Test Report: PMP30602

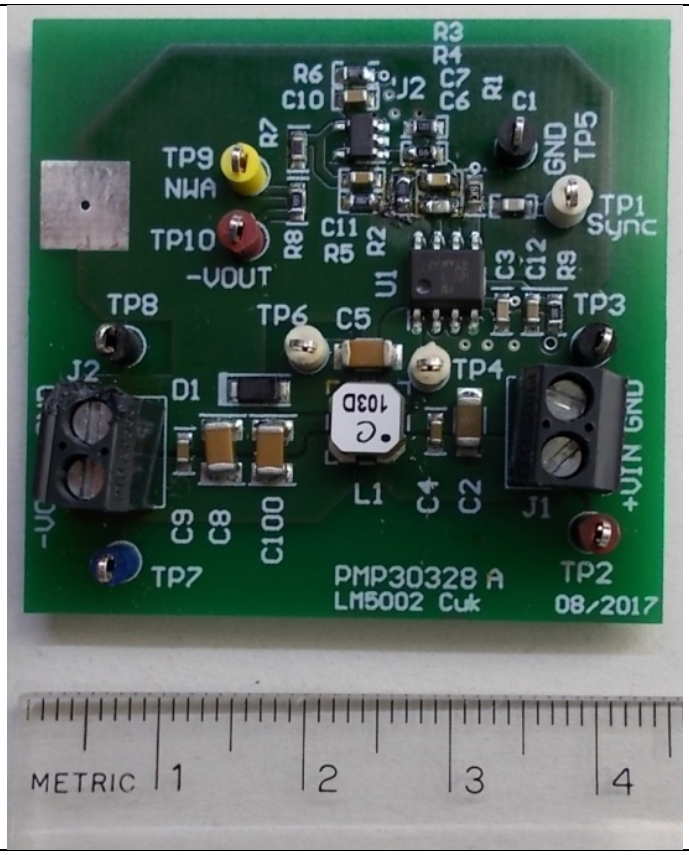
Tiny -60 V cuk reference design for automotive applications

Description

This tiny reference design delivers -60 V output voltage from an input voltage around 5V typically generated by an automotive pre regulator. The LM5001-Q1 is the controller,TLV271-Q1 converts the negative output voltage to be suitable for positive feedback (FB) input of the LM5001.
In general this converter is used as auxiliary supply for LiDAR applications. Due to duty cycle limitations some controllers are limited inverting 5V input to -60V output - PMP30602 and PMP30603 are offering cost effective solution to do so.

Features PMP30602:

- Small board space 30mm x 30mm, two layers, single side assembly
- Cost effective boost controller LM5001 with integrated low side FET
- Peak efficiency 75% despite large duty cycle, total power losses <500mW
- Fine thermal behavior, temperature rise less than +20K at full load
- Load regulation less than 30mV means less than 0.05%
- Output ripple around 200mVpp
- Low reflected ripple (=conducted emissions) by Cuk topology (=inverting SEPIC)
- Tiny dual inductor 5mm x 5mm from stock



1 Test Prerequisites

1.1 Voltage and Current Requirements

Table 1. Voltage and Current Requirements

PARAMETER	SPECIFICATIONS
Input Voltage Range	4.5 V to 5.5 V
Output Voltage	-60 V
Maximum Output Current	20 mA

1.2 Considerations

The measured switching frequency is around 285 kHz.
Unless otherwise mentioned, all measurements were done with 5 V input voltage and 20 mA.
UVLO: The circuit starts with switching with 2.9 V (with an output voltage of -50 V) and stops with switching around 2.8 V.
Resistors were used as load.

