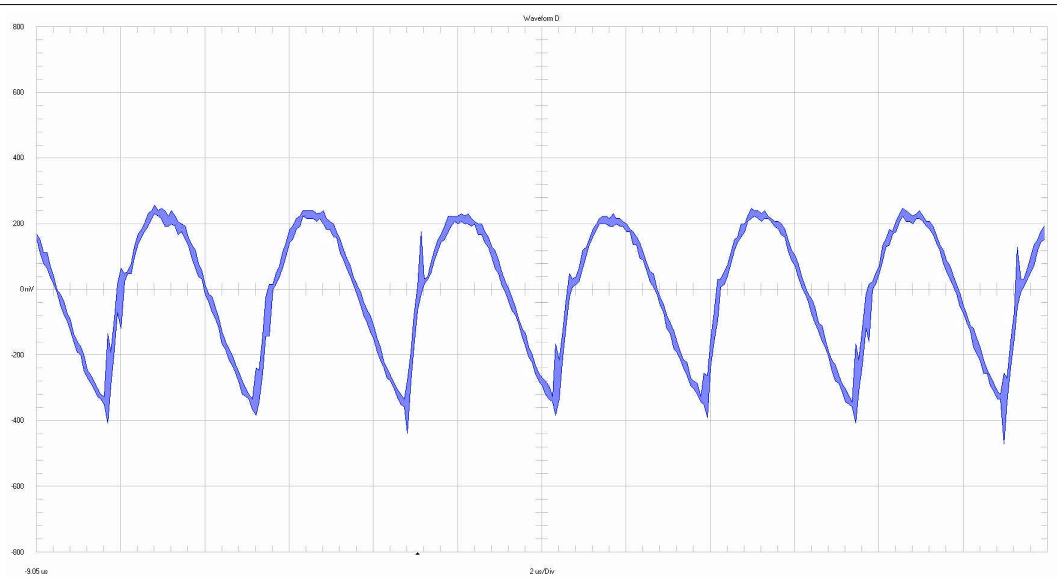


50 mV / div
(AC coupled)
2 µs / div
full bandwidth

The amplitude of the waveform is around 200 mV_{pp} sinusoidal.

Figure 3-3. Input Voltage Ripple

3.3 Output Voltage Ripple



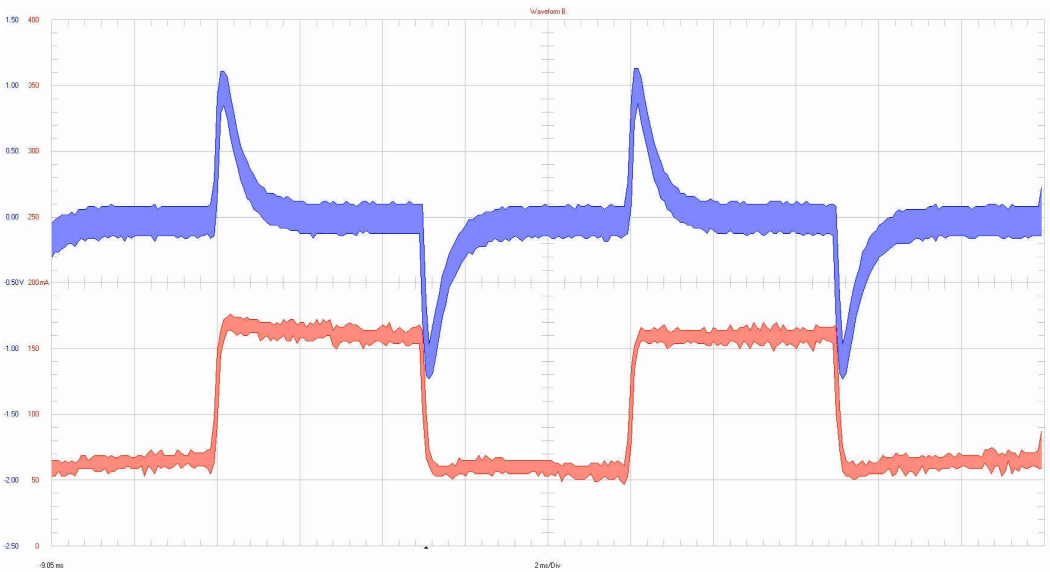
200 mV / div
(AC coupled)
full bandwidth

The amplitude of the waveform is around 600 mV_{pp}.

Figure 3-4. Output Voltage Ripple

3.4 Load Transients

The electronic load switches between 0.6 A to 0.12 A with a frequency of 100 Hz – deviation 3% of V_{OUT}.



