

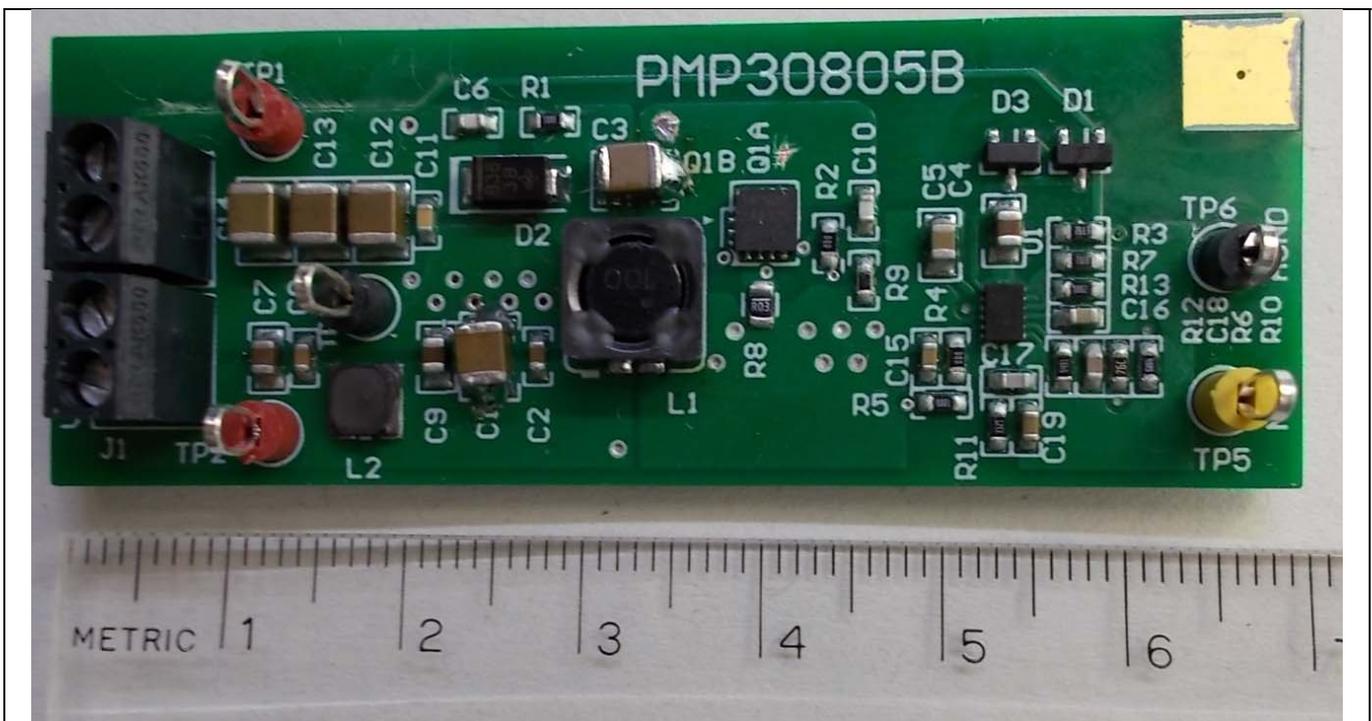
# Test Report: PMP30805

## Tiny Automotive SEPIC Reference Design



### Description

This tiny automotive SEPIC reference design contains a 6 W auxiliary power supply and is designed for a 12 V bias rail. The wide input accepts cranking down to 4.5 V<sub>min</sub> and surge up to 40 V<sub>max</sub>. Due to switching frequency of 2 MHz, the dual inductor is fairly small, resulting in excellent dynamic behavior. TI controller LM5155x-Q1 is cost effective and its housekeeping currents are minimized. The optional input filter attenuates reflected ripple, and the SEPIC topology supports fine EMI behavior by continuous input current.



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## 1 Test Prerequisites

### 1.1 Voltage and Current Requirements

**Table 1. Voltage and Current Requirements**

PARAMETER	SPECIFICATIONS
Input Voltage Range	6.0 V-18 V, 12.0 V nom., 4.5 V cranking, 40.0 V peak
Output Voltage	12 V @ 500 mA
Switching Frequency	2 MHz
Topology	Nonsynchronous SEPIC

### 1.2 Considerations

- Due to availability **BSZ340N08NS3** was used as Q1A.
- The circuit started up at 5.7 V input voltage and shut down at 4.4 V.
- Switching frequency has been verified at 2.022MHz for this prototype.
- Current sense trips at load current 670mA at minimum input voltage 4.5V, margin 30%+.
- At nominal input 12V the converter has been tested up to 800mA.

Unless otherwise indicated, the input voltage was set to 12 V and the output current was adjusted to full load 500 mA with a variable resistor.