2 Testing and Results

2.1 Efficiency Graphs

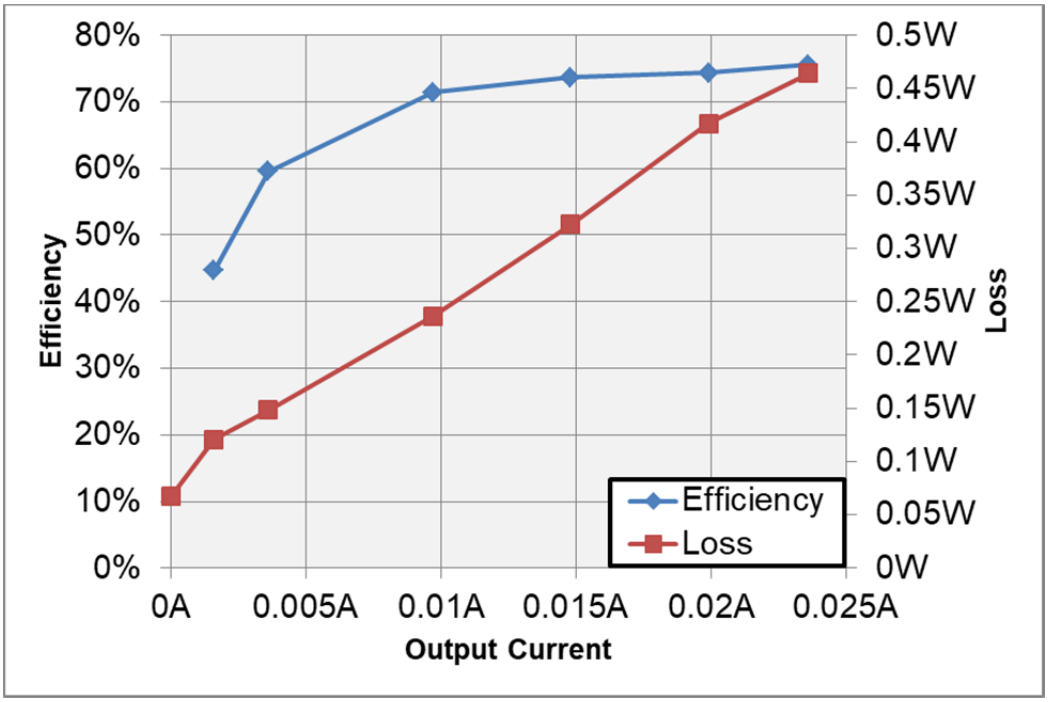


Figure 1 Efficiency and Loss vs Output Current

2.2 Load Regulation

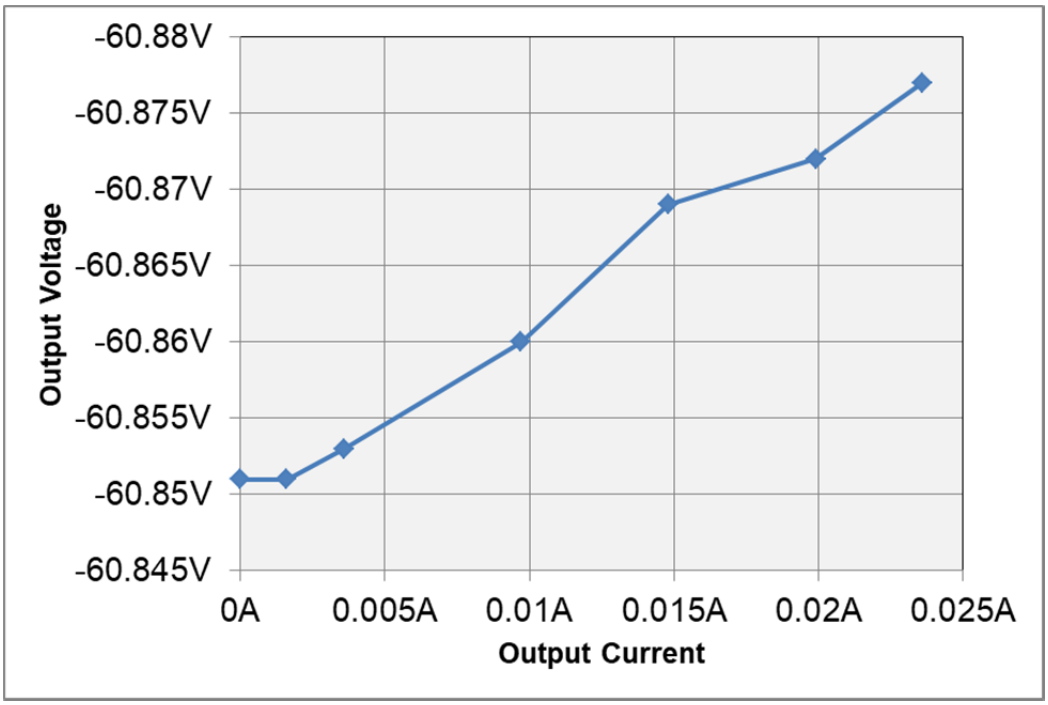