Output Voltage (upper curve)
0.5 V / div
full bandwidth

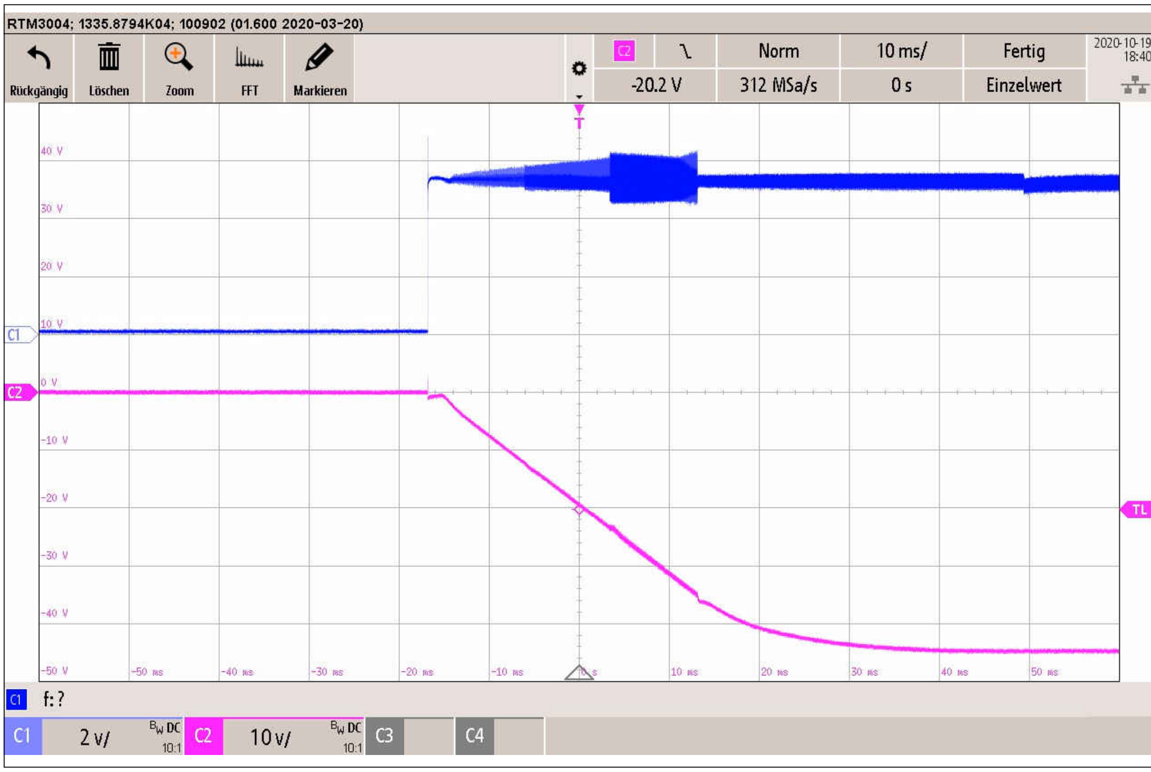
Ouput Current (lower curve)
50 mA / div
10 kHz bandwidth

2 ms /div

Figure 3-5. Load Transient 0.6 A - 0.12 A

3.5 Start-Up Sequence

The bandwidth was set to 20 MHz for both channels and soft start was set around 40 ms to 50 ms.



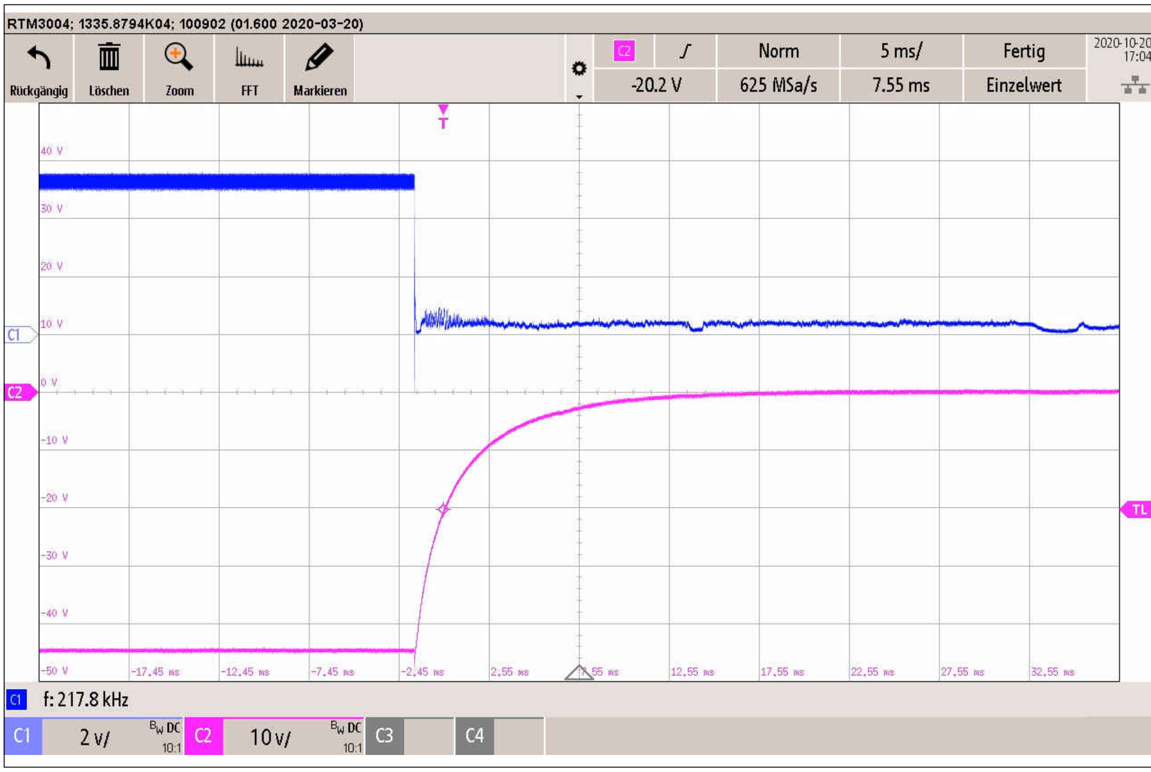
Channel C1 input voltage

Channel C2 output voltage

Figure 3-6. Start-up Sequence

3.6 Shutdown Sequence

The bandwidth was set to 20 MHz for both channels.



Channel C1 input voltage

Channel C2 output voltage

Figure 3-7. Shutdown Sequence