## 2 Testing and Results

### 2.1 Efficiency Graphs

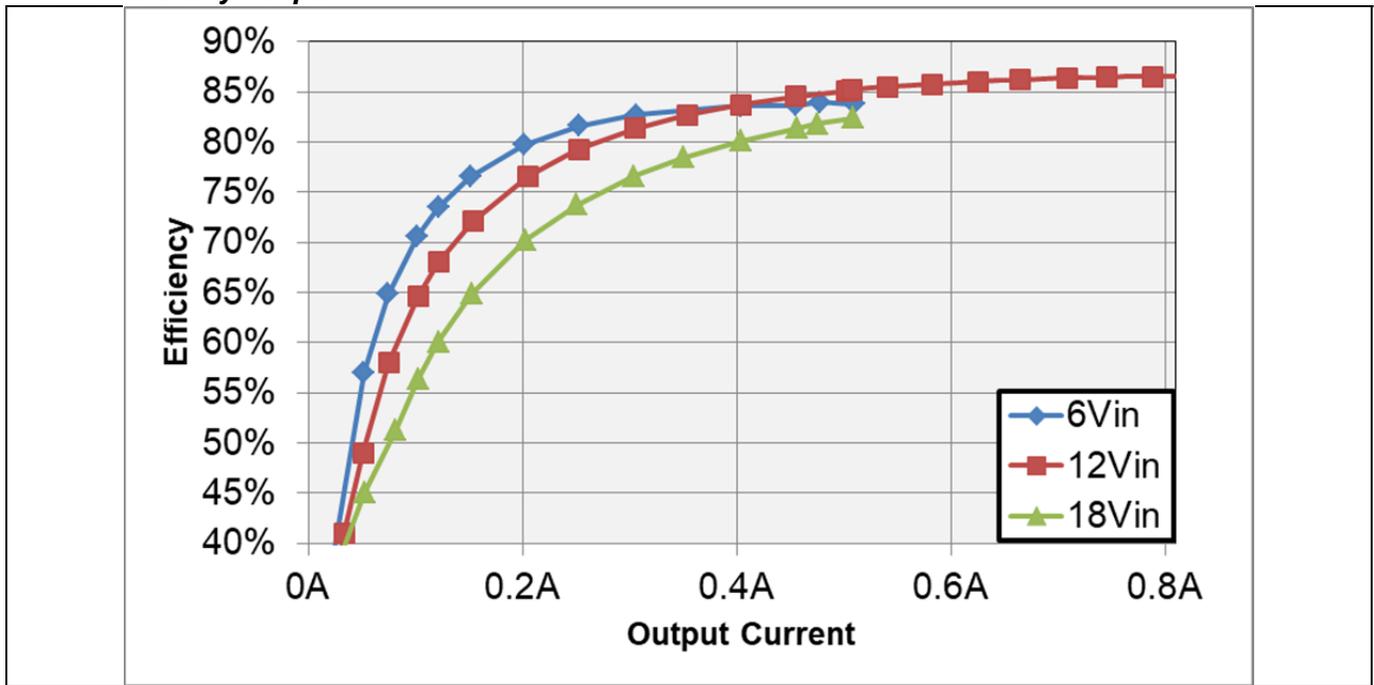


Figure 1 Efficiency vs Output Current

### 2.2 Loss

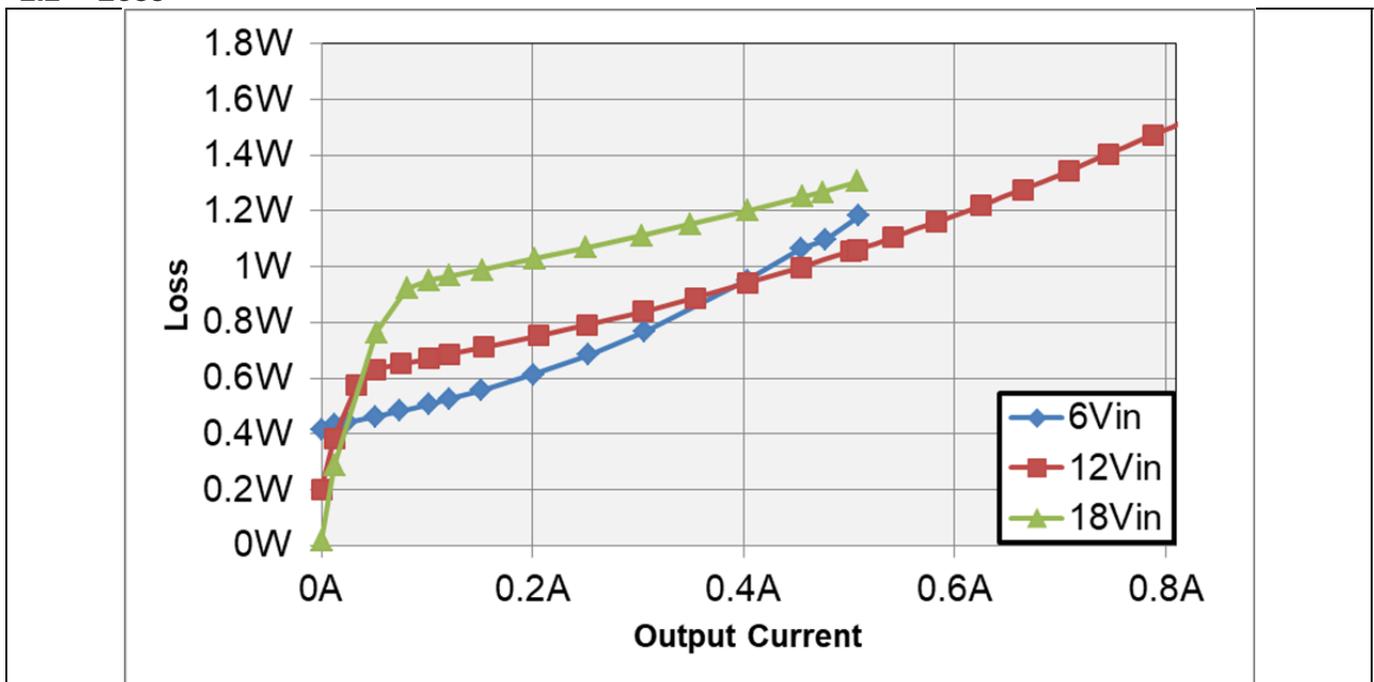


Figure 2 Loss vs Output Current

### 2.3 Load Regulation

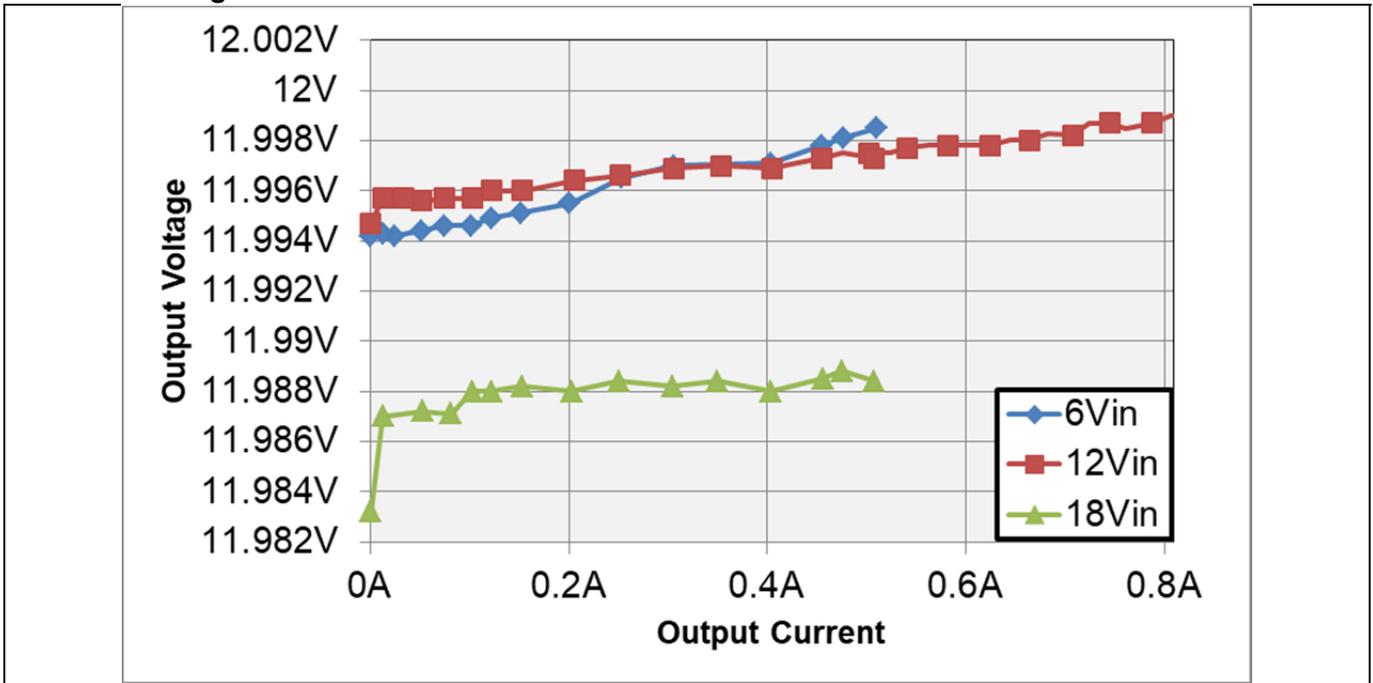
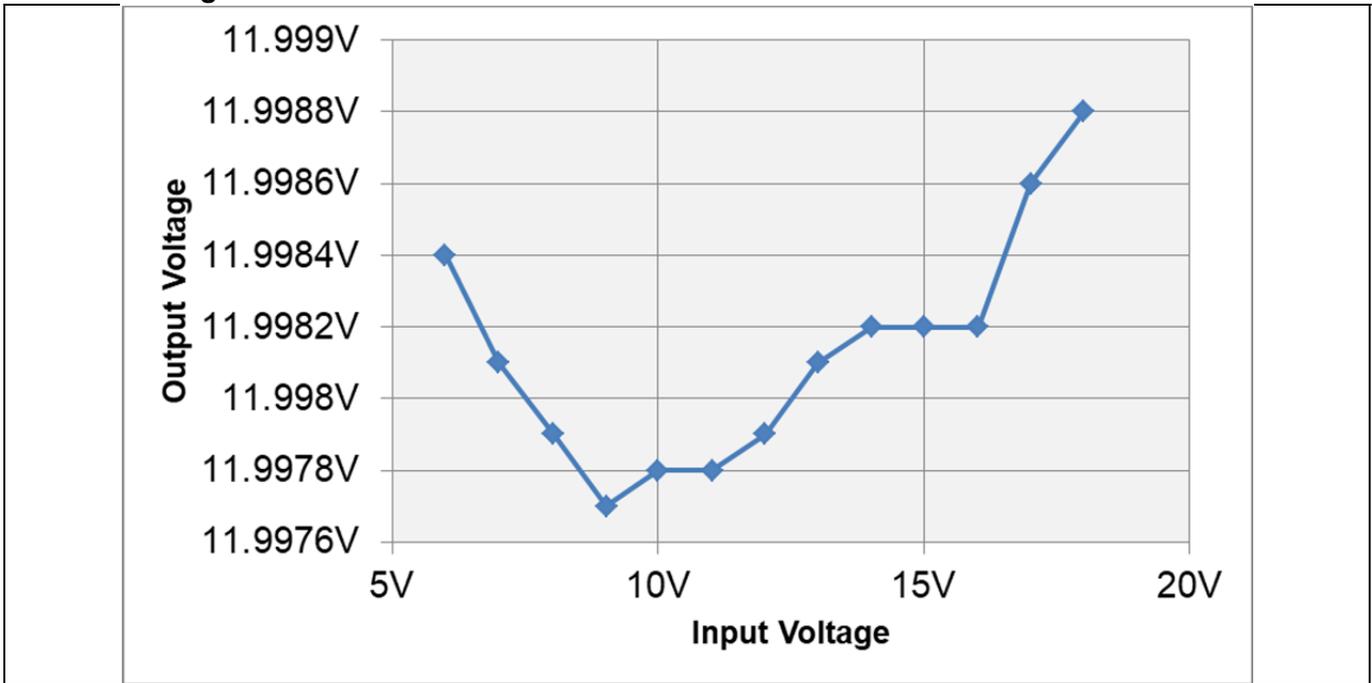


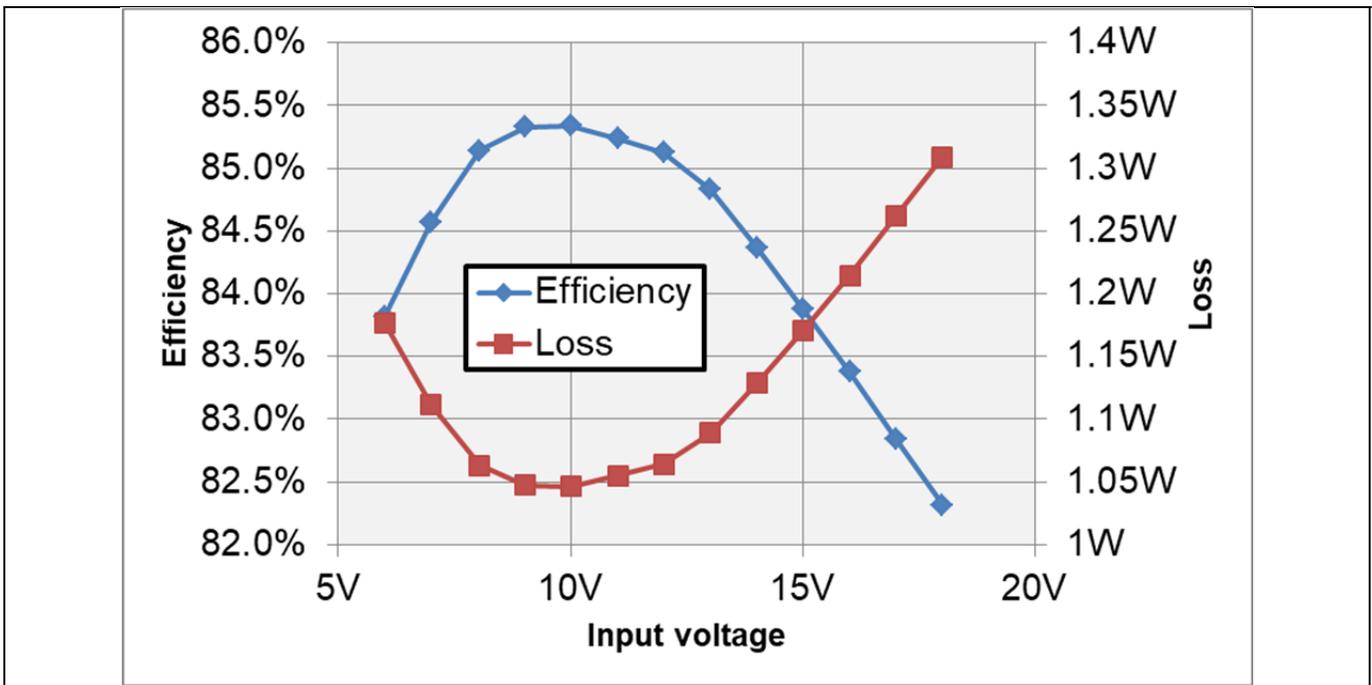
Figure 3 Output Voltage vs Output Current

### 2.4 Line Regulation



**Figure 4 Output Voltage vs Input Voltage**

Efficiency and Loss were also calculated.



