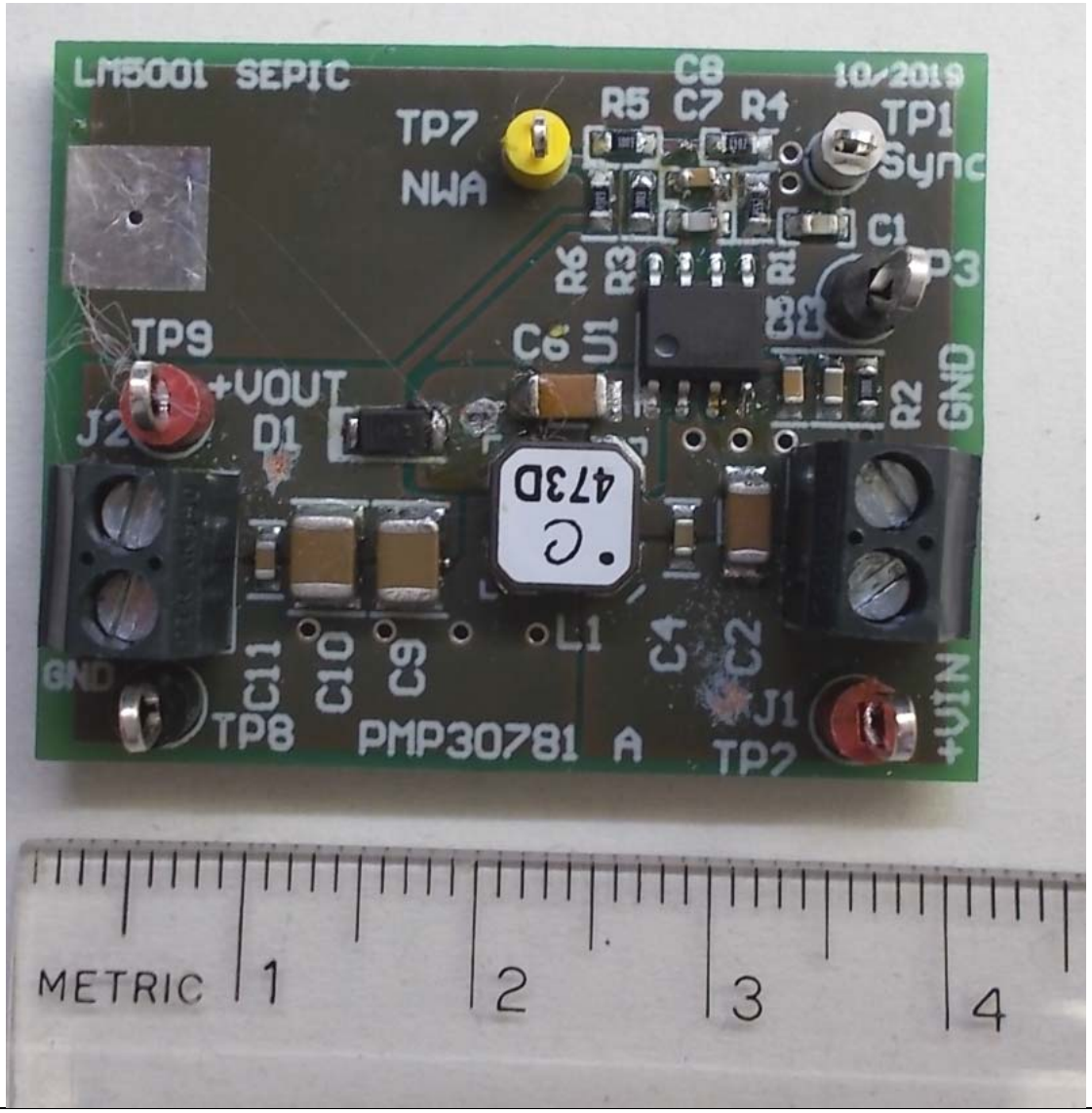
## *Test Report: PMP30781*

# *Tiny Automotive 2-W Bias Power Supply Reference Design*

### Description

This reference design provides a tiny auxiliary +12 V supply for general purpose. In this case, SEPIC topology supports wide input range from 6 V to 60 V. Even at input as low as 3.5 V, this solution is able to provide half of the output power. Another benefit of SEPIC is low reflected ripple, resulting in less conducted emissions. The small magnetizing inductance sets Right Half Plane Zero fairly high, so loop bandwidth can be increased, and allows a small output capacitance by keeping good transient response.

*This design is the complementary solution to PMP30373, inverting SEPIC (=Cuk) to provide negative output voltage.*



# 1 Test Prerequisites

## 1.1 Voltage and Current Requirements

**Table 1. Voltage and Current Requirements**

| PARAMETER | SPECIFICATIONS |
|---|---|
| Input Voltage | 6 V to 60 V |
| Output Voltage | 12 V |
| Maximum Output Current | 0.2 A |
| Switching Frequency | 500 kHz |
| Topology | SEPIC |

*Measured switching frequency at prototype 480kHz;*

*Provides 200mA full power as low as 5V input voltage;*
*Provides 150mA as low as 4V input voltage;*
*Provides 100mA+ as low as 3.5V input voltage.*

## 1.2 Considerations

The switching frequency is around 480 kHz.
Unless otherwise indicated the measurements were done with 0.2 A output current adjusted by a resistor.