Figure 2 Output Voltage vs Output Current

2.3 Thermal Images

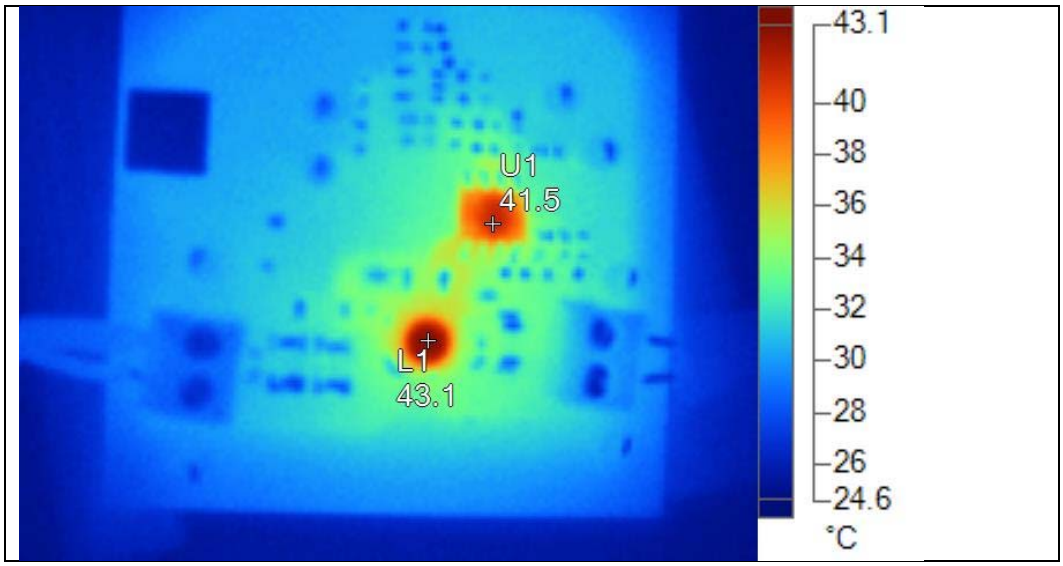


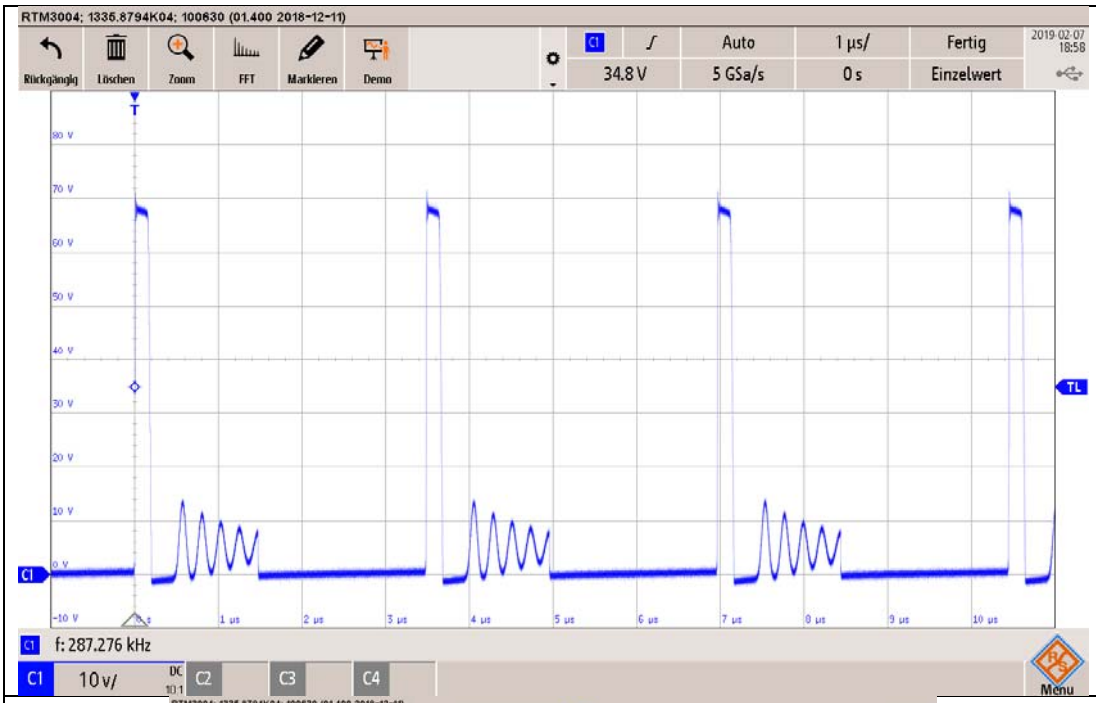
Figure 3 thermal IR-Foto

Name	Temperature
L1	43.1°C
U1	41.5°C