**Figure 5 Efficiency and Loss vs Input Voltage**

## 2.5 Thermal Images

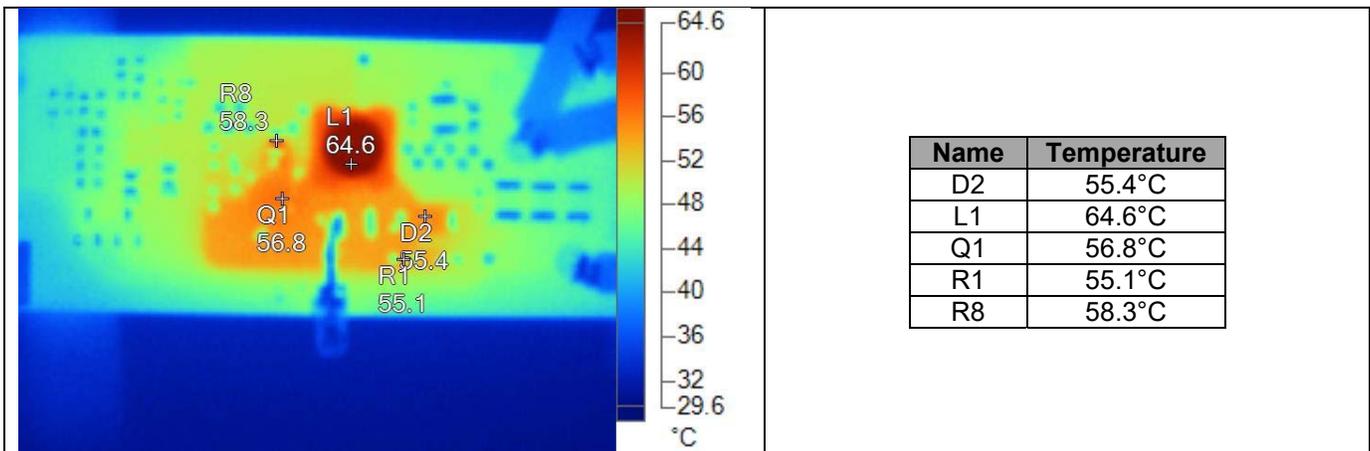


Figure 6 IR-Image @ 6 V Input Voltage

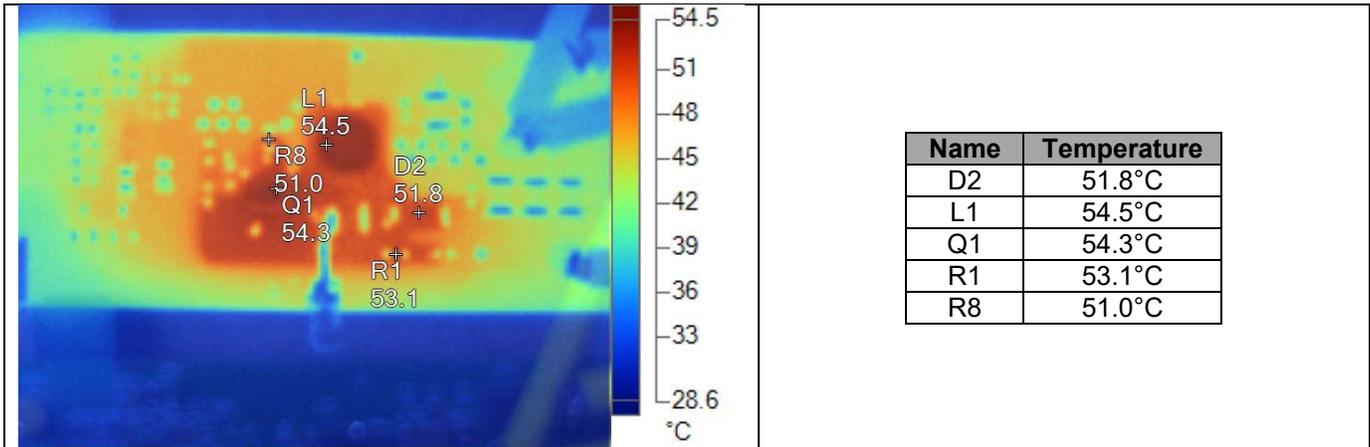


Figure 7 IR-Image @ 12 V Input Voltage – at nominal input  $dt < +35K$  (!)

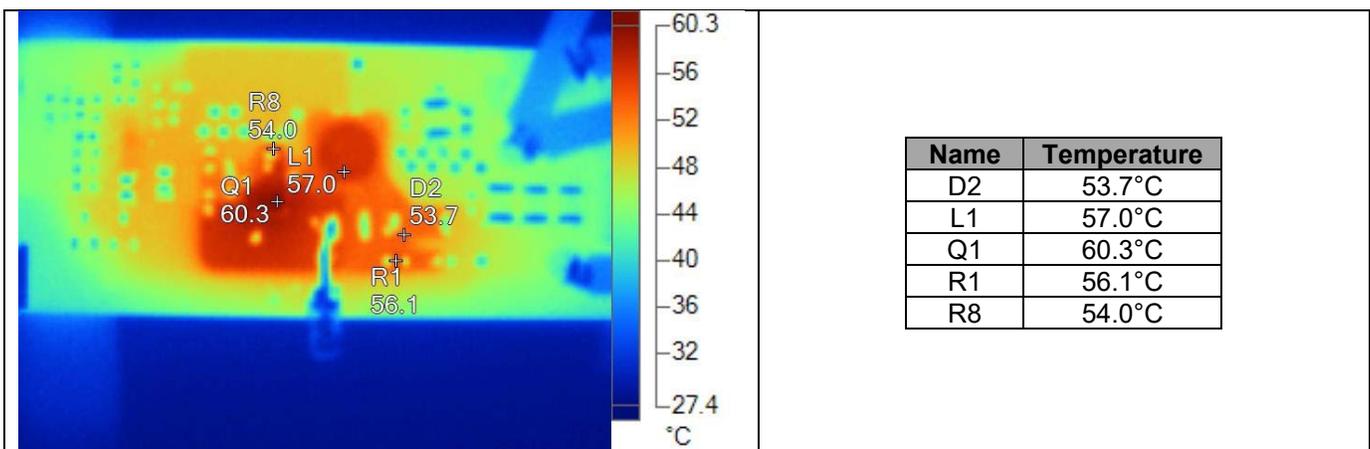


Figure 8 IR-Image @ 18 V Input Voltage

## 2.6 Dimensions

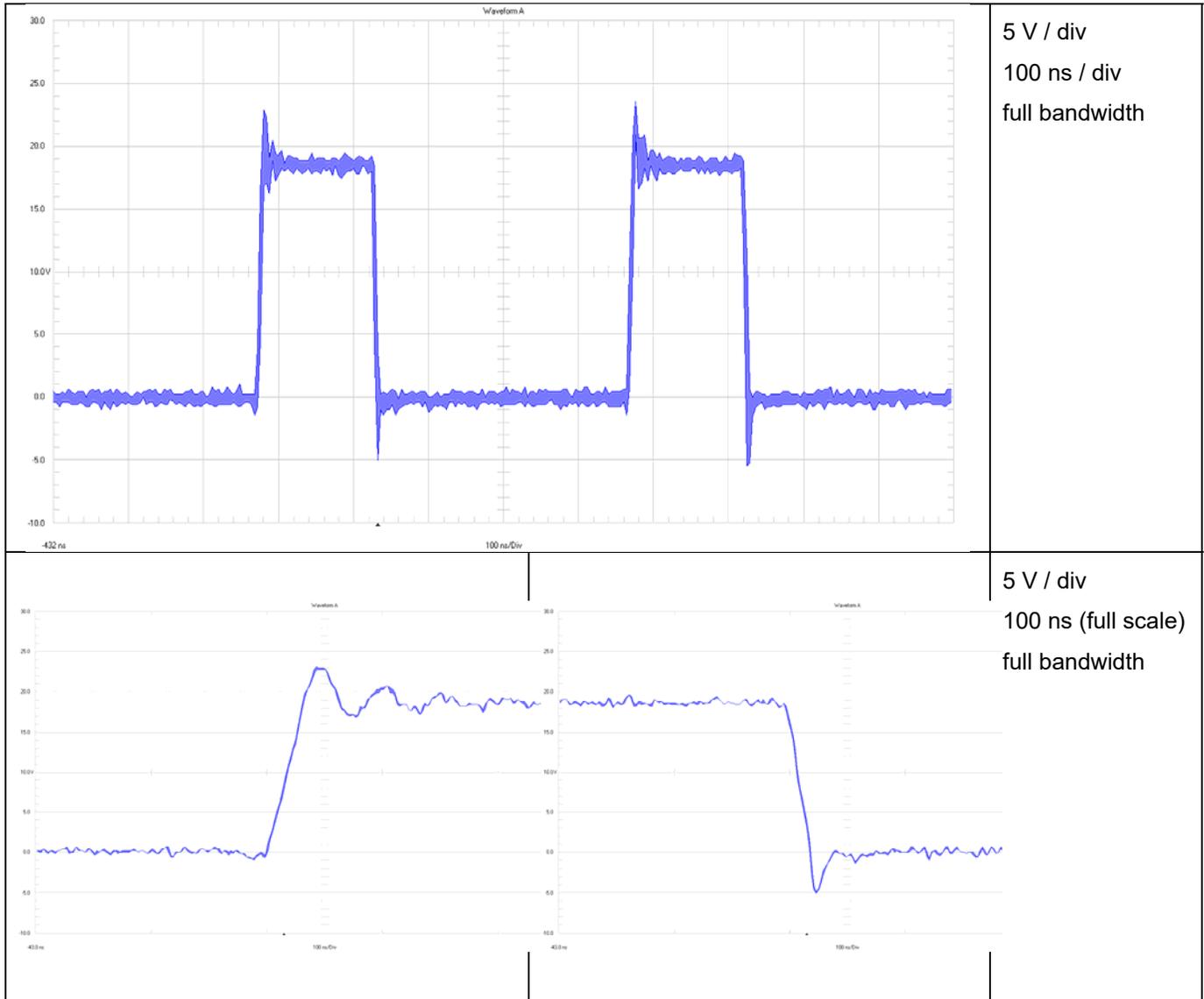
The size of this PCB is 68.6 mm x 25.4 mm, two layers board 70um each and assembly is single sided