# 2 Testing and Results

## 2.1 Efficiency Graphs

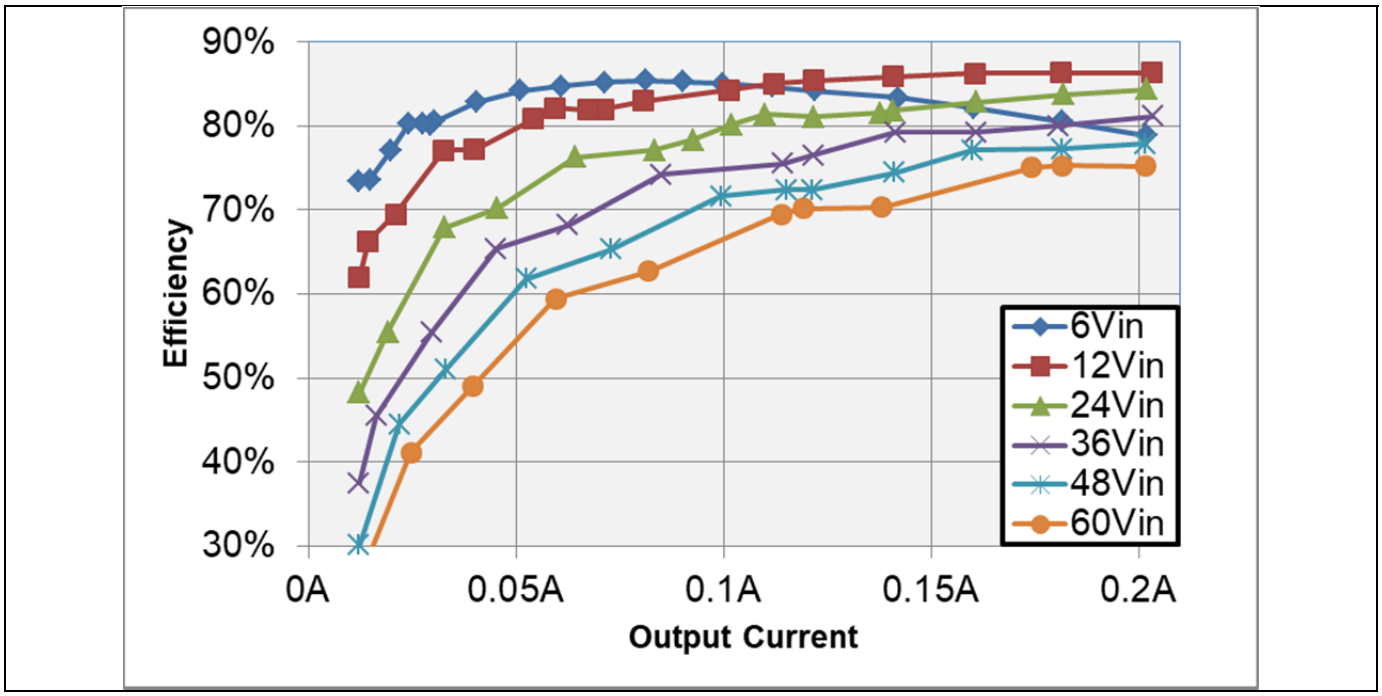



**Figure 1 Efficiency vs Output Current**

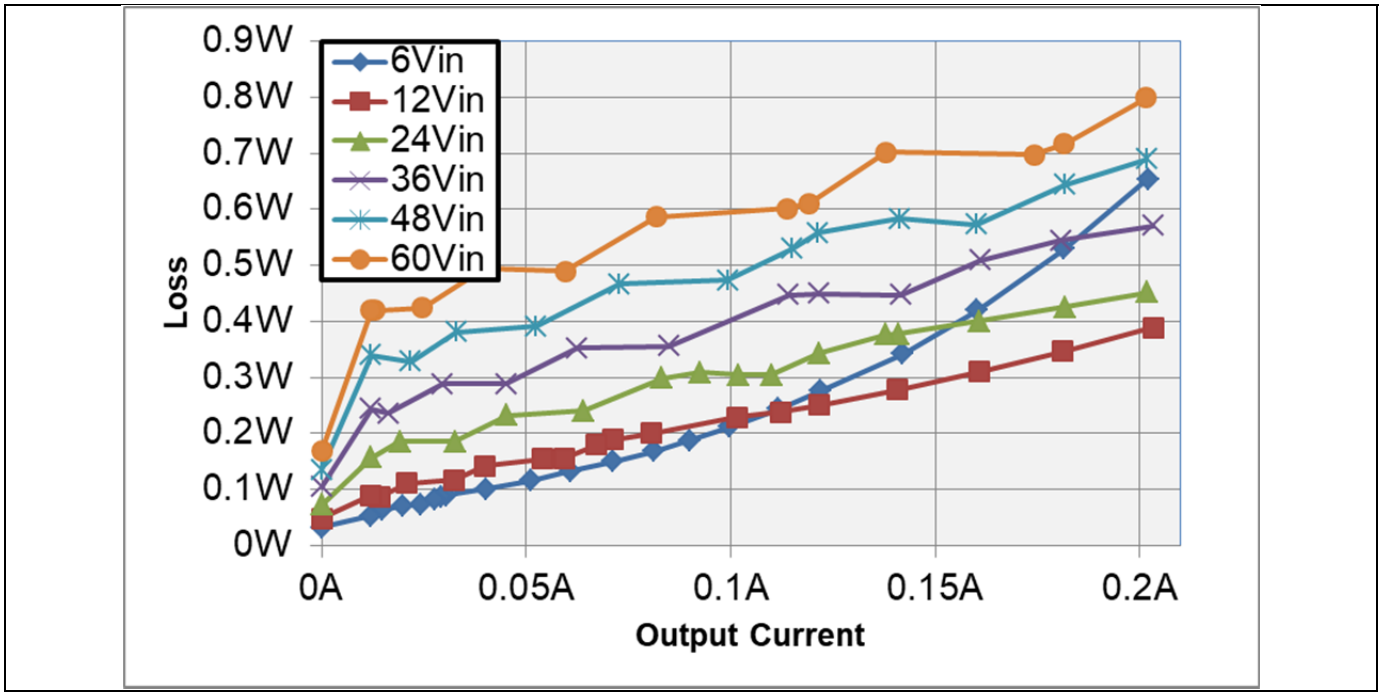



**Figure 2 Loss vs Output Current**

### 2.2 Line Regulation

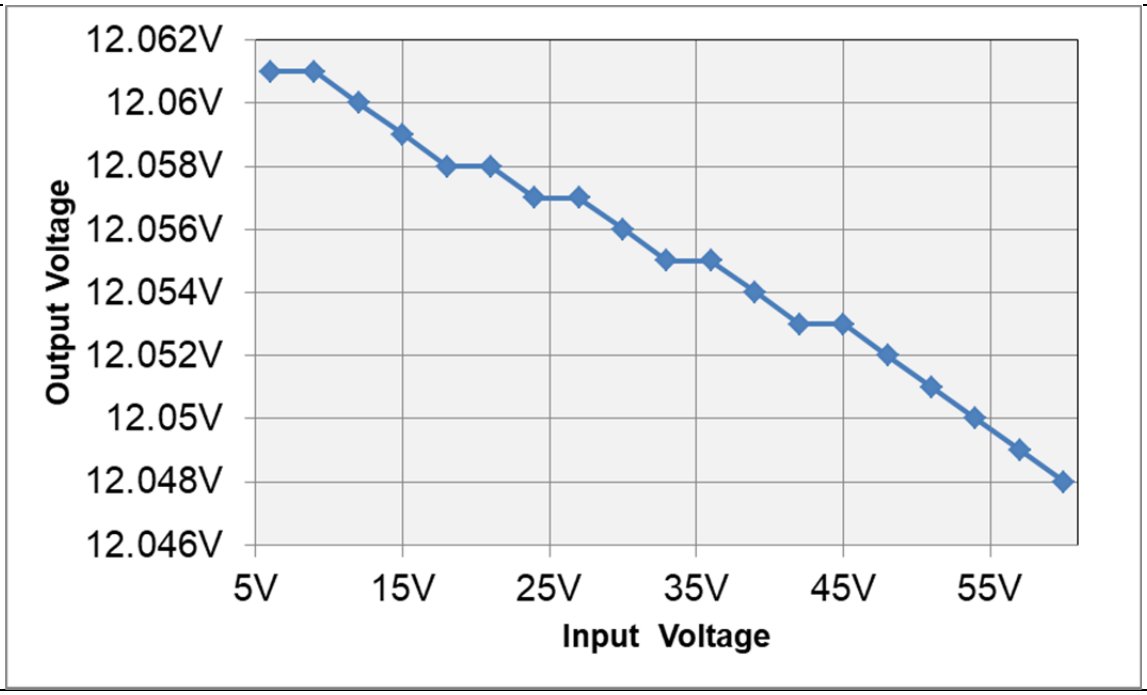



**Figure 3 Output Voltage vs Input Voltage**

With the same measurement setup efficiency and loss were calculated.

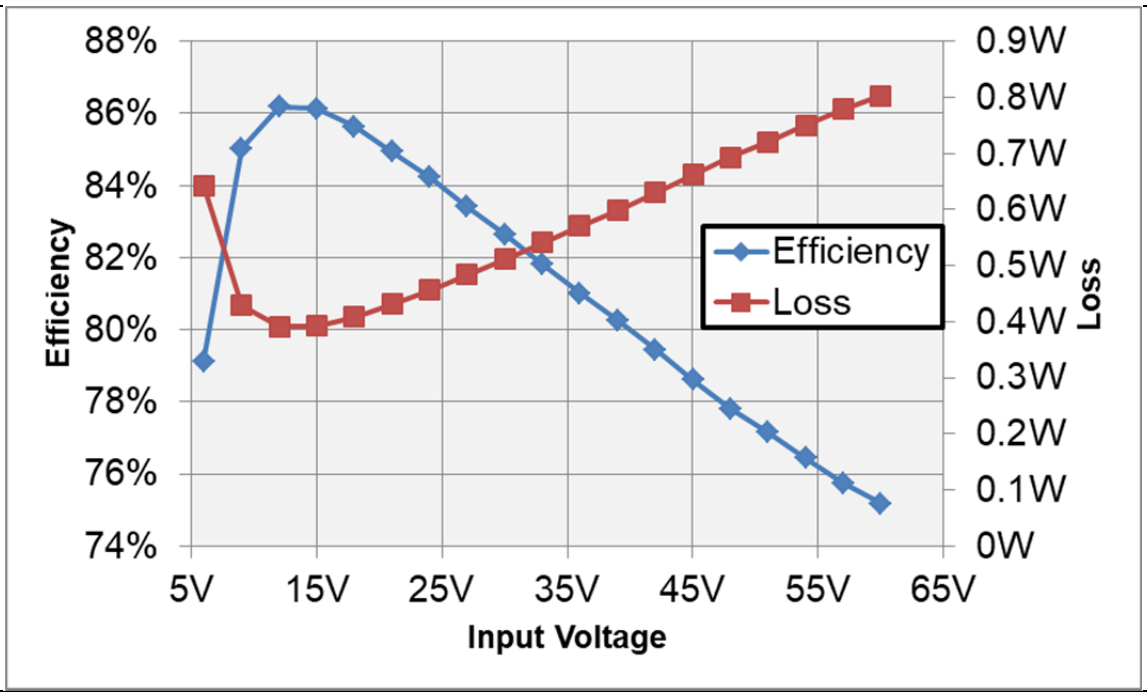



**Figure 4 Efficiency and Loss vs Input Voltage**

### 2.3 Load Regulation

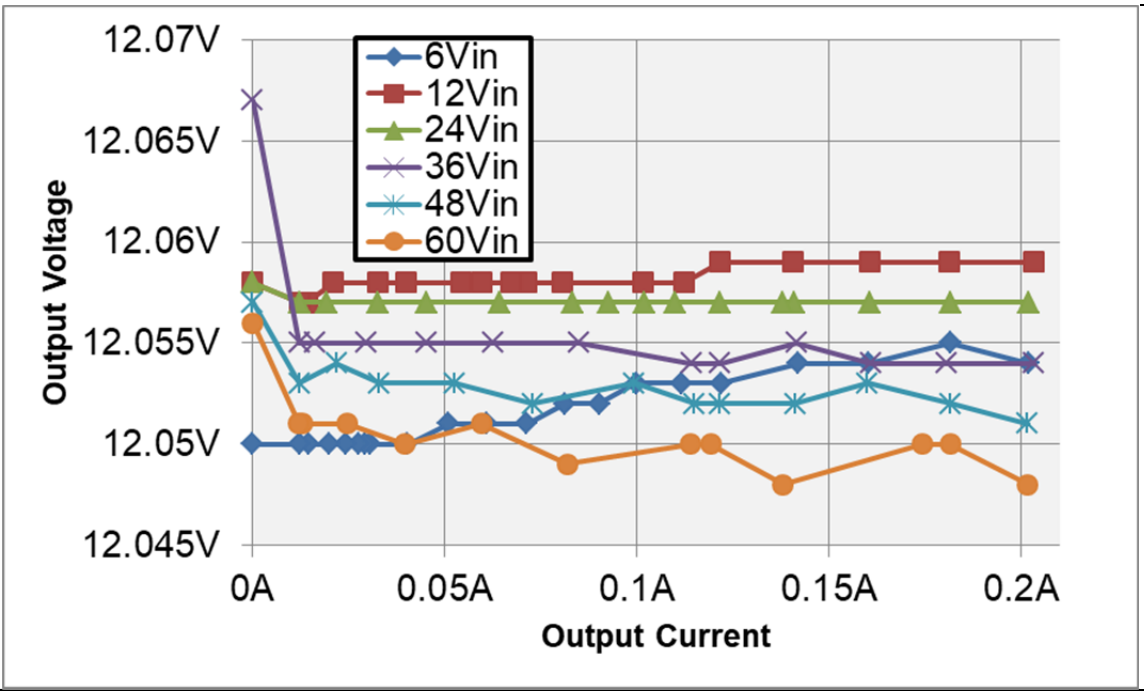
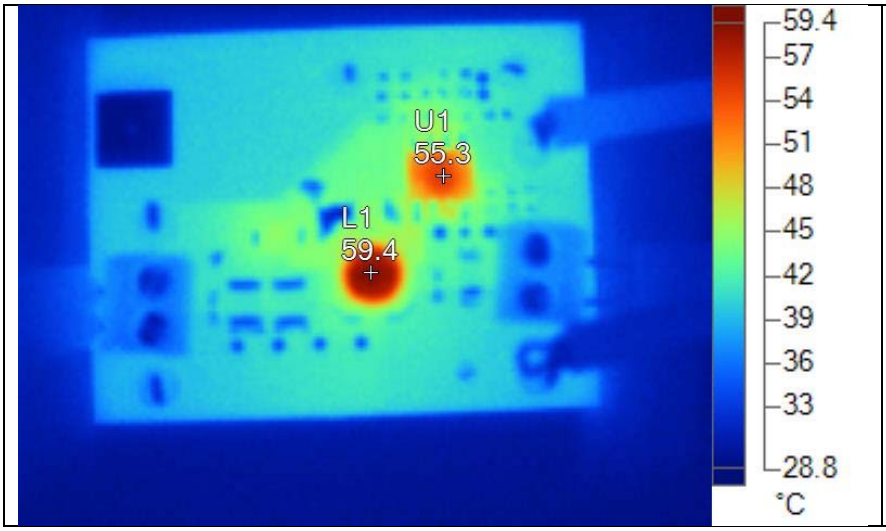



