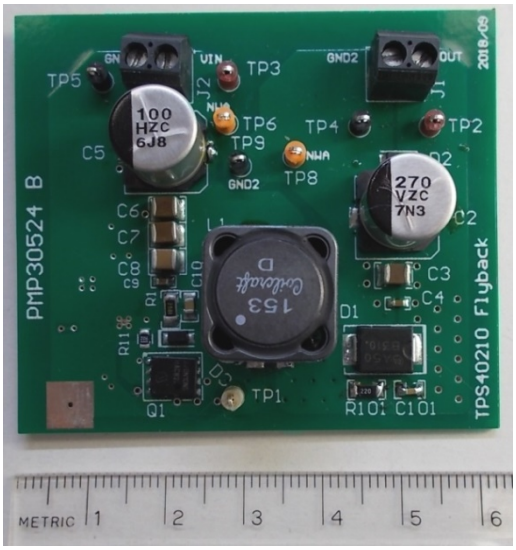
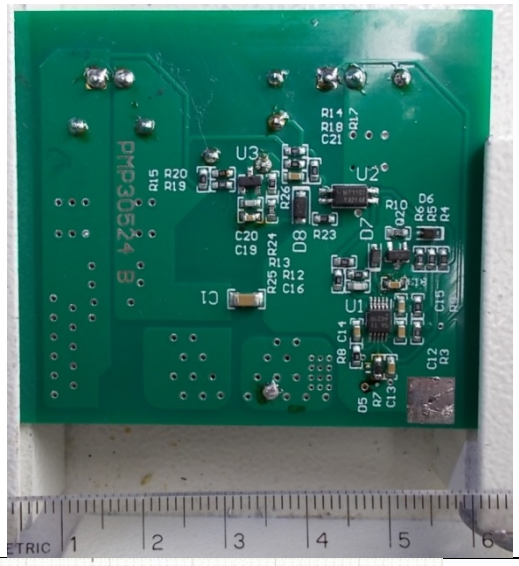
Test Report: PMP30524

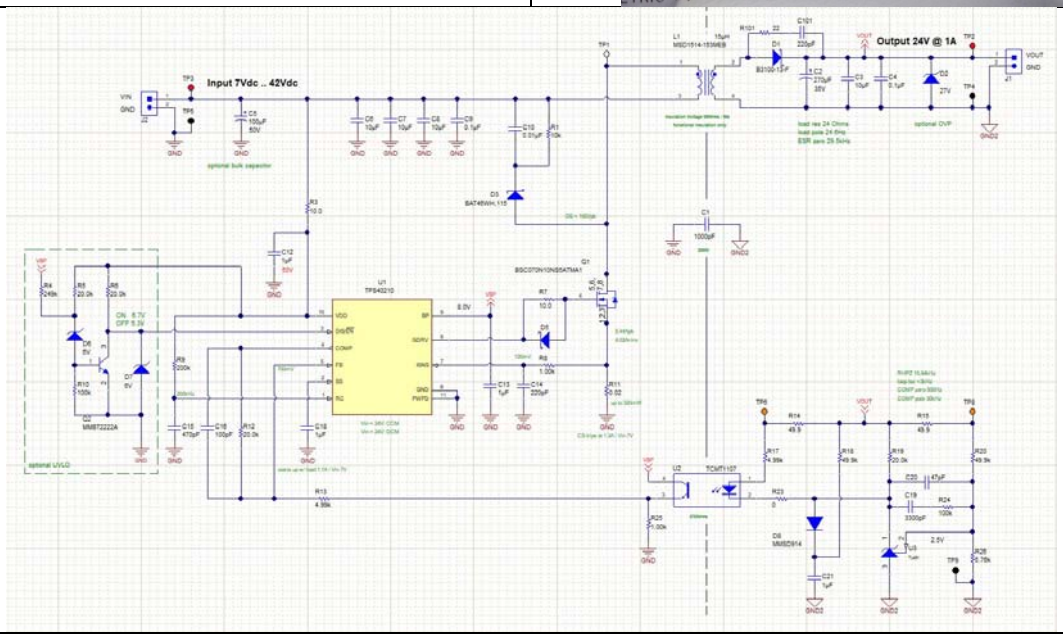
Isolated 24-W Flyback Reference Design for Industrial and Automotive Applications

Description

This reference design provides functional isolation 500 Vrms by simply using a dual inductor from stock. Overall, the design is driven by minimum cost using TPS40210 and adding discrete UVLO. Also, the input range of 1:6 exceeds industrial standard by 7 V to 42 V, which makes this reference design ideal for several applications.







1 Test Prerequisites

1.1 Voltage and Current Requirements

Table 1. Voltage and Current Requirements

PARAMETER	SPECIFICATIONS
Input Voltage	7 V to 42 V
Output Voltage	24V
Output Current (max)	1A
Isolation	here: 500Vrms functional*

* limited by dual inductor; Xcap allows up to 2kV, opto isolator up to 3.75kV

1.2 Considerations

Unless otherwise indicated, resistor was used as load. The output current was adjusted to 1A.
The circuit switches on at 6.7 V and off at 6.3 V. This individual circuit switches around 205 kHz.

The converter itself works in boundary mode, means CCM at low input voltage and respectively DCM at high input voltage. Reducing magnetizing inductance results in smaller transformer geometry and increased loop bandwidth due to bigger RHPZ – but accepting slightly increased peak currents.

The transfer region DCM to CCM could be seen around:

7Vin 150mAout
12Vin 350mAout
24Vin 800mAout
>32Vin 1000mAout

2 Testing and Results

2.1 Efficiency Graphs