### 3 Waveforms

#### 3.1 Switching

##### 3.1.1 Q1 Drain to GND

##### 3.1.1.1 6 V Input Voltage



**Figure 9 Waveform Q1 Drain to GND @ 6 Vin**

3.1.1.2 12 V Input Voltage

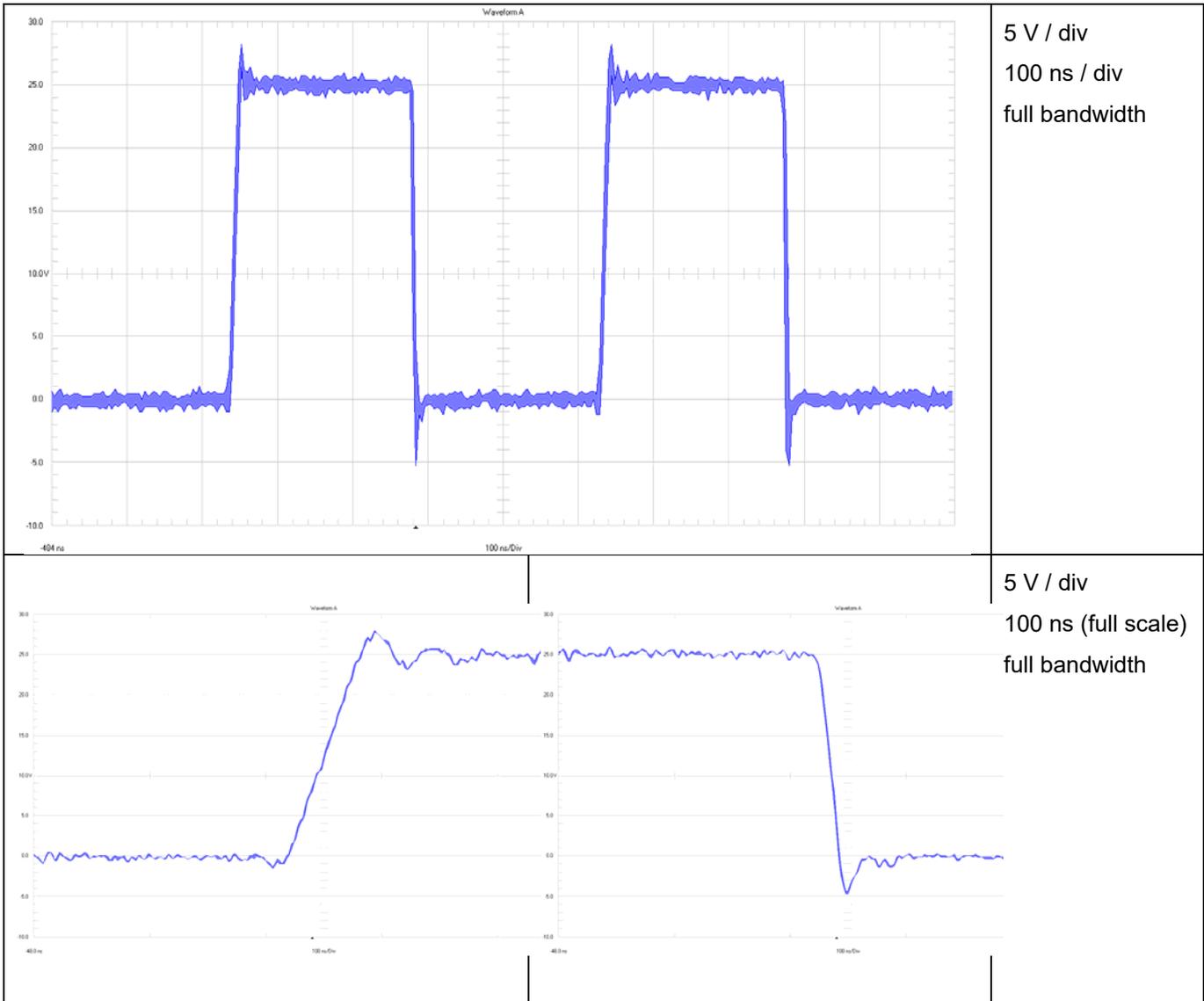
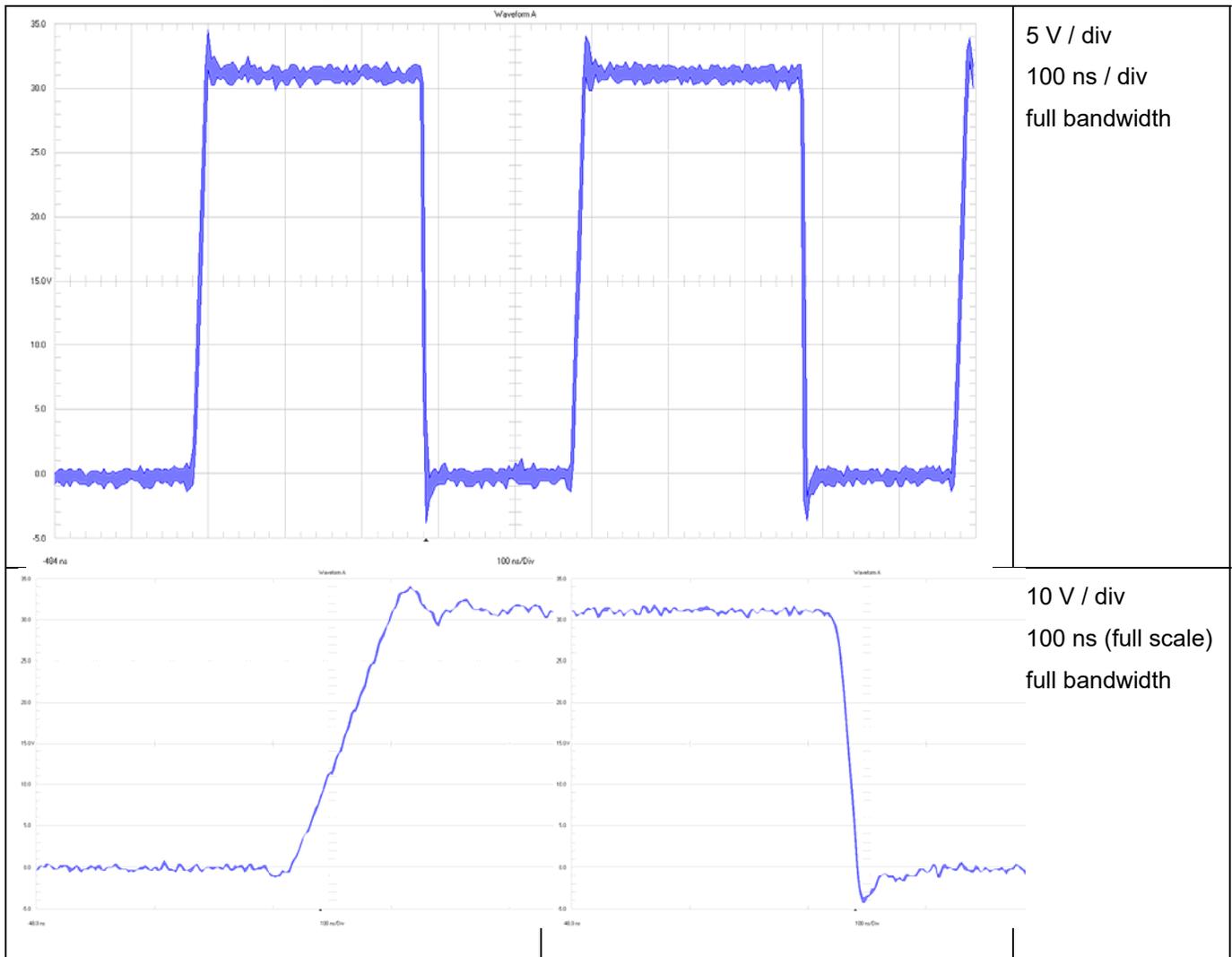


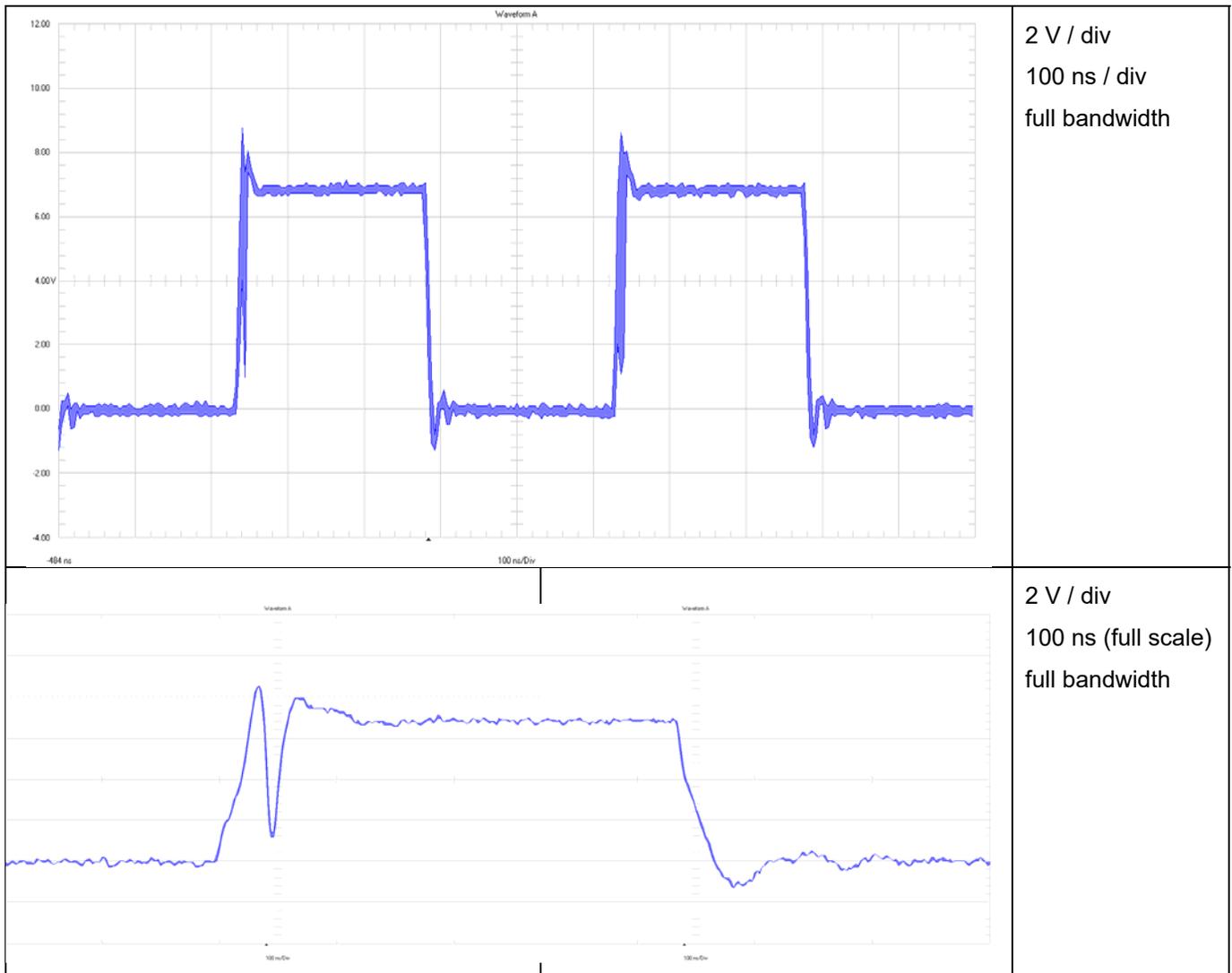
Figure 10 Waveform Q1 Drain to GND @ 12 Vin – almost neither overshoot nor ringing (!)