3 Waveforms – converter is in discontinuous mode DCM

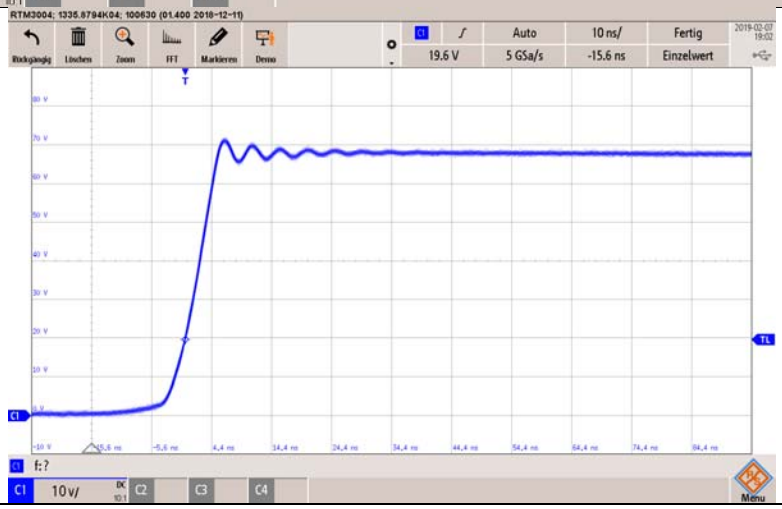
3.1 Switching

3.1.1 TP4 to GND



10 V/ div
1 µs/ div

full bandwidth



10 V/ div
10 ns/ div

full bandwidth

Figure 4 Switchnode (TP4)