**Figure 5 Output Voltage vs Output Current**

## 2.4 Thermal Images

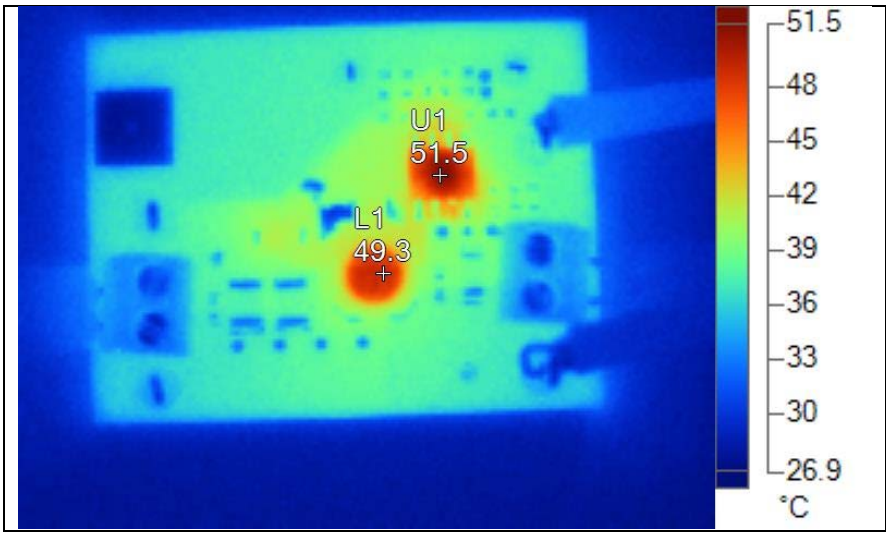
### 2.4.1 6 V Input Voltage




| Name | Temperature |
|---|---|
| L1 | 59.4°C |
| U1 | 55.3°C |

**Figure 6 Thermal Image at 6 V Input Voltage**

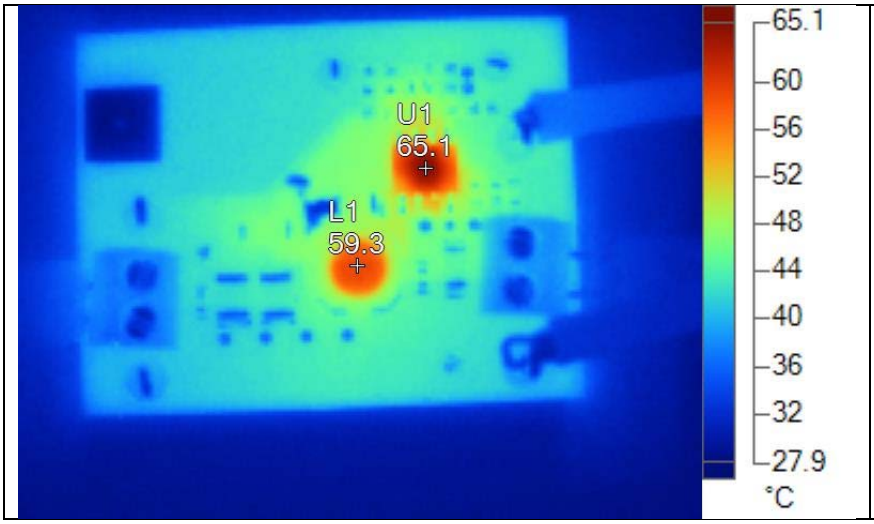
### 2.4.2 36 V Input Voltage




| Name | Temperature |
|---|---|
| L1 | 49.3°C |
| U1 | 51.5°C |

**Figure 7 Thermal Image at 36 V Input Voltage**

### 2.4.3 60 V Input Voltage




| Name | Temperature |
|---|---|
| L1 | 59.3°C |
| U1 | 65.1°C |

**Figure 8 Thermal Image at 60 V Input Voltage**

## *2.5 Dimensions*

The size of the boards is 39.4mm x 30.5mm

# 3 Waveforms

## 3.1 Switching

### 3.1.1 SW to GND

#### 3.1.1.1 6 V Input Voltage

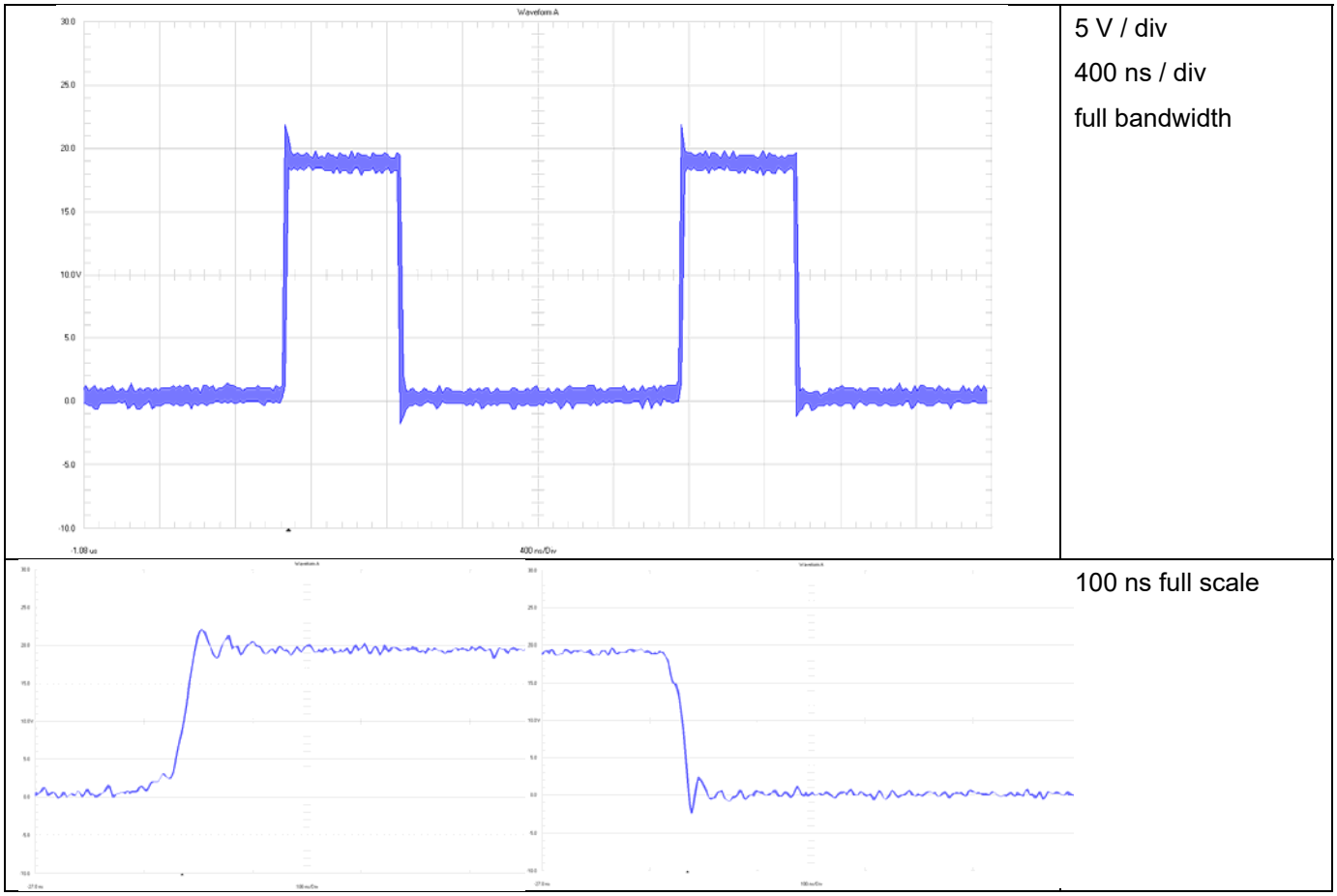