**3.1.1.3 18 V Input Voltage**



**Figure 11 Waveform Q1 Drain to GND @ 18 Vin**

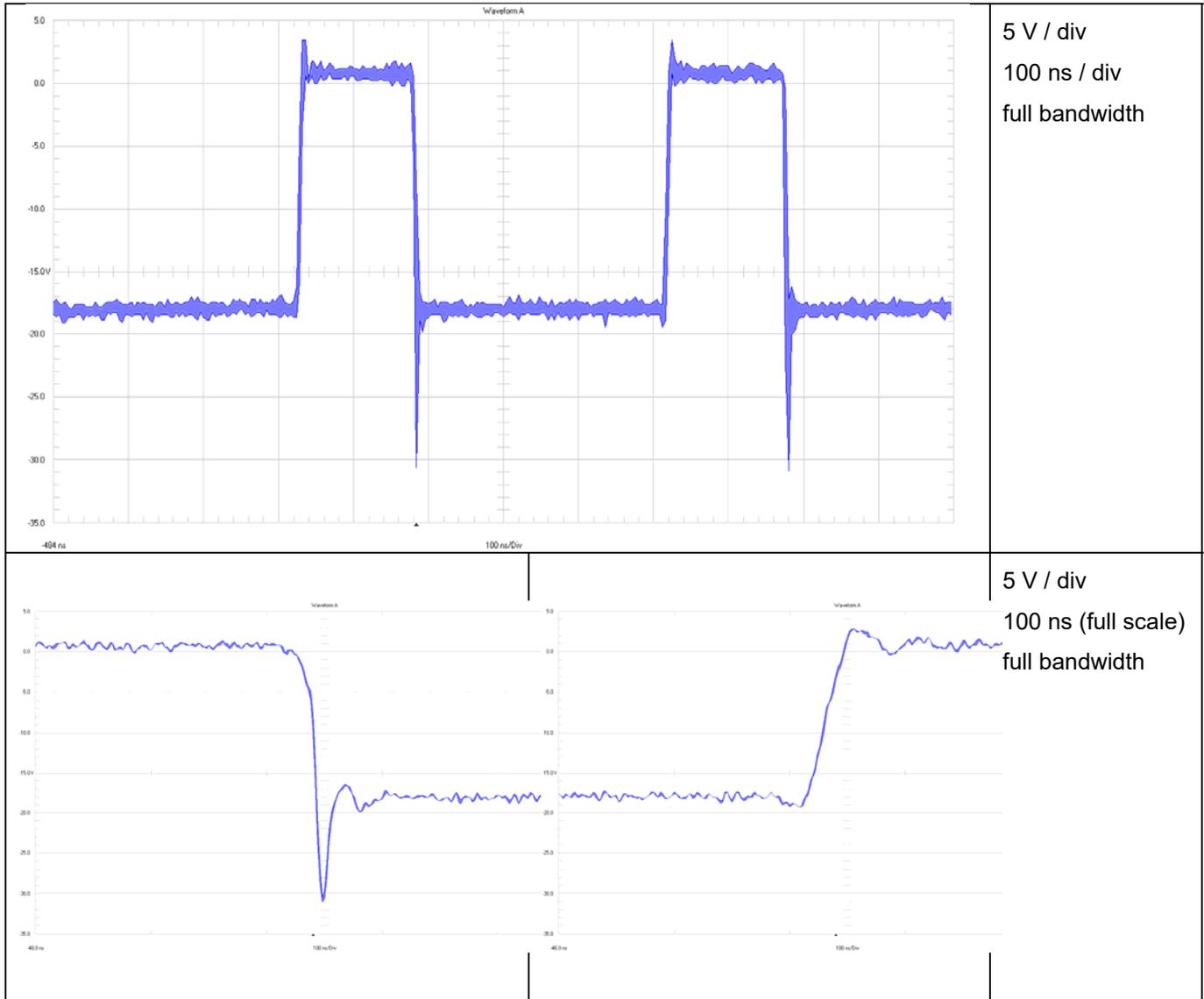
### 3.1.2 Q1 Gate to GND



**Figure 12 Waveform Q1 Gate to GND @ 12 Vin**

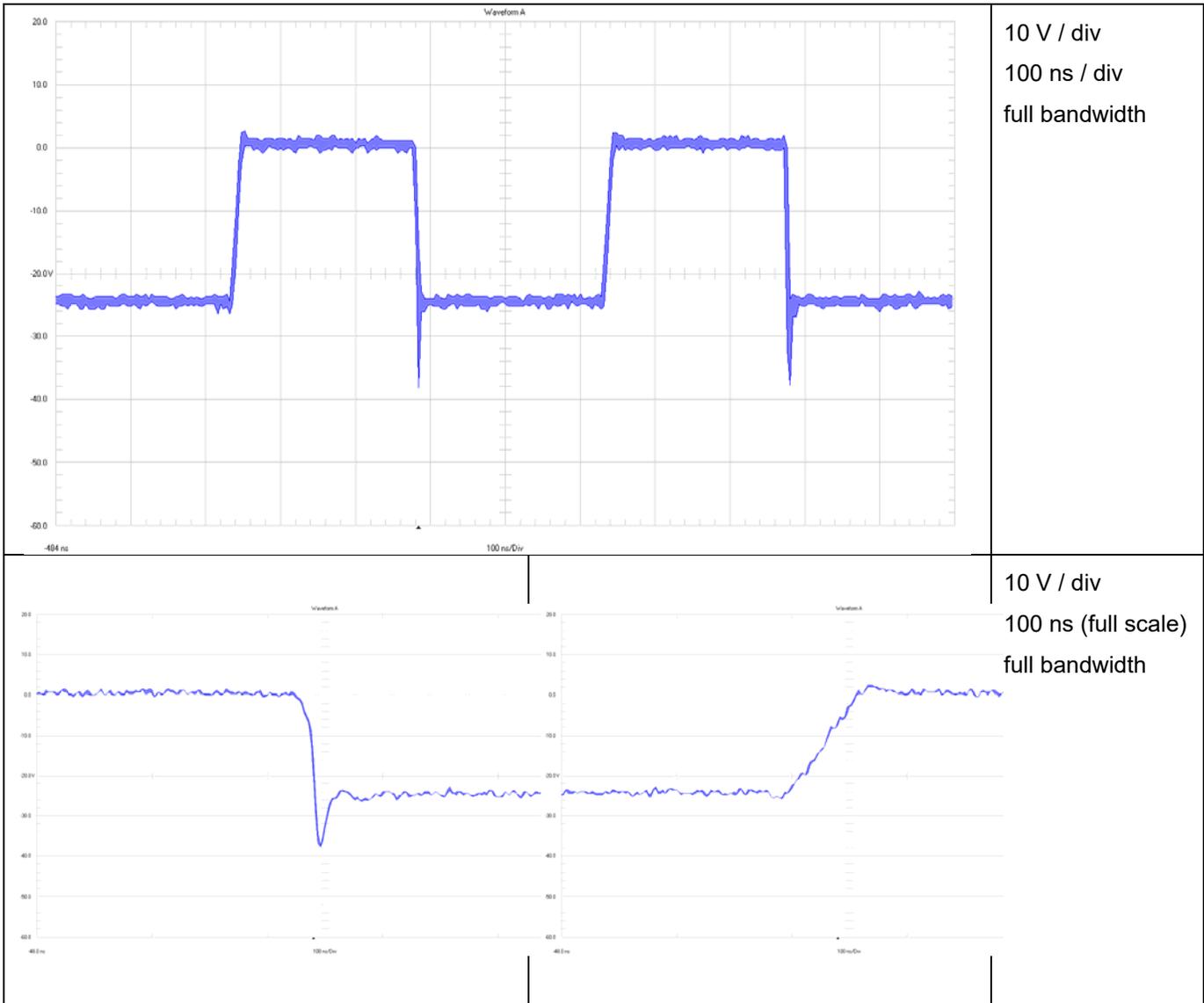
### 3.1.3 Diode D2 (referenced to VOUT)

#### 3.1.3.1 6 V Input Voltage



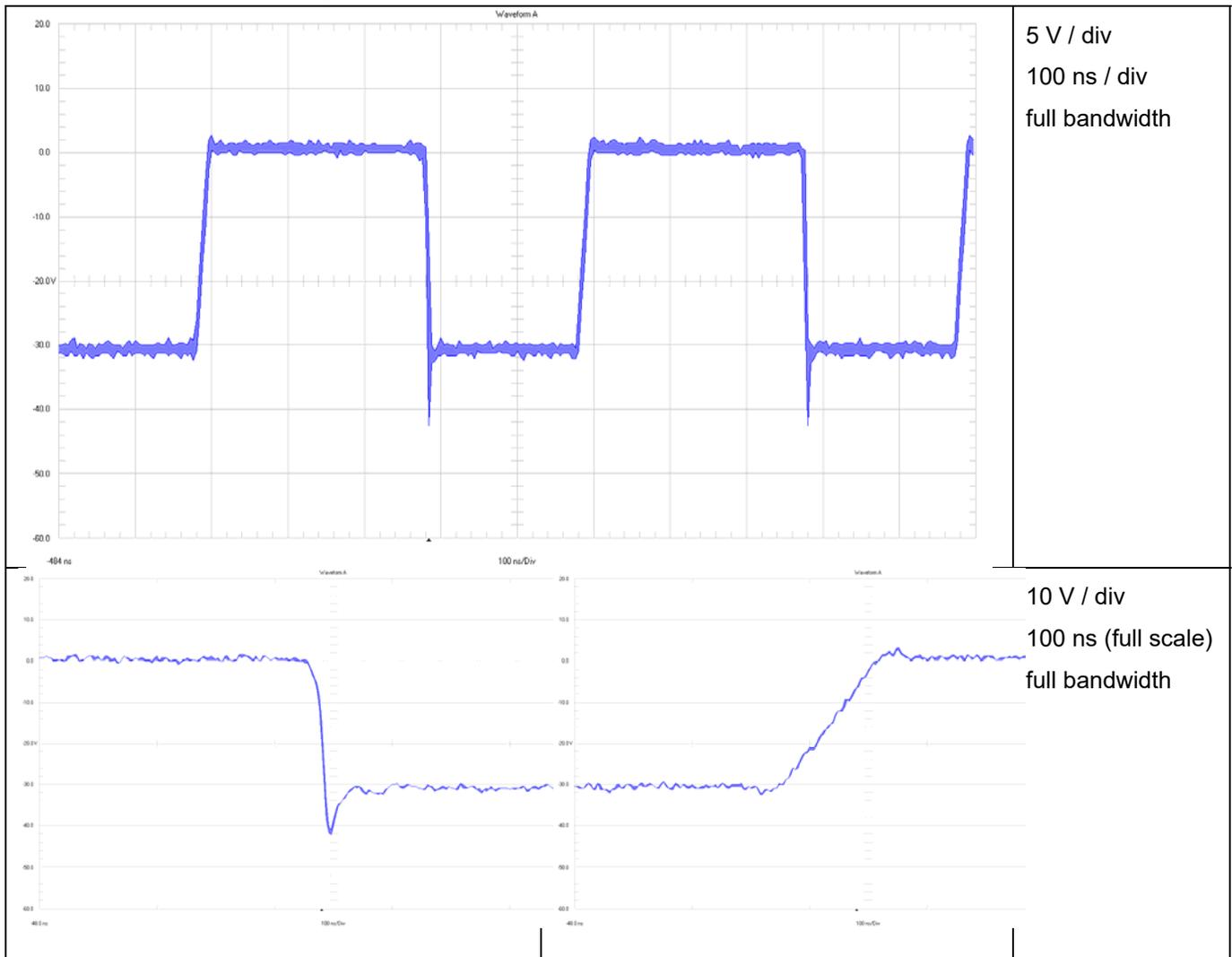
**Figure 13 Waveform D2 to VOUT @ 6 Vin**