3.1.2 Diode D1

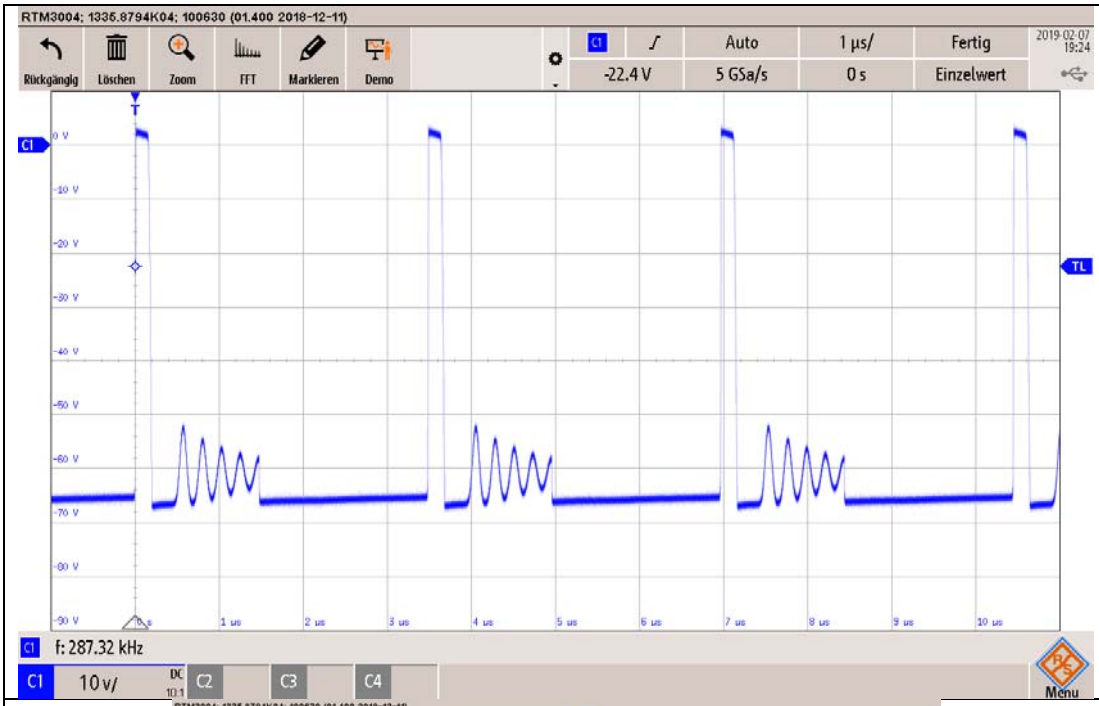
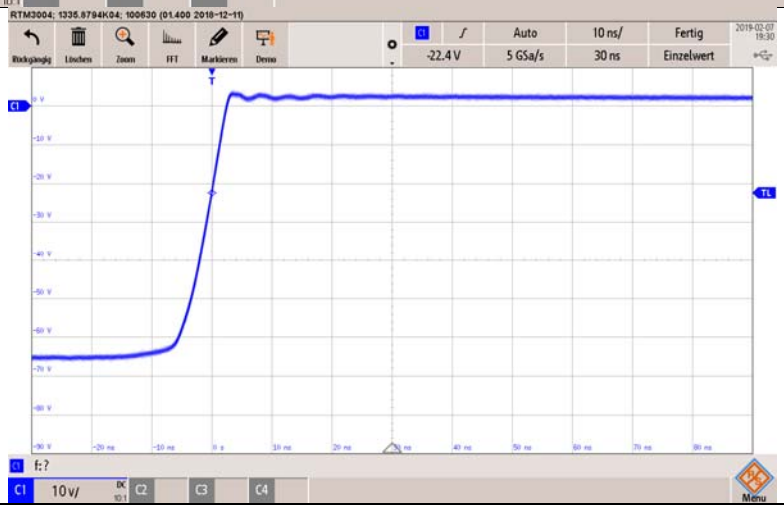
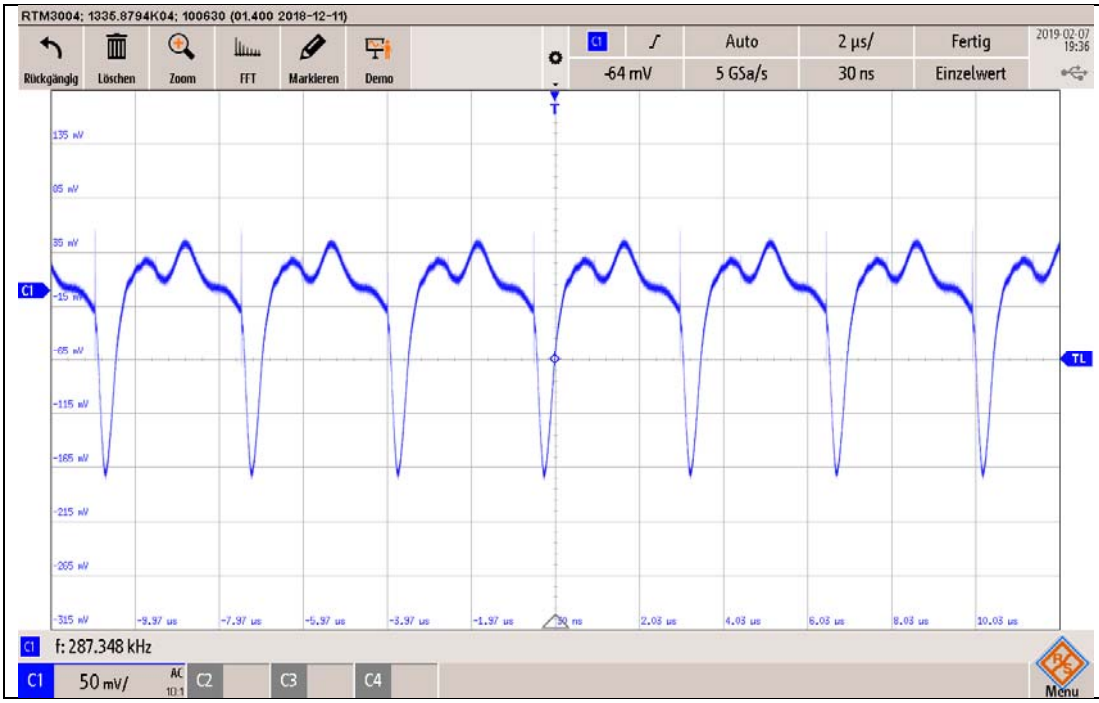
	10 V/ div 1 µs/ div full bandwidth
	10 V/ div 10 ns/ div full bandwidth