**Figure 9 SW-to GND @ 6 V Input Voltage**

### 3.1.1.2 36 V Input Voltage

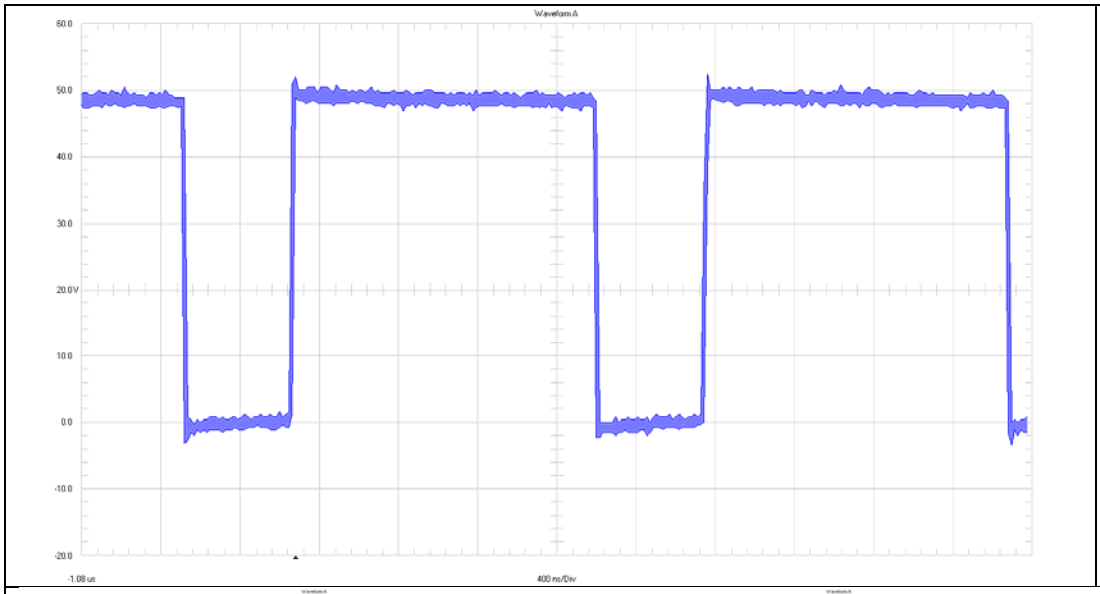



**Figure 10 SW-to GND @ 36 V Input Voltage**

### 3.1.1.3 60 V Input Voltage

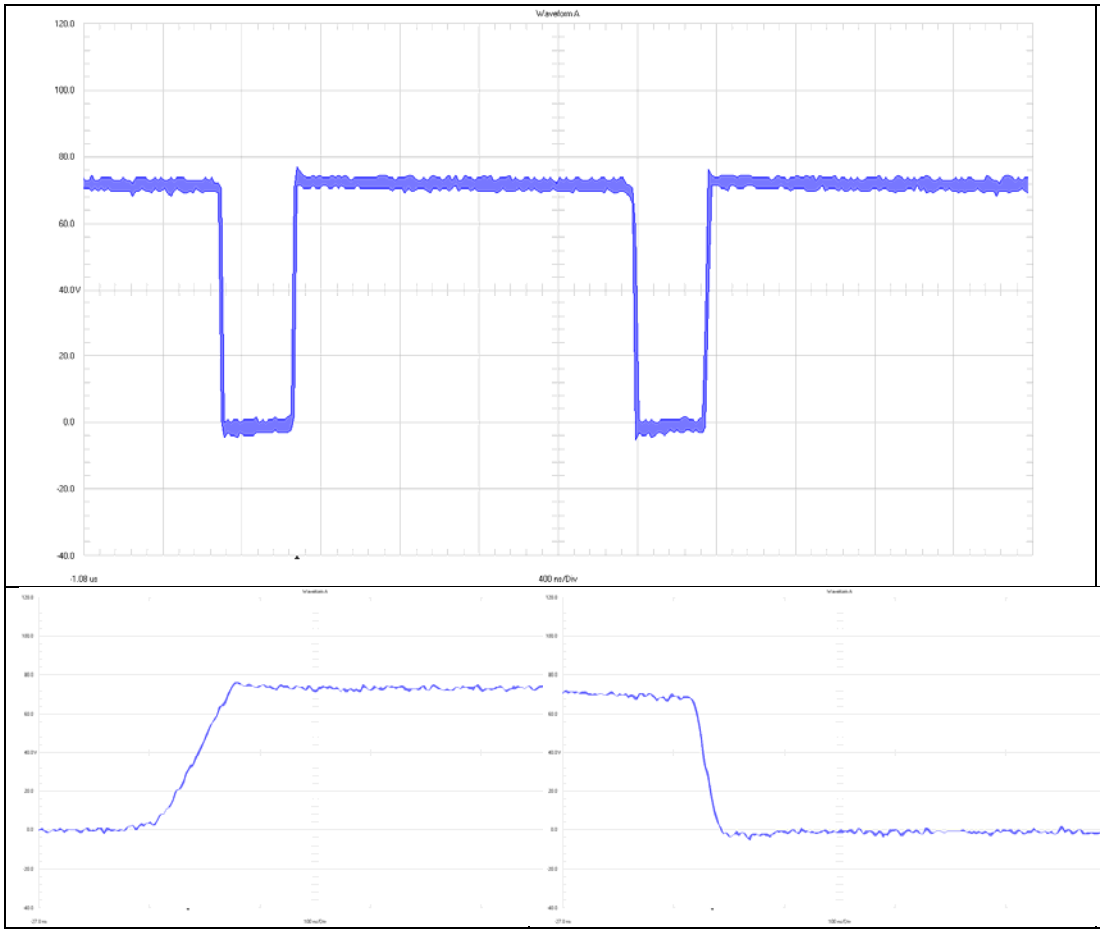



**Figure 11 SW-to GND @ 60 V Input Voltage**

### 3.1.2 Diode D1 (referenced to VOUT)

#### *3.1.2.1 6 V Input Voltage*

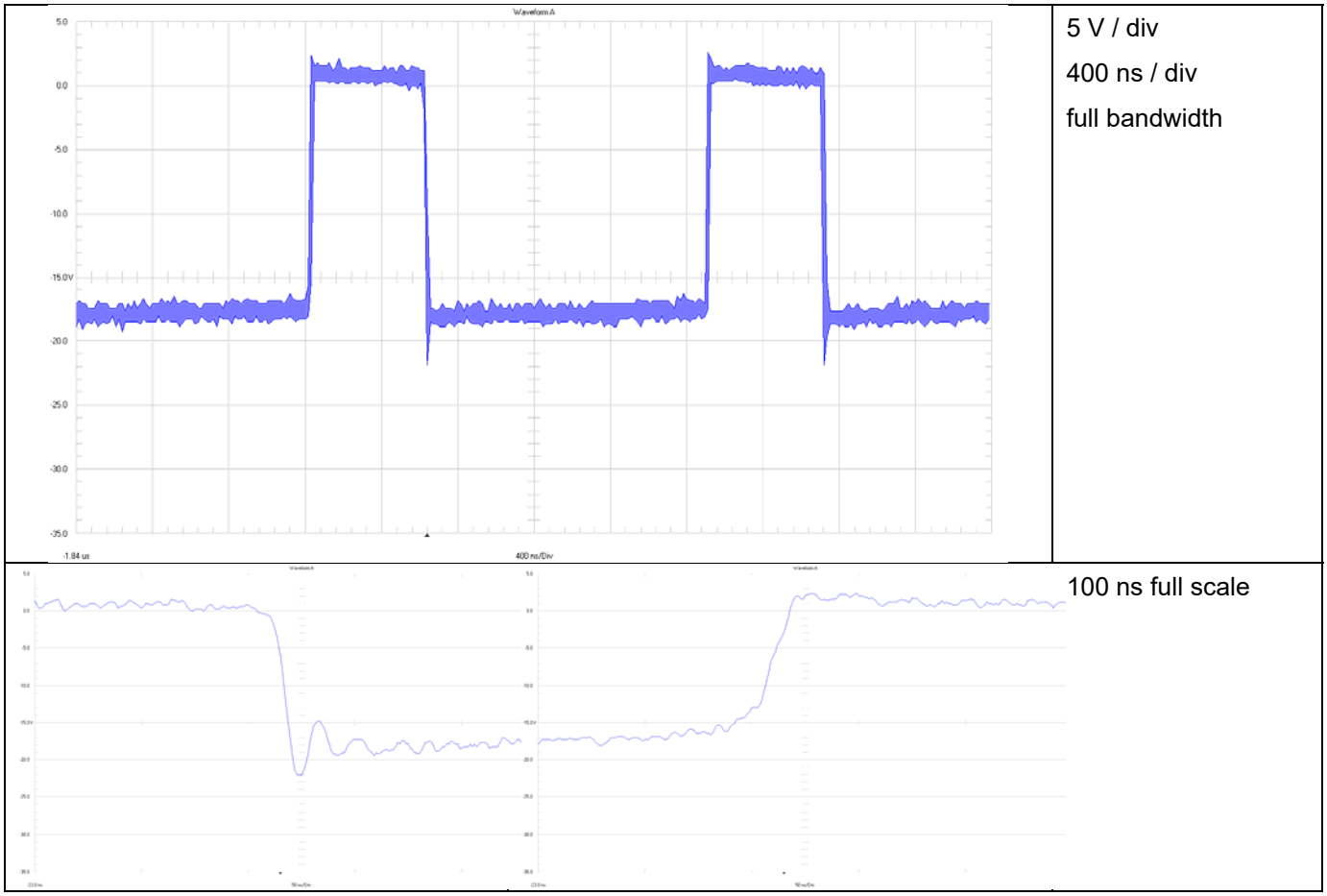



**Figure 12 D1 @ 6 V Input Voltage**

### 3.1.2.2 36 V Input Voltage

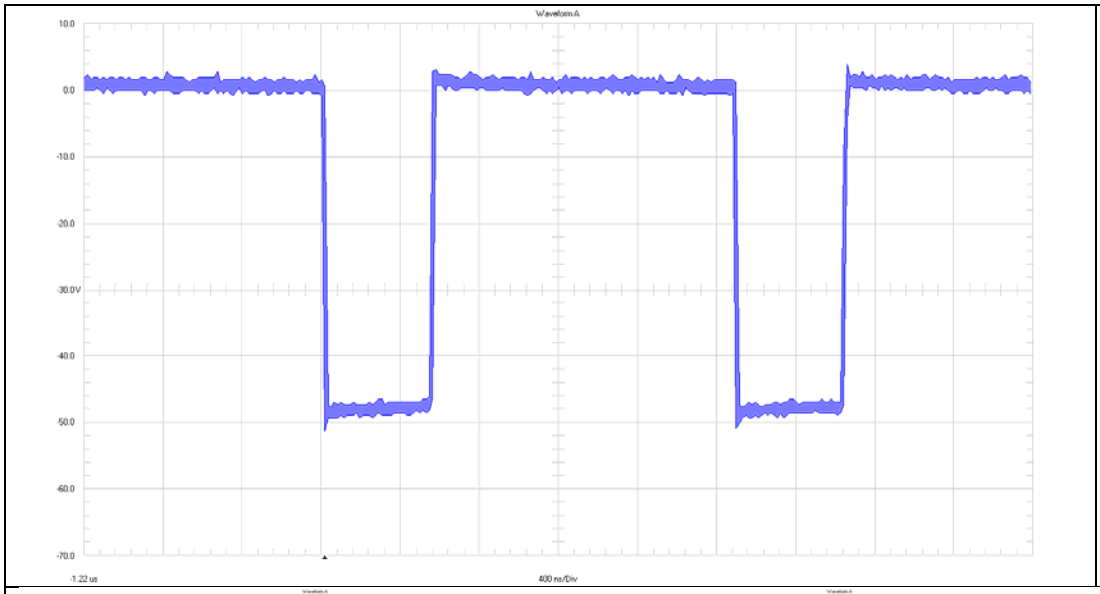



**Figure 13 D1 @ 36 V Input Voltage**

### 3.1.2.3 60 V Input Voltage

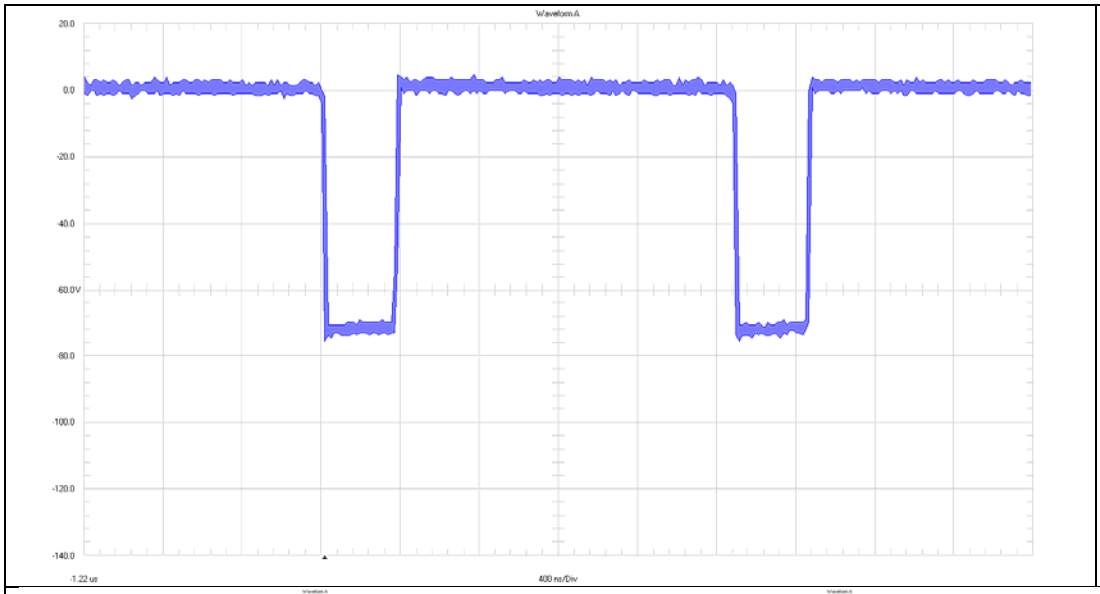
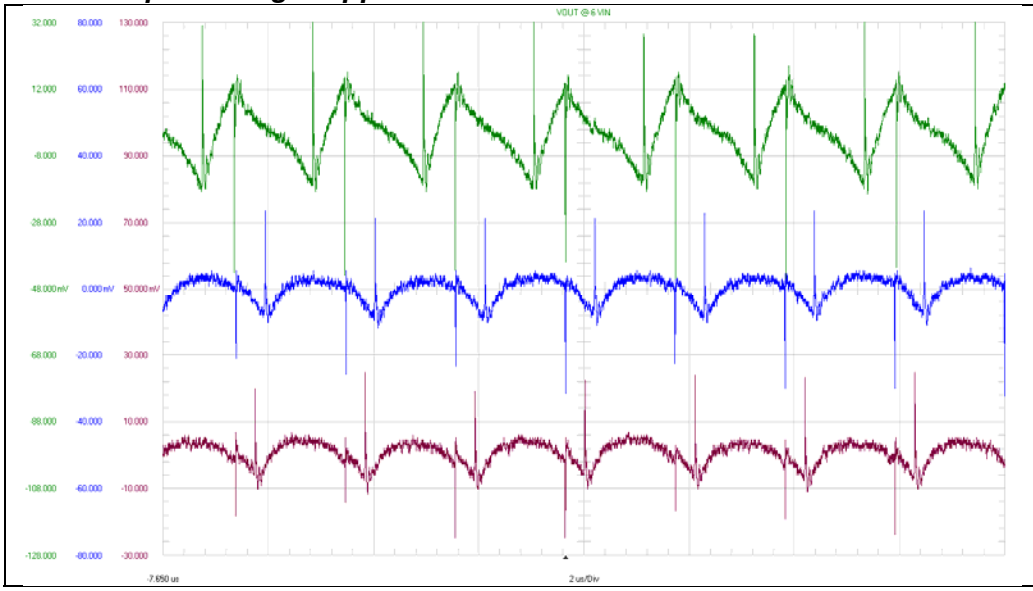



**Figure 14 D1 @ 60 V Input Voltage**

No ringing, no overshoot reduces RF content to ensure low radiated emissions.