### 3.1.3.2 12 V Input Voltage



**Figure 14 Waveform D2 to VOUT @ 12 Vin**

### 3.1.3.3 18 V Input Voltage



**Figure 15 Waveform D2 to VOUT @ 18 Vin**

### 3.2 Output Voltage Ripple

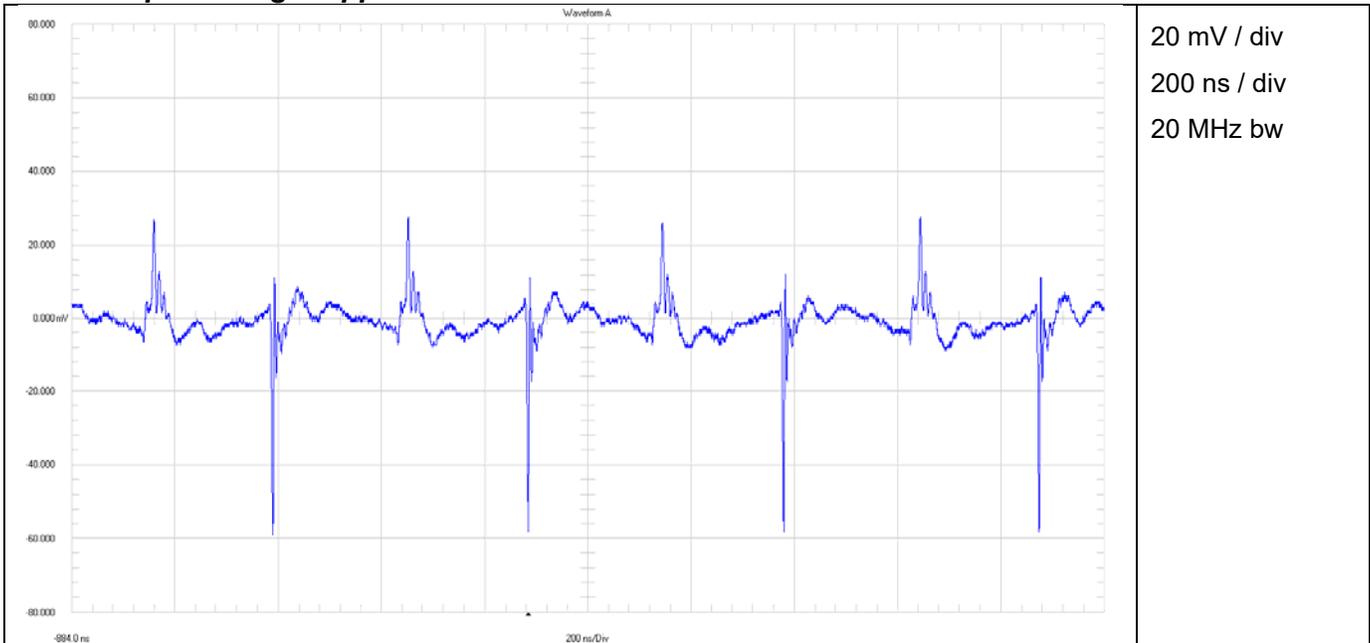


Figure 16 Output Ripple @ 12 V Input Voltage, **output ripple 90mVpp, <1% Vout (!)**

### 3.3 Input Voltage Ripple

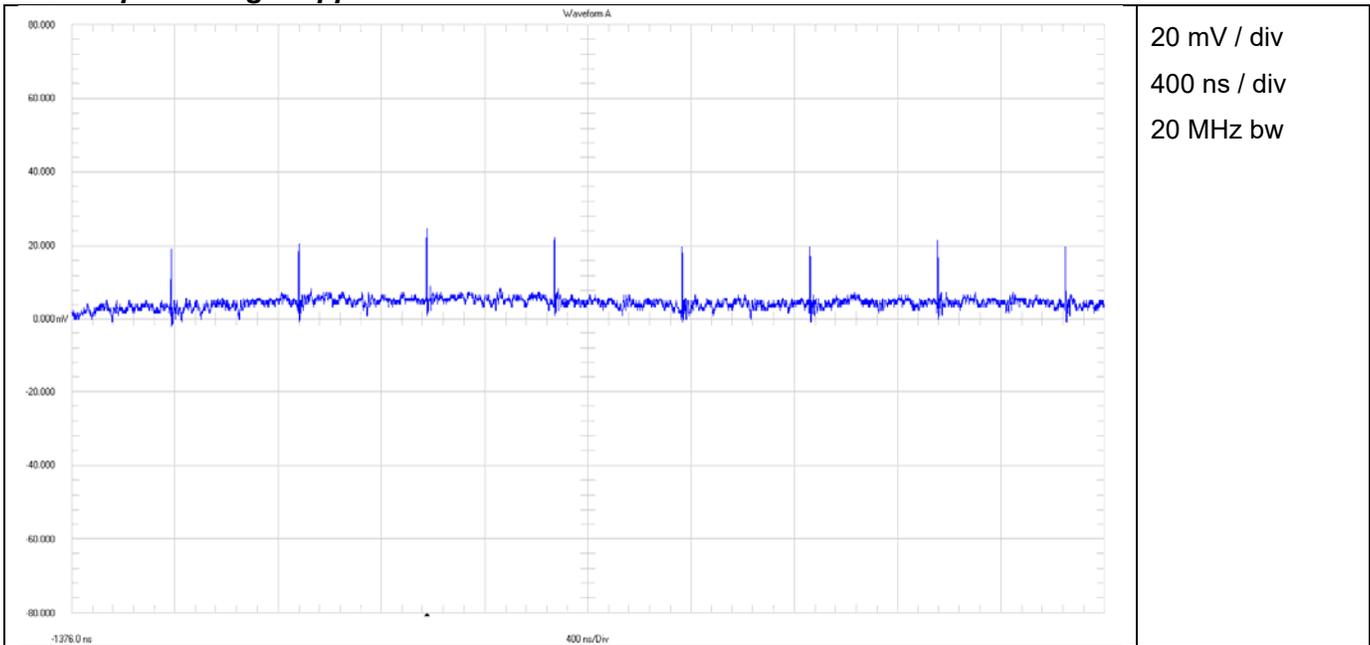
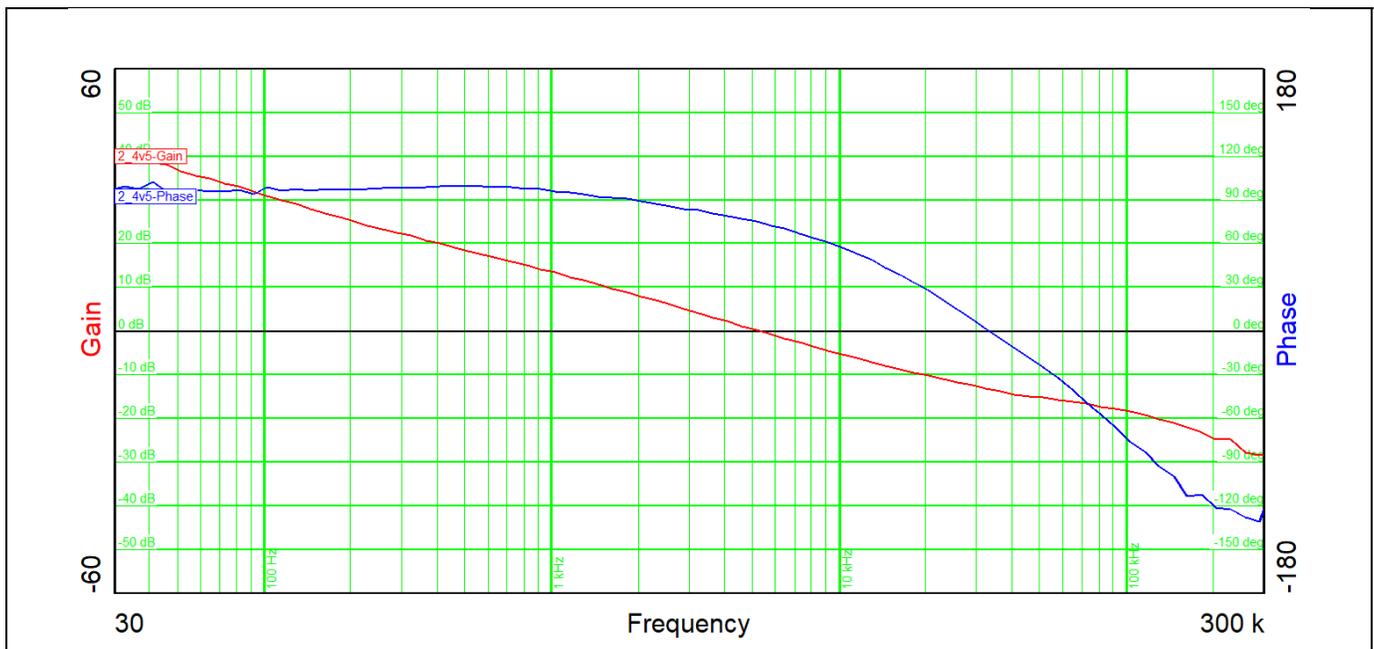


Figure 17 Filtered Input Ripple @ 12 V Input Voltage, **reflected ripple 20mVpp (!)**

### 3.4 Bode Plot

	4.5 Vin	6 Vin	12 Vin	18 Vin
<b>Bandwidth (kHz)</b>	5.28	7.32	12.7	16.6
<b>Phasemargin</b>	74°	75°	76°	71°
<b>slope (20dB/decade)</b>	-0.98	-1.0	-1.0	-1.0
<b>gain margin (dB)</b>	-13.3	-14.9	-17.4	-17.6
<b>slope (20dB/decade)</b>	-0.7	-0.74	-1.31	-1.45
<b>freq (kHz)</b>	33.1	45.1	72.4	84.6

**Table 1 Summary of the Bode Plots**



**Figure 18 Bode Plot for 4.5 V Input Voltage**

Loop bandwidth >5kHz ensures best dynamic behavior. Due to high Fsw 2MHz resulting in small magnetizing inductance the RHPZ is fairly high, so Fco could be increased.