Figure 5 Diode D1

3.2 Output Voltage Ripple

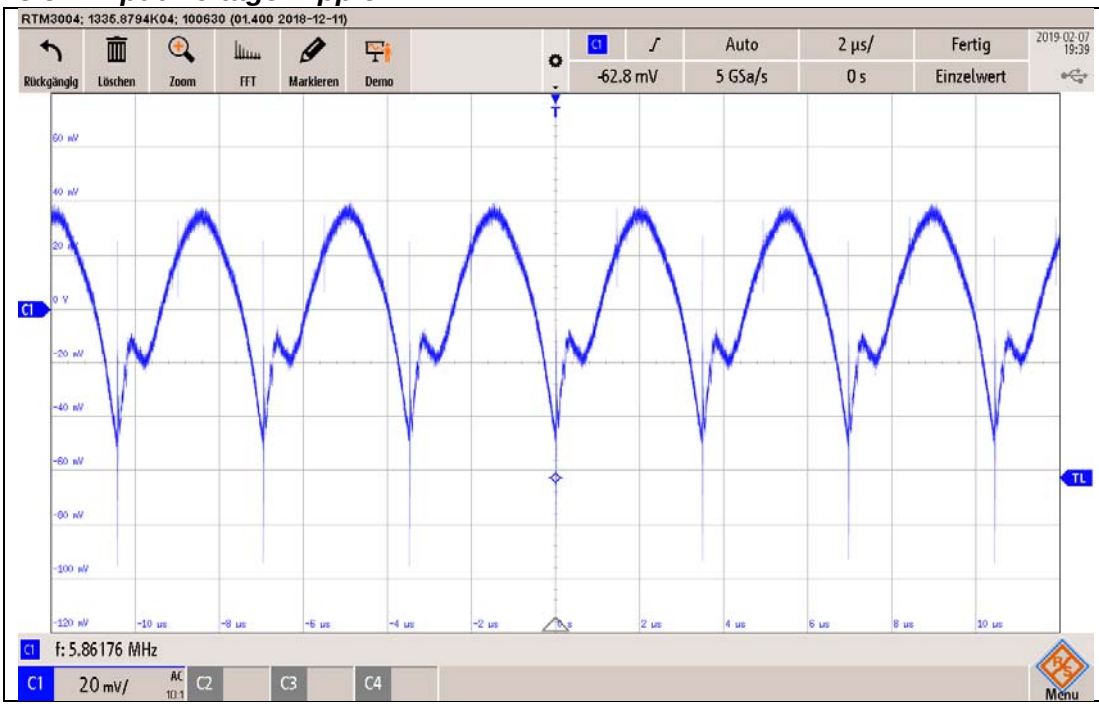


50 mV/div
2 µs/div

full bandwidth

Figure 6 Output Voltage Ripple

3.3 Input Voltage Ripple



20 mV/div