### 3.2 Output Voltage Ripple




Ch1=>VOUT @ 6Vin

Ch2=>VOUT @ 36Vin

Ch3=>VOUT @ 60Vin

20 mV / div
(AC coupled)

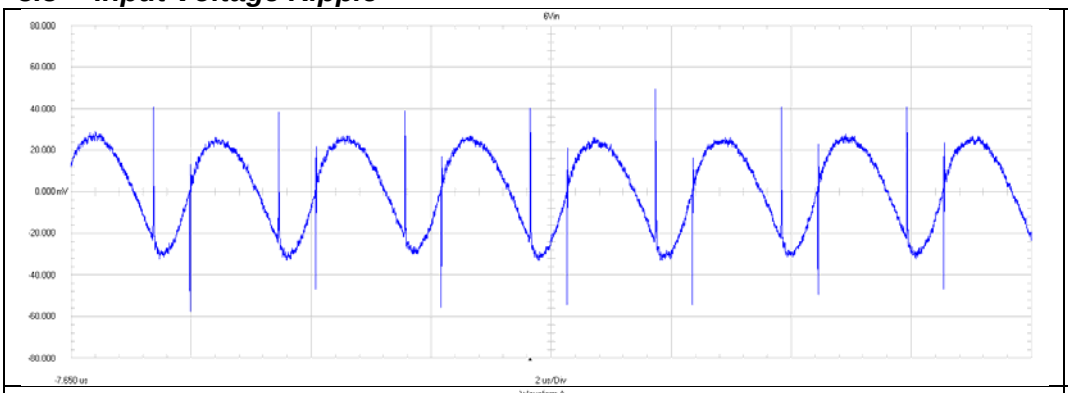
2 µs / div

20 MHz bandwidth

**Figure 15 VOUT @ 6 V Input Voltage**

All waveforms were captured separately – output voltage ripple is below 0.5% of DC output voltage.

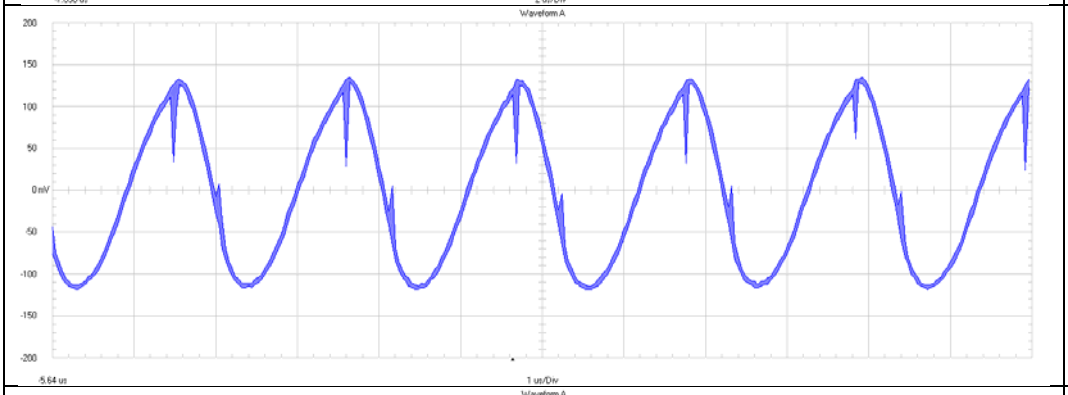
### 3.3 Input Voltage Ripple




6 V Input

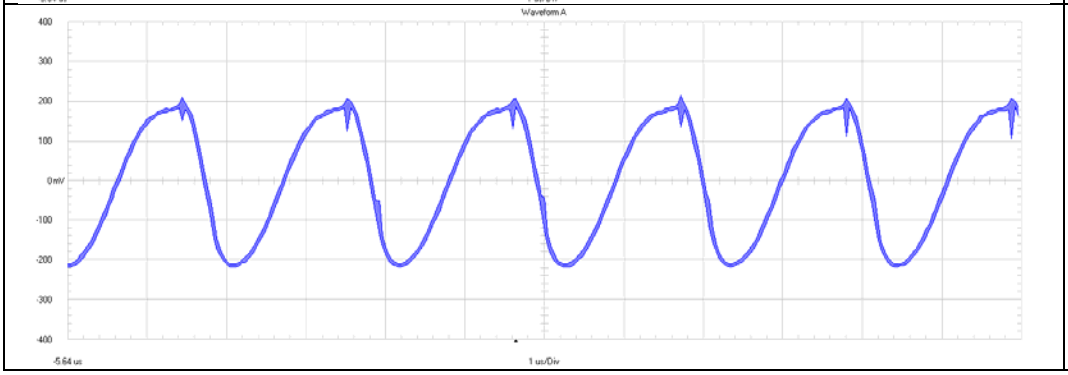
**20 mV / div**
(AC coupled)

2 µs / div
20 MHz bandwidth




36 V Input
**50 mV / div**
(AC coupled)

2 µs / div
20 MHz bandwidth




60 V Input
**100 mV / div**
(AC coupled)

2 µs / div
20 MHz bandwidth

**Figure 16 Input Voltage Ripple for 6 V, 36 V and 60 V Input Voltage**

Sinusoidal input ripple by SEPIC topology, less harmonic content.