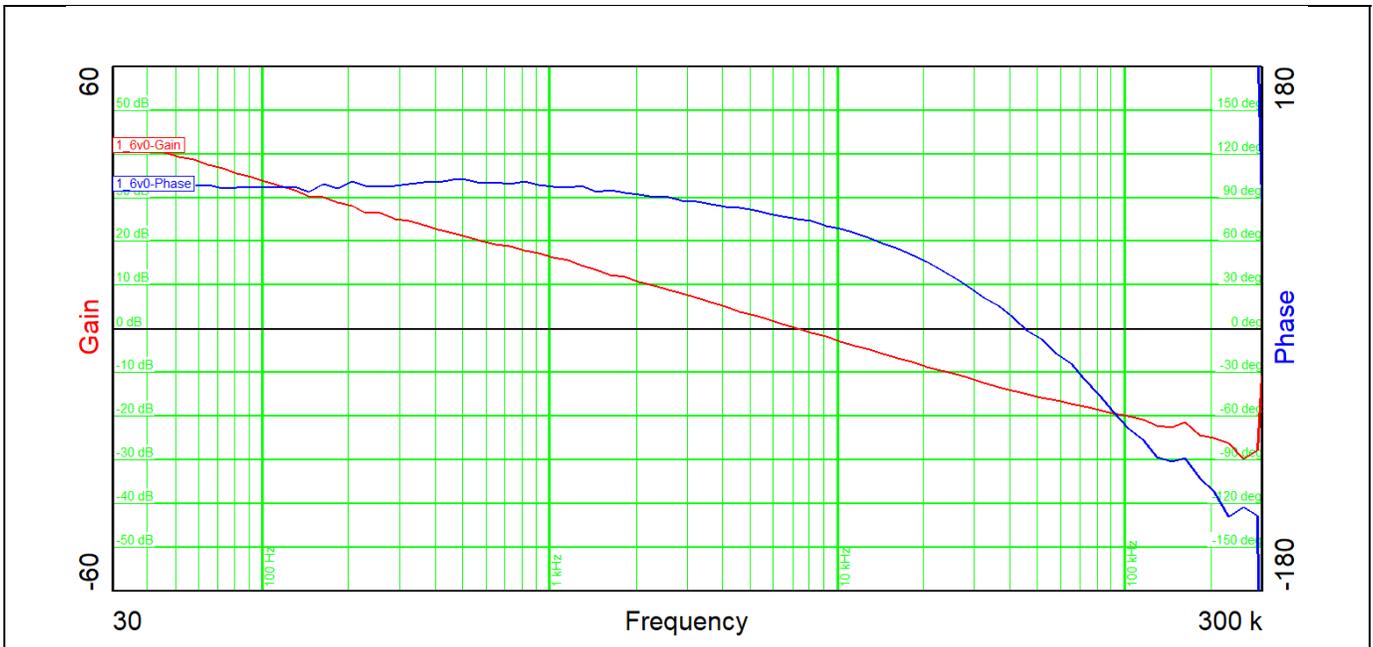


Figure 19 Bode Plot for 6 V Input Voltage

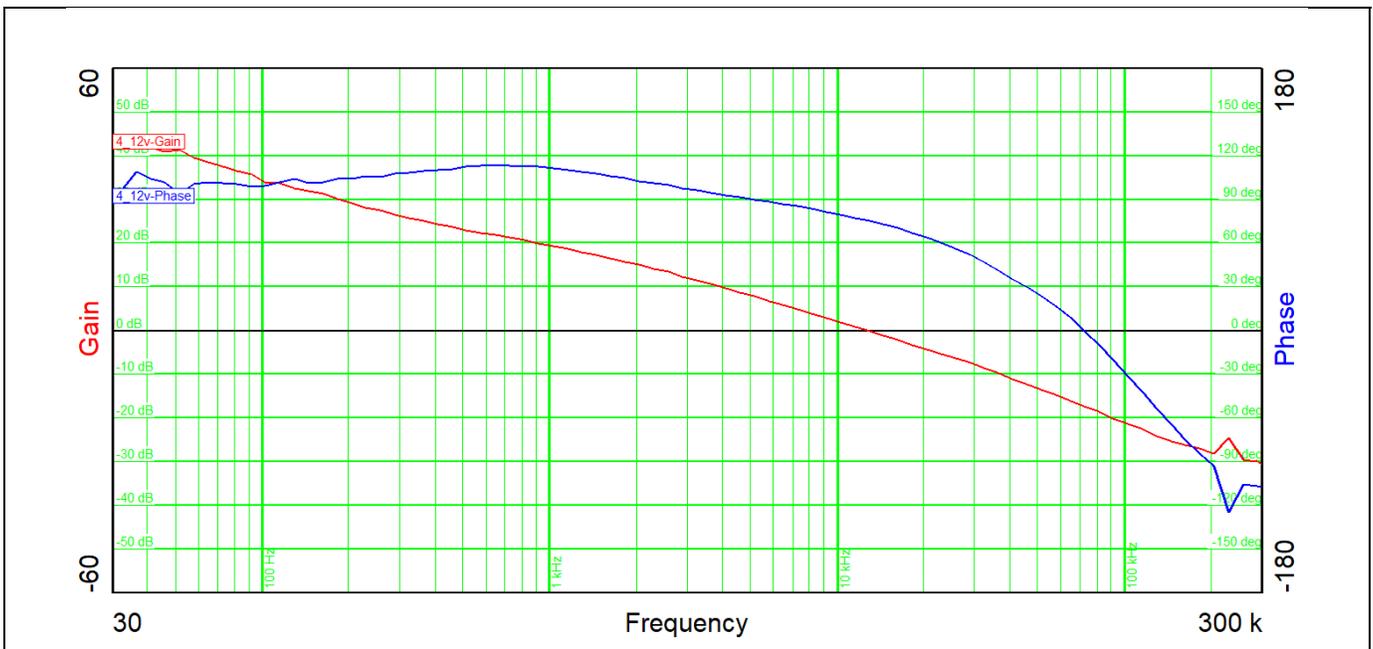
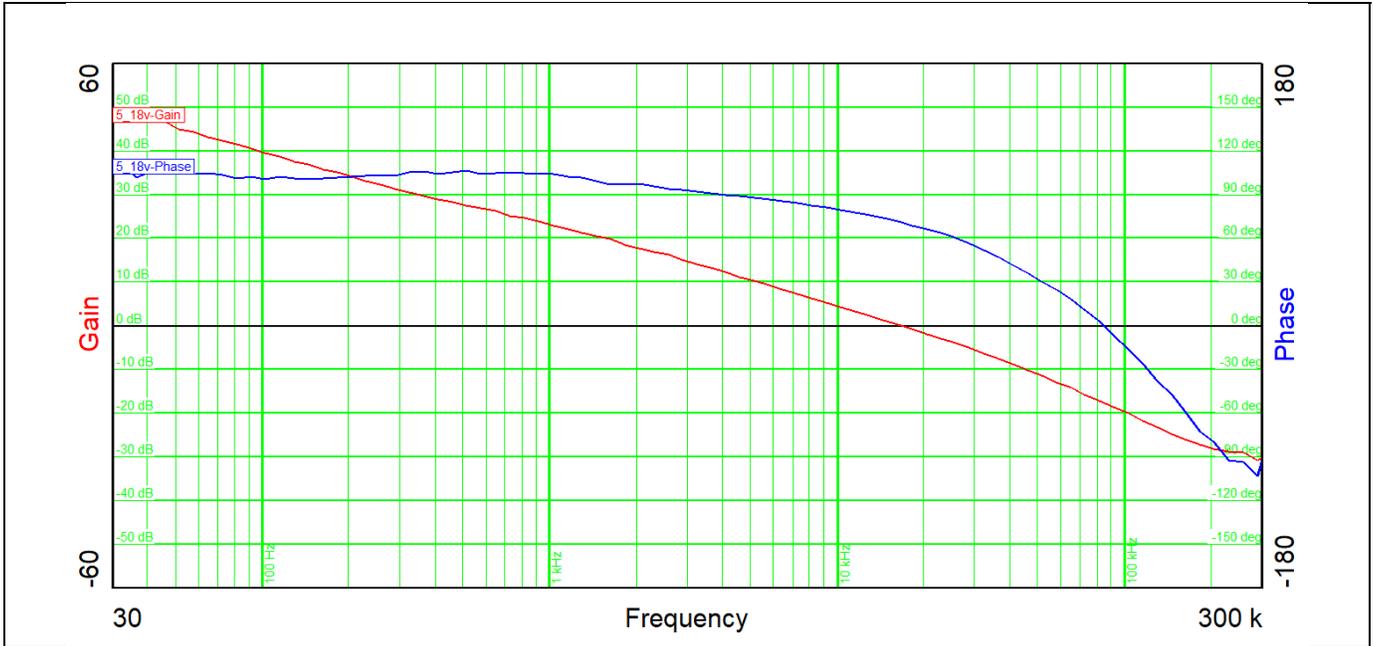


Figure 20 Bode Plot for 12 V Input Voltage



**Figure 21 Bode Plot for 18 V Input Voltage**

### 3.5 Load Transients

The electronic load switches from 0.25 A to 0.5 A @ 100 Hz

#### 3.5.1 6 V Input Voltage

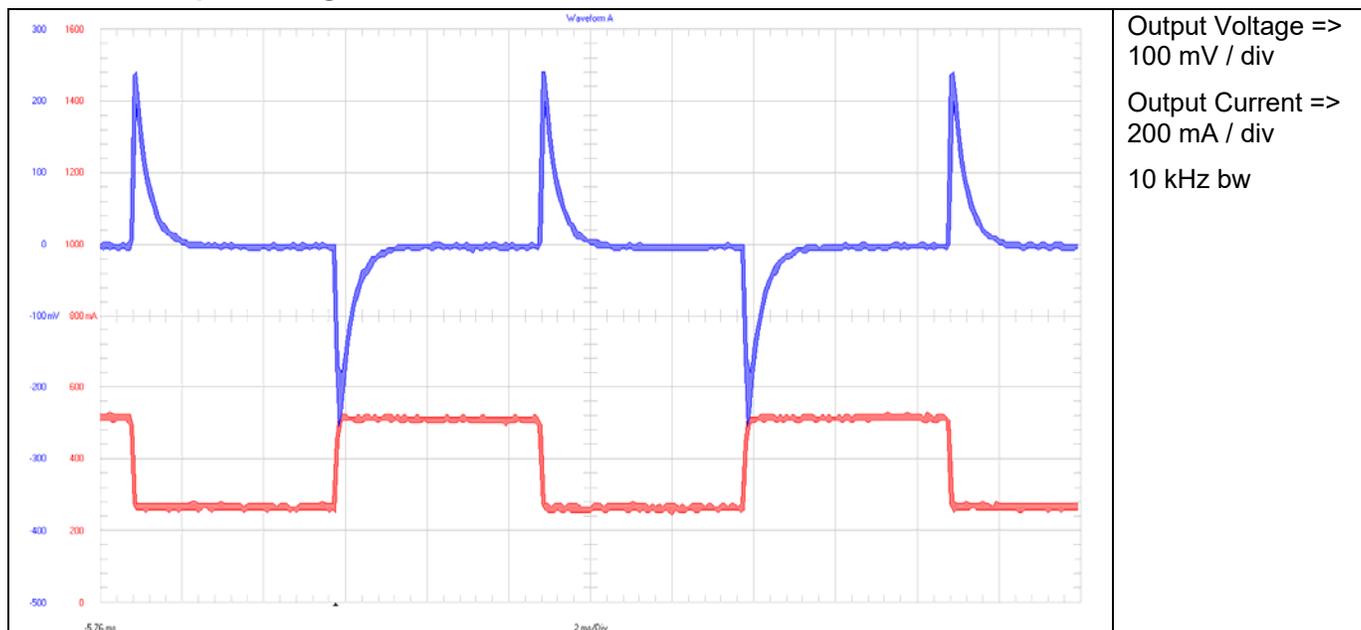


Figure 22 Load Transient @ 6 V Input Voltage – **worst case deviation 240mVpk, 2% of Vout (!)**