2 µs/div

full bandwidth

Figure 7 Input Voltage Ripple

3.4 Bode Plot

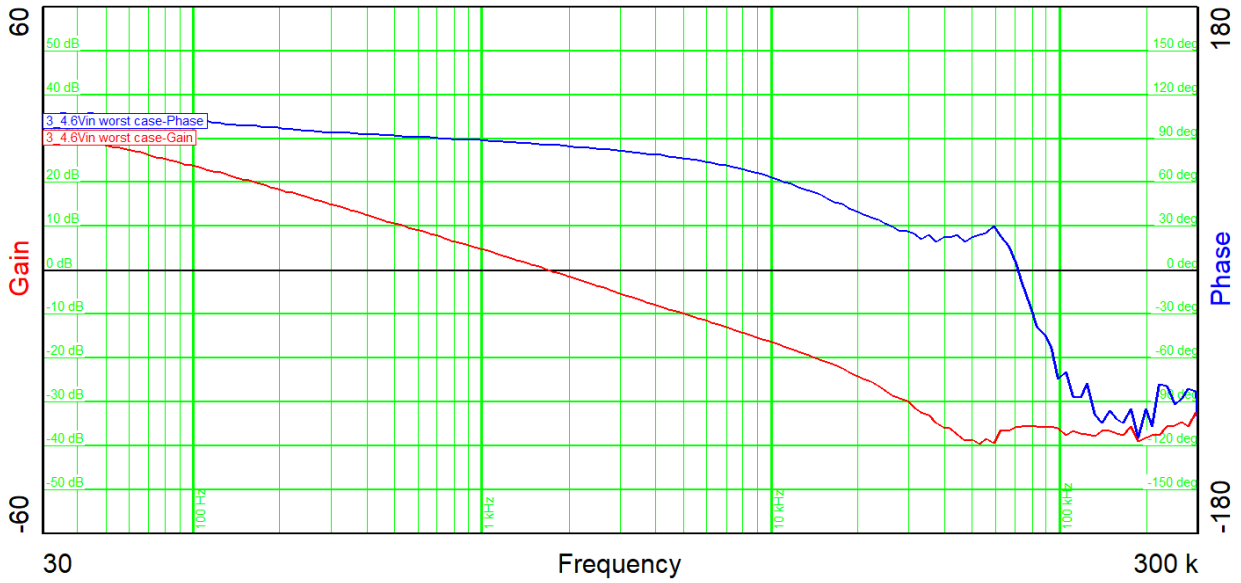


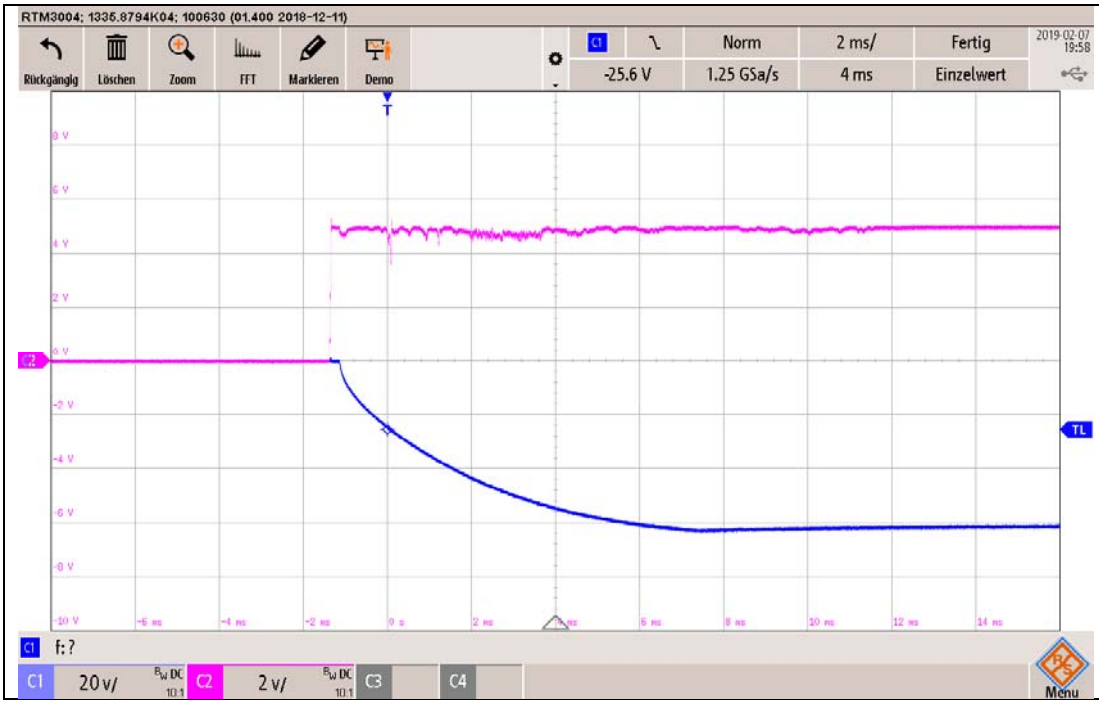
Figure 8 Bode Plot (4.5 V Input Voltage)