### 3.4 Bode Plot

| | 6 Vin | 36 Vin | 60 Vin |
|---|---|---|---|
| **Bandwidth (kHz)** | 3.97 | 10.2 | 8.6 |
| **Phasemargin** | 75° | 78° | 80° |
| **slope (20dB/decade)** | -0.99 | -1.0 | -1.0 |
| | | | |
| **gain margin (dB)** | -15.1 | -21.2 | -23.55 |
| **slope (20dB/decade)** | -0.5 | -1.49 | -1.4 |
| **freq (kHz)** | 33.9 | 81.9 | 85.2 |

**Table 1 Summery of the Bode Plots**

#### 3.4.1 6 V Input Voltage

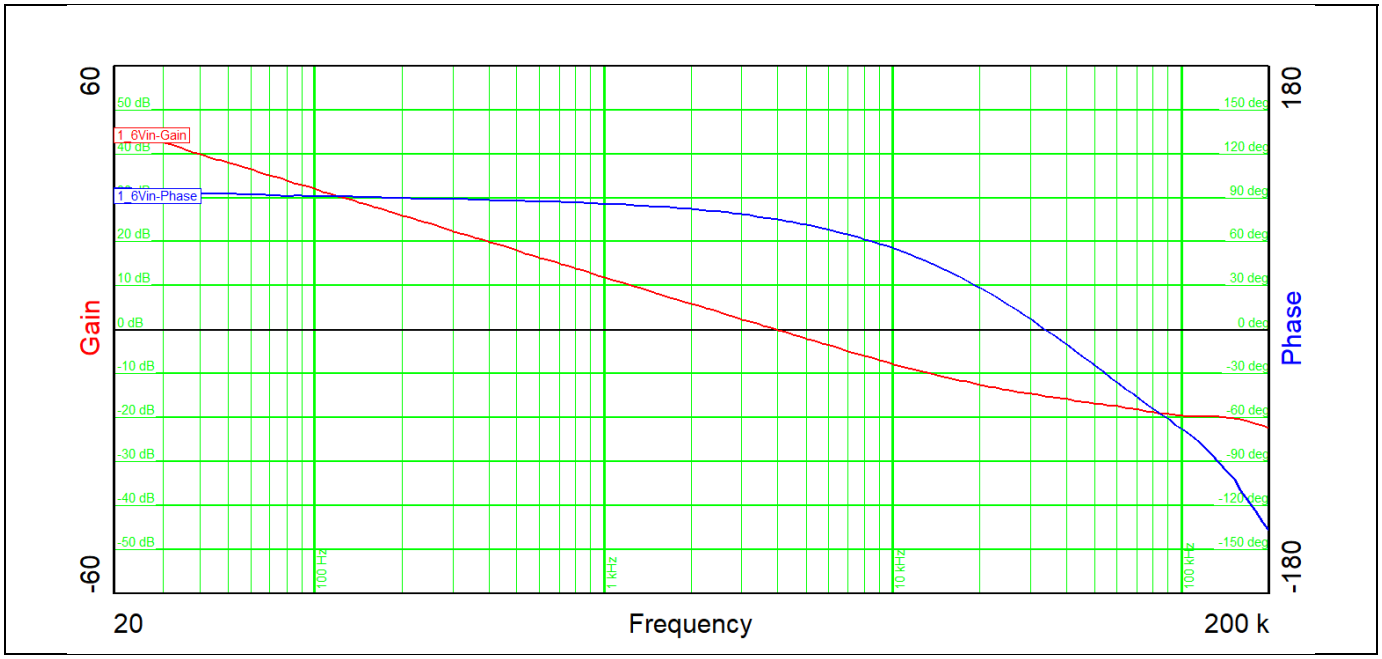



**Figure 17 Frequency Response for 6 V Input Voltage**

RHPZ at 45kHz limits loop bandwidth to 4kHz by keeping gain margin of -15dB.

### 3.4.2 36 V Input Voltage

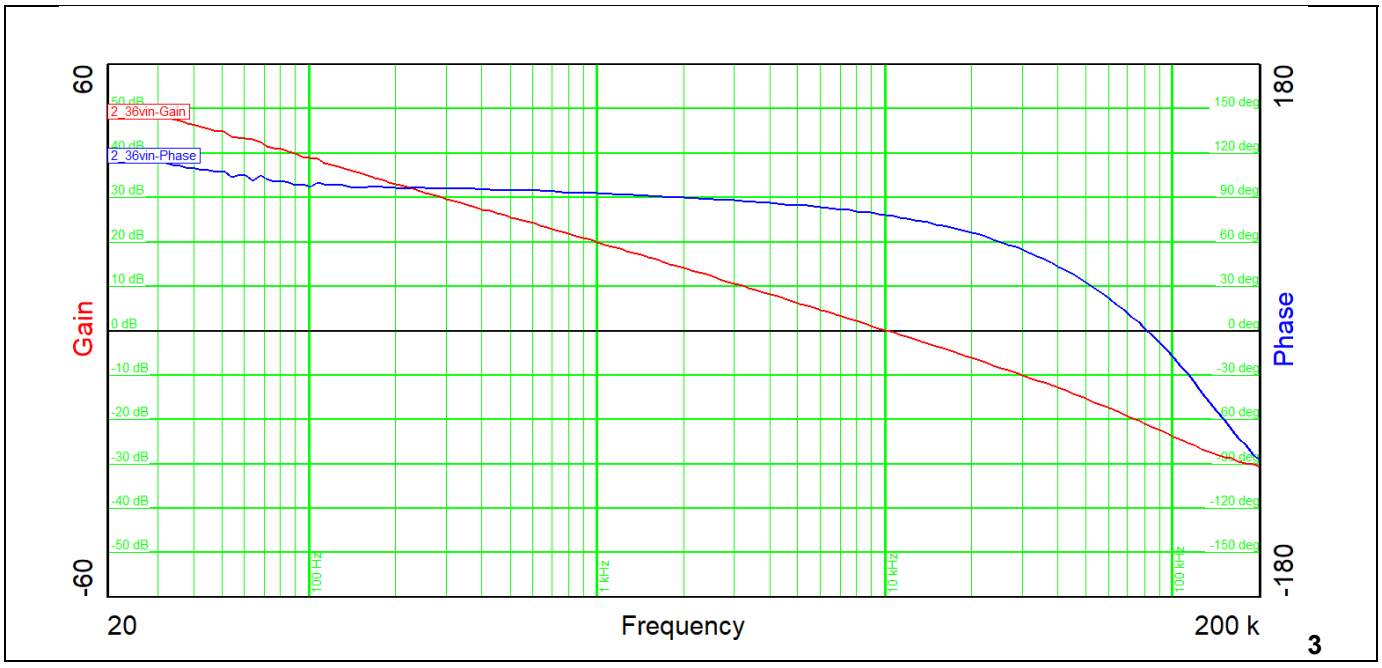



**Figure 18 Frequency Response for 36 V Input Voltage**

### 3.4.3 60 V Input Voltage

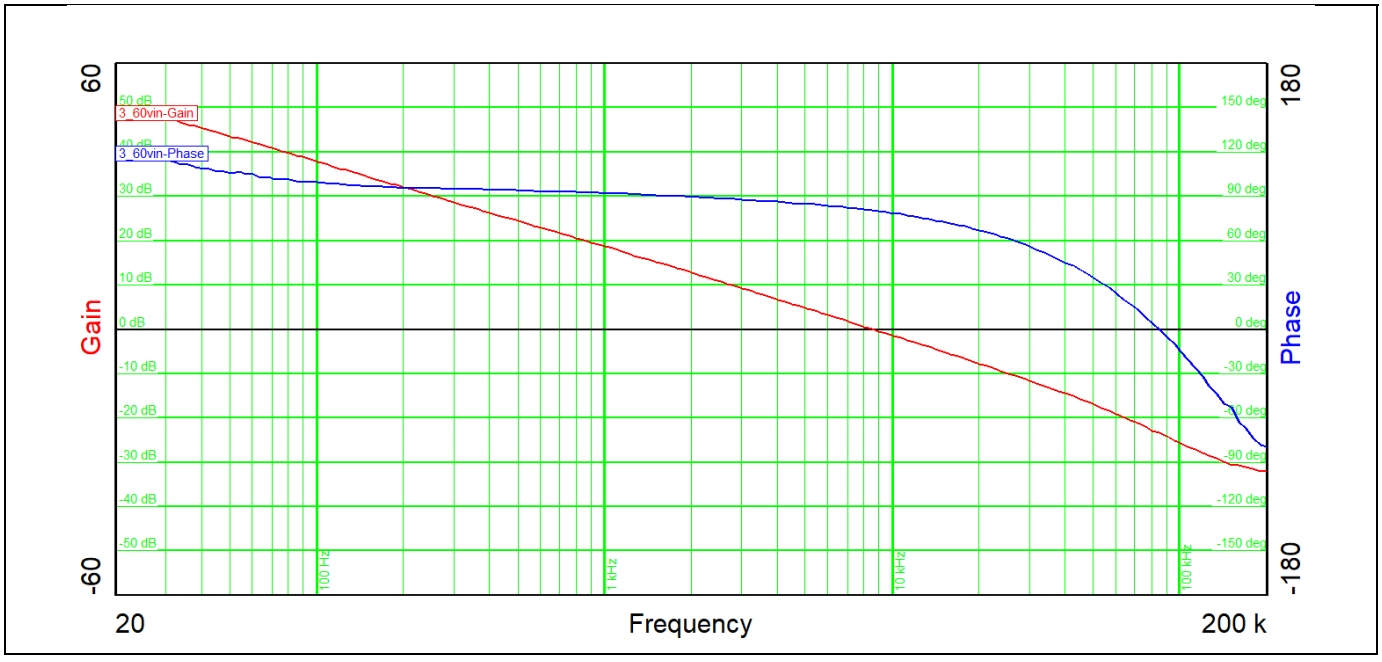
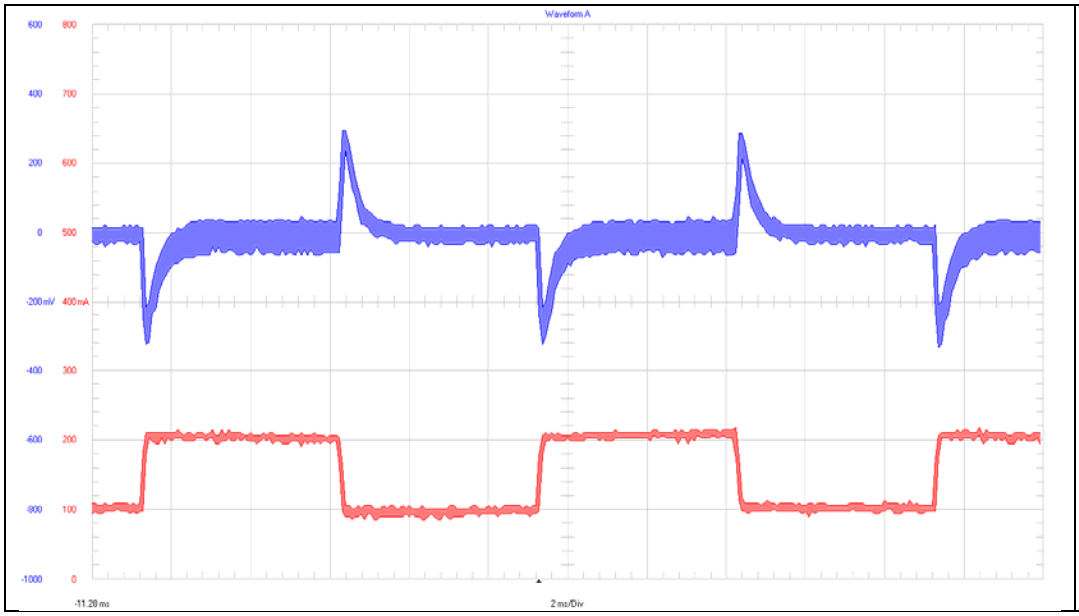



**Figure 19 Frequency Response for 60 V Input Voltage**

## 3.5 Load Transients

The electronic load switched between 0.1 A and 0.2 A with a frequency of 100 Hz.