#### 3.5.2 12 V Input Voltage

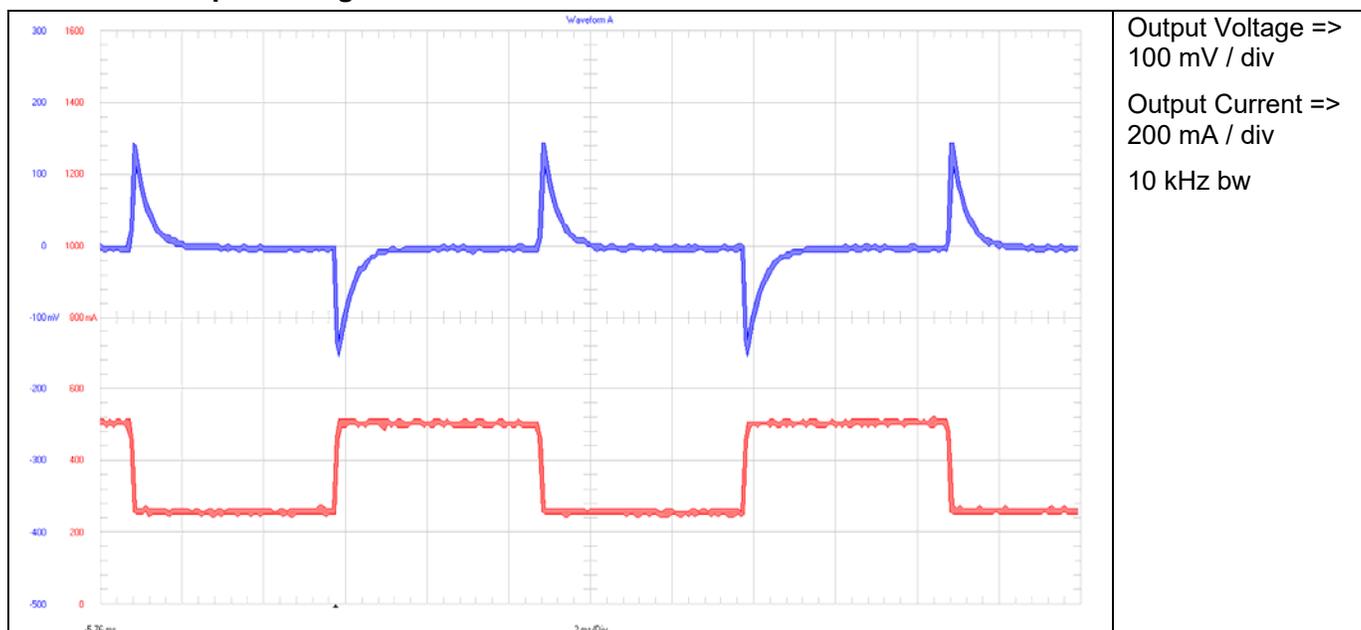
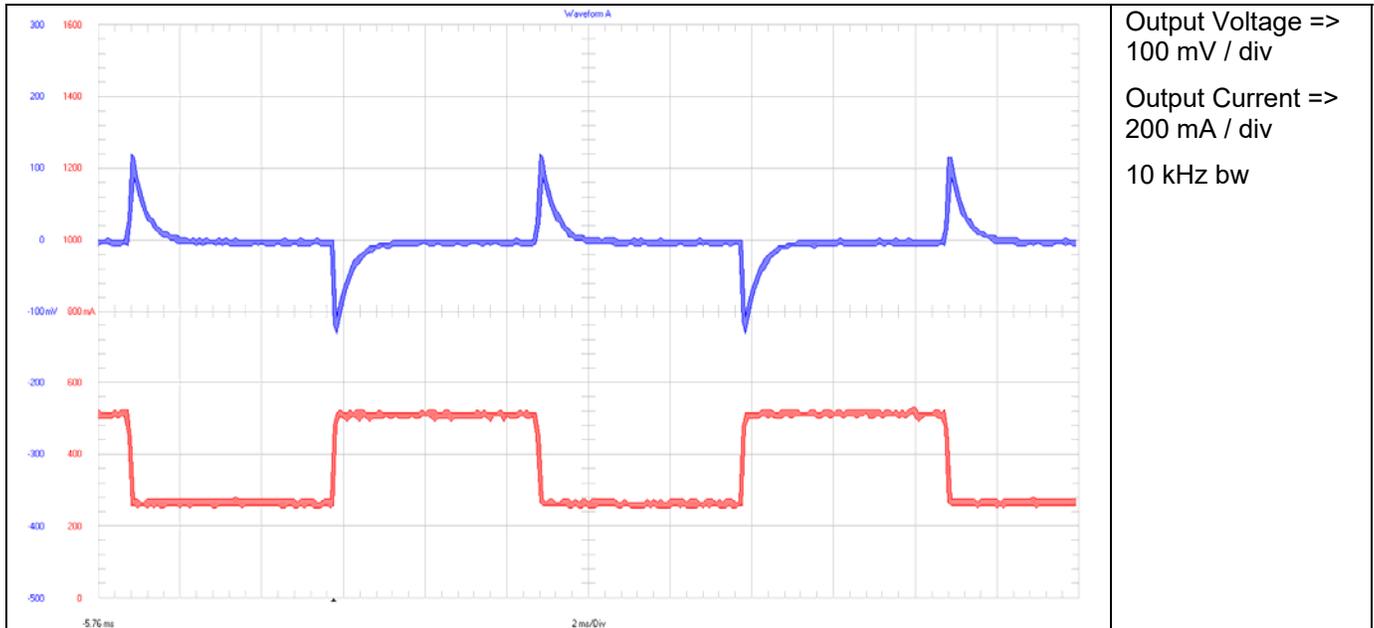


Figure 23 Load Transient @ 12 V Input Voltage

### 3.5.3 18 V Input Voltage



**Figure 24 Load Transient @ 18 V Input Voltage**

### 3.6 Start-up Sequence, soft start time 10ms

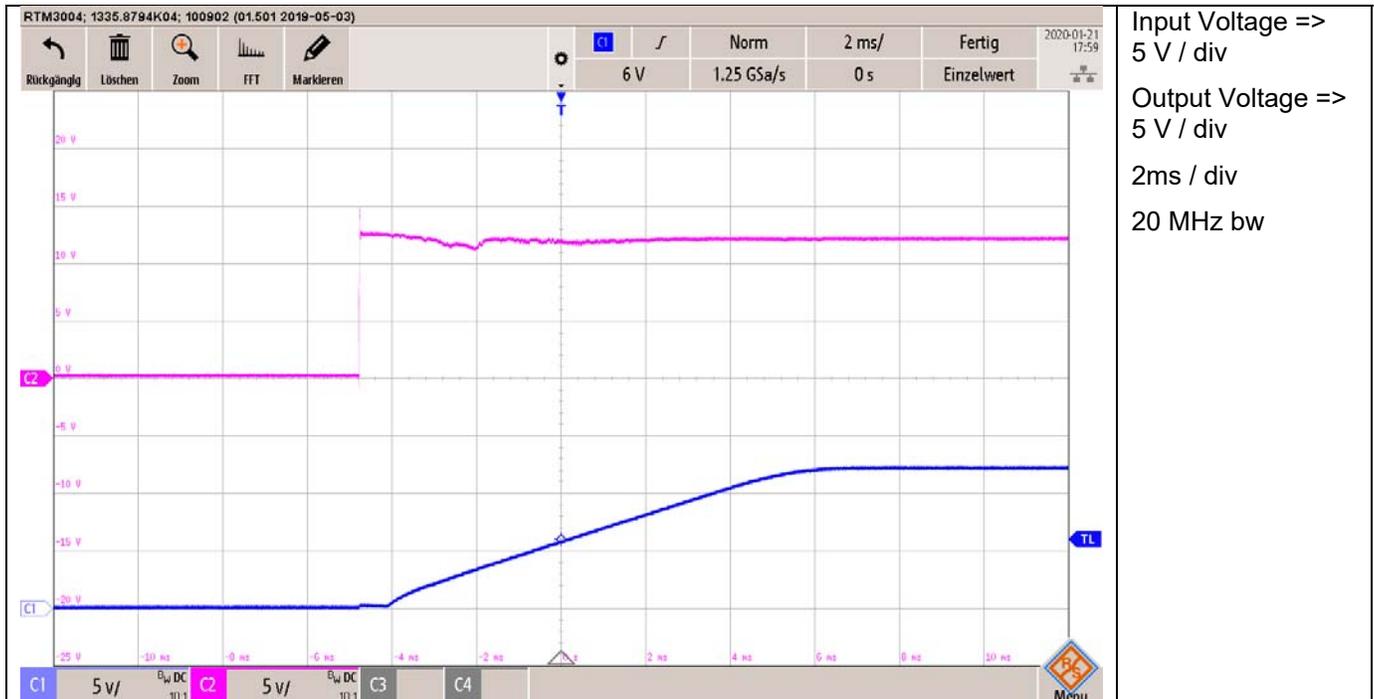


Figure 25 Start-Up @ 12 V Input Voltage, *t<sub>ss</sub>* 10ms ensures low inrush current during startup

### 3.7 Shutdown Sequence

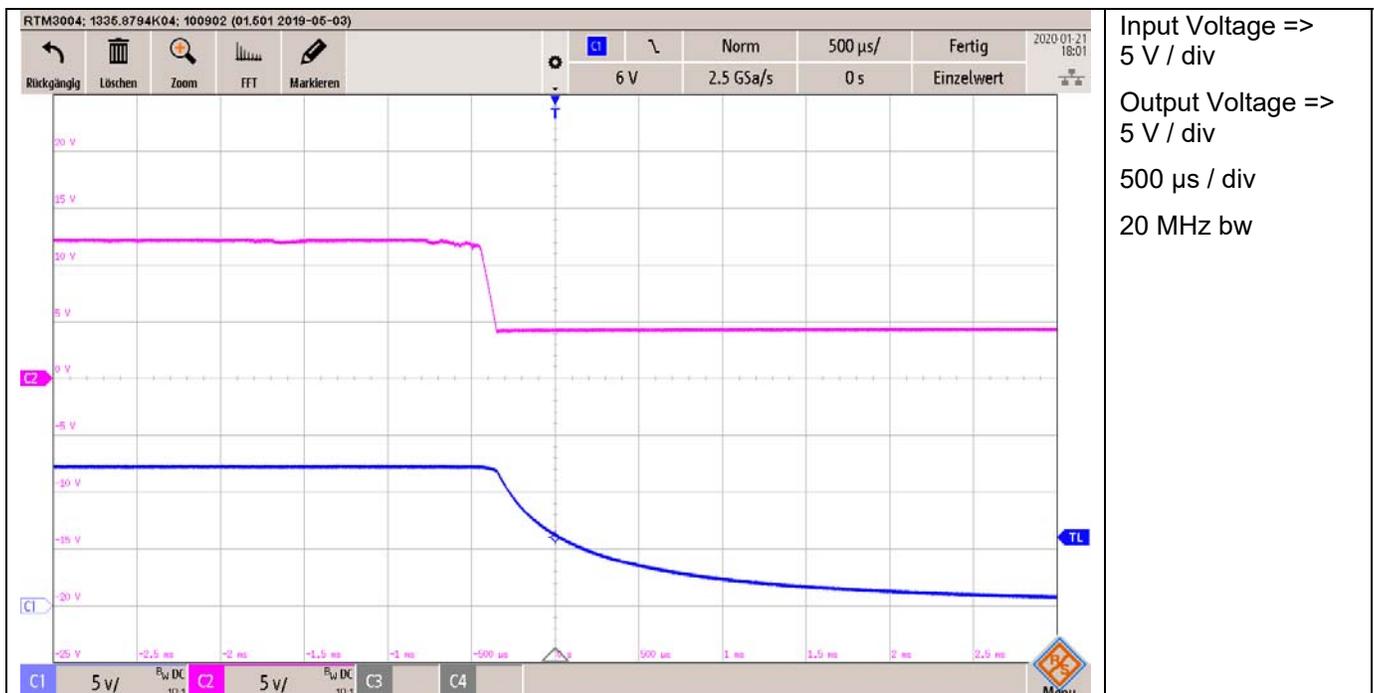


Figure 26 Shutdown @ 12 V Input Voltage

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