	4.5 Vin
Bandwidth (kHz)	1.7
Phasemargin	85.6°
slope (20dB/decade)	-1.0
gain margin (dB)	-36
slope (20dB/decade)	+0.25
freq (kHz)	72

Table 1 Bode Plot Values

3.5 Start-up Sequence

Power supply was plugged in.



Channel 2 => input voltage
2 V/div

Channel 1 => output voltage
20 V/div

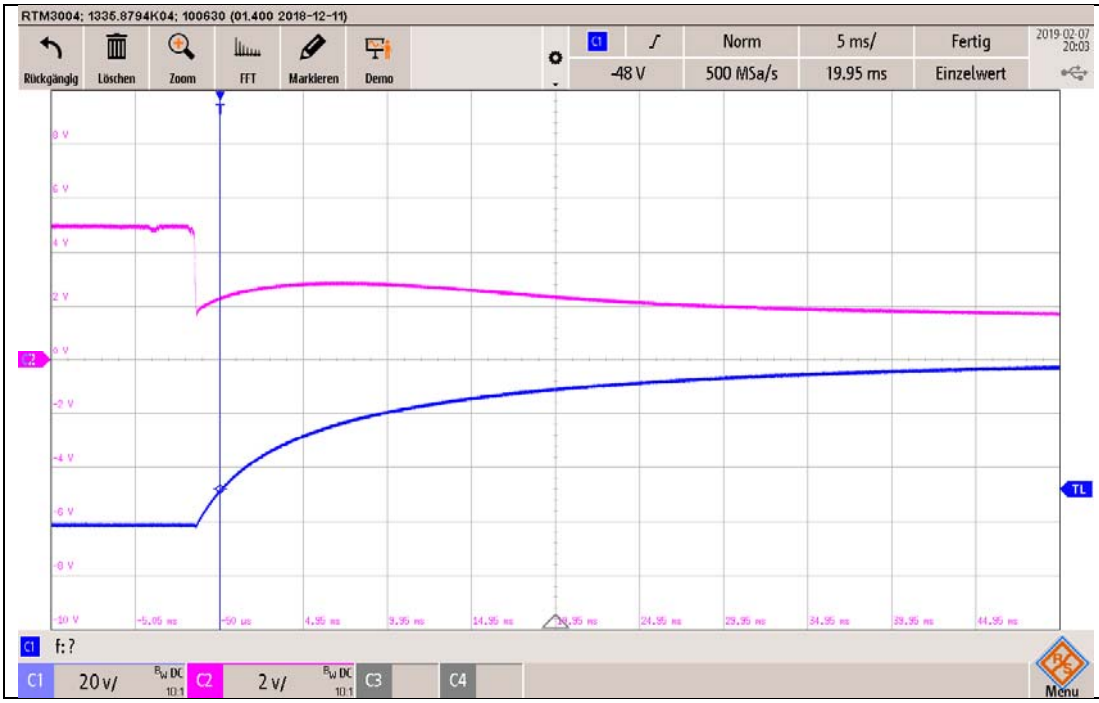
2 ms/div

20MHz bandwidth

Figure 9 Start-up Sequence

3.6 Shutdown Sequence

Power supply was disconnected.



Channel 2 => input voltage
2 V/div

Channel 1 => output voltage
20 V/div

5 ms/div

20MHz bandwidth

Figure 10 Shutdown Sequence

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Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265