### 3.5.1 6 V Input Voltage



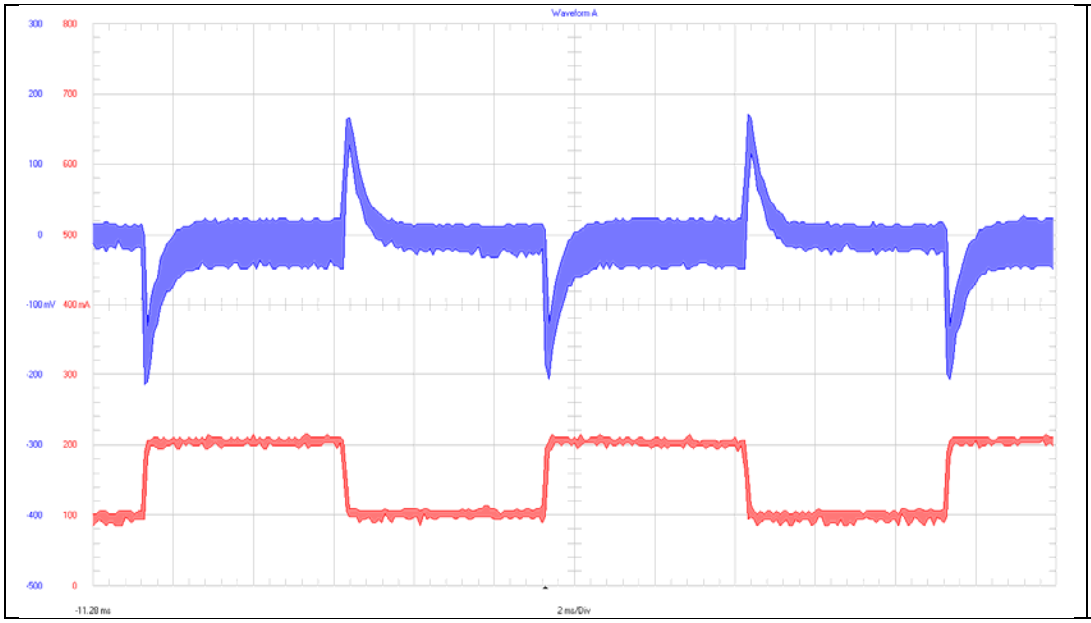
Output Voltage (AC)
=>
**200 mV / div**
20 MHz bandwidth

Output Current =>
100 mA / div
10 kHz bandwidth

2 ms / div

**Figure 20 Load Transient for 6 V Input Voltage**

### 3.5.2 36 V Input Voltage



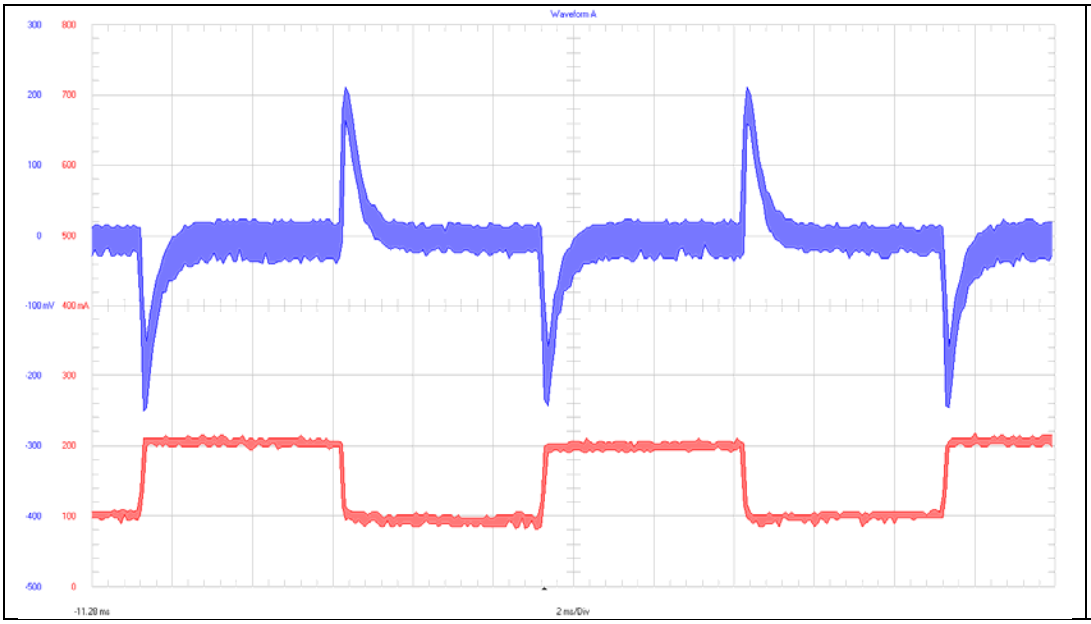
Output Voltage (AC)
=>
**100 mV / div**
20 MHz bandwidth

Output Current =>
100 mA / div
10 kHz bandwidth

2 ms / div

**Figure 21 Load Transient for 36 V Input Voltage**

### 3.5.3 60 V Input Voltage



Output Voltage (AC) =>
**100 mV / div**
20 MHz bandwidth

Output Current =>
100 mA / div
10 kHz bandwidth

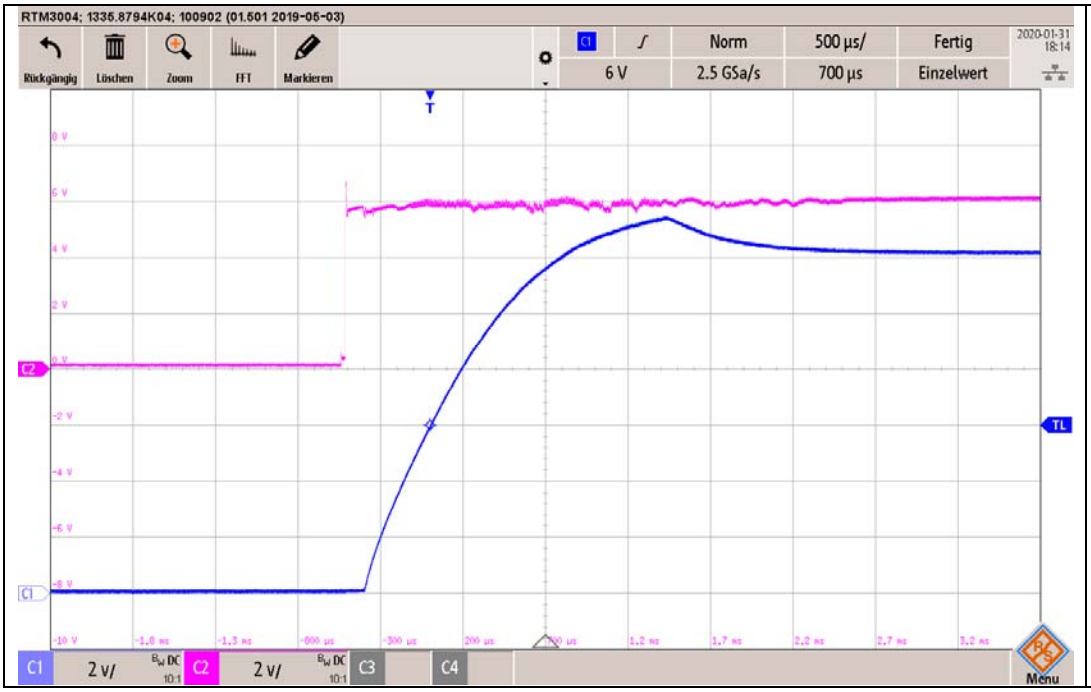
2 ms / div

**Figure 22 Load Transient for 60 V Input Voltage**

Despite small output capacitance transient response is 2.5% of Vout worst case (input voltage 6V)

## *3.6 Start-up Sequence*

### 3.6.1 6 V Input Voltage




Input Voltage =>
**2 V / div**
20 MHz bandwidth

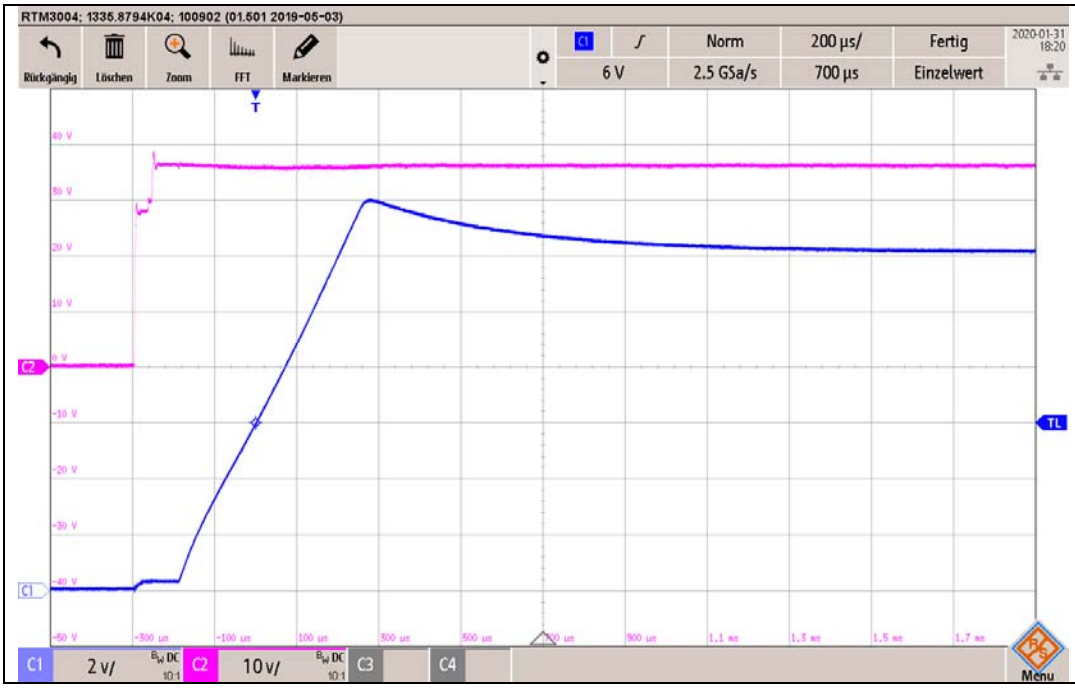
Output Voltage =>
2 V / div

20 MHz bandwidth

500 µs / div

**Figure 23 Start-up @ 6 V Input Voltage**

### 3.6.2 36 V Input Voltage




Input Voltage =>
**10 V / div**
20 MHz bandwidth

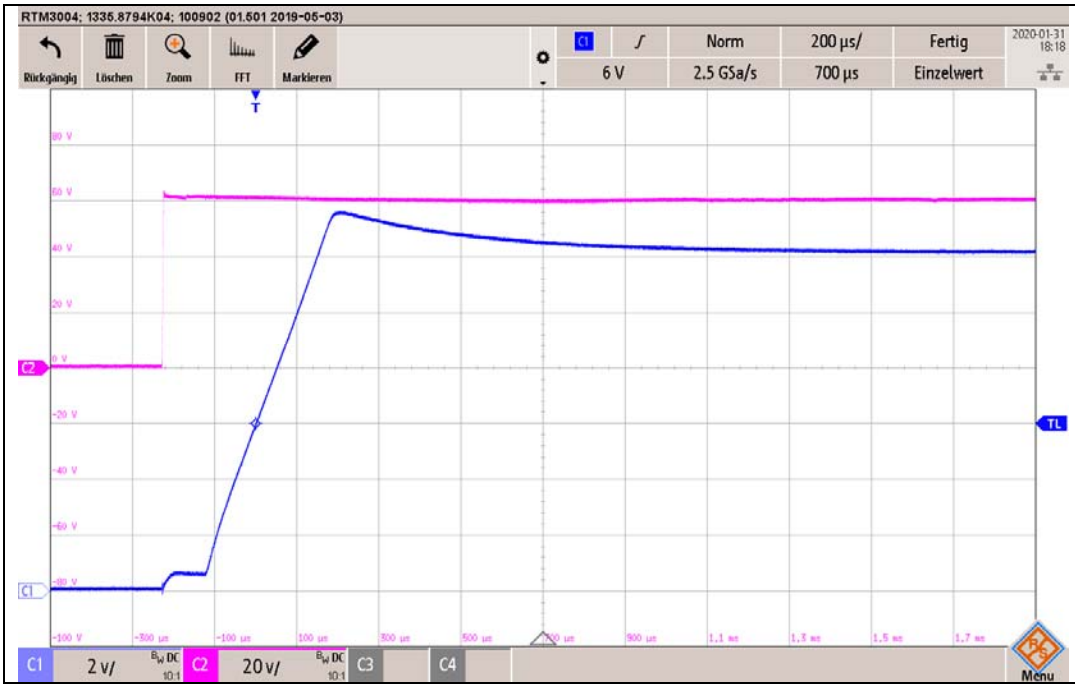
Output Voltage =>
2 V / div

20 MHz bandwidth

200 µs / div

**Figure 24 Start-up @ 36 V Input Voltage**

### 3.6.3 60 V Input Voltage




Input Voltage =>
**20 V / div**
20 MHz bandwidth

Output Voltage =>
2 V / div

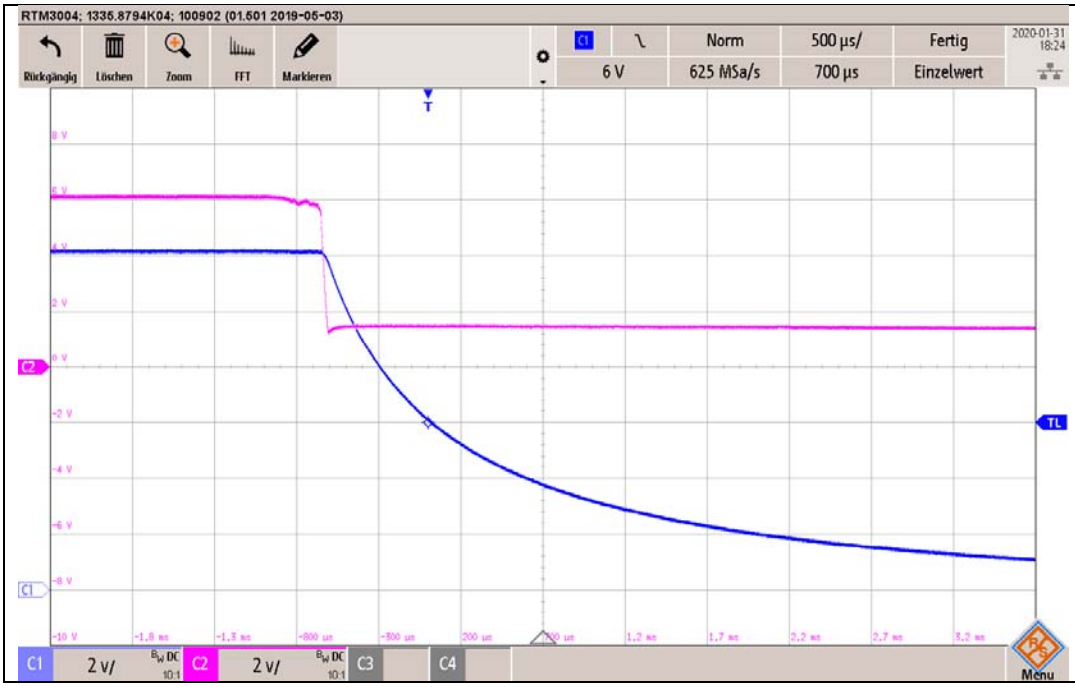
20 MHz bandwidth

200 µs / div

**Figure 25 Start-up @ 60 V Input Voltage**

## 3.7 Shut-down Sequence

### 3.7.1 6 V Input Voltage




Input Voltage =>
**2 V / div**
20 MHz bandwidth

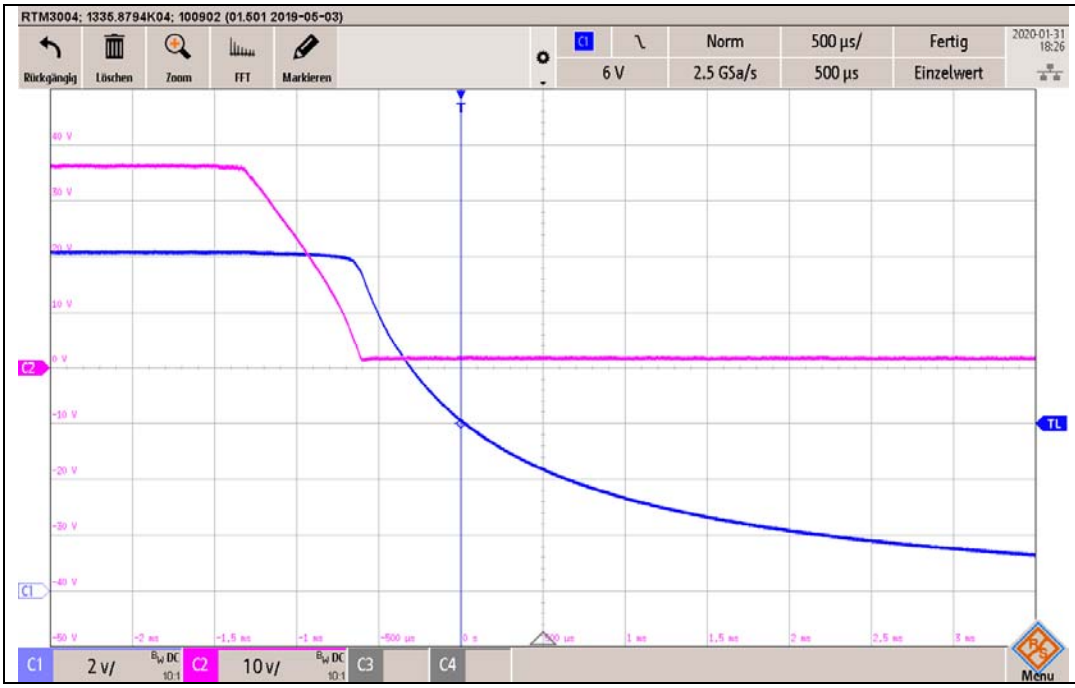
Output Voltage =>
2 V / div

20 MHz bandwidth

500 µs / div

**Figure 26 Shut-down @ 6 V Input Voltage**

### 3.7.2 36 V Input Voltage




Input Voltage =>
**10 V / div**
20 MHz bandwidth

Output Voltage =>
2 V / div

20 MHz bandwidth

500 µs / div

**Figure 27 Shut-down @ 36 V Input Voltage**

### 3.7.3 60 V Input Voltage


Input Voltage =>
**20 V / div**
20 MHz bandwidth

Output Voltage =>
2 V / div

20 MHz bandwidth

500 µs / div

**Figure 28 Shut-down @ 60 V Input Voltage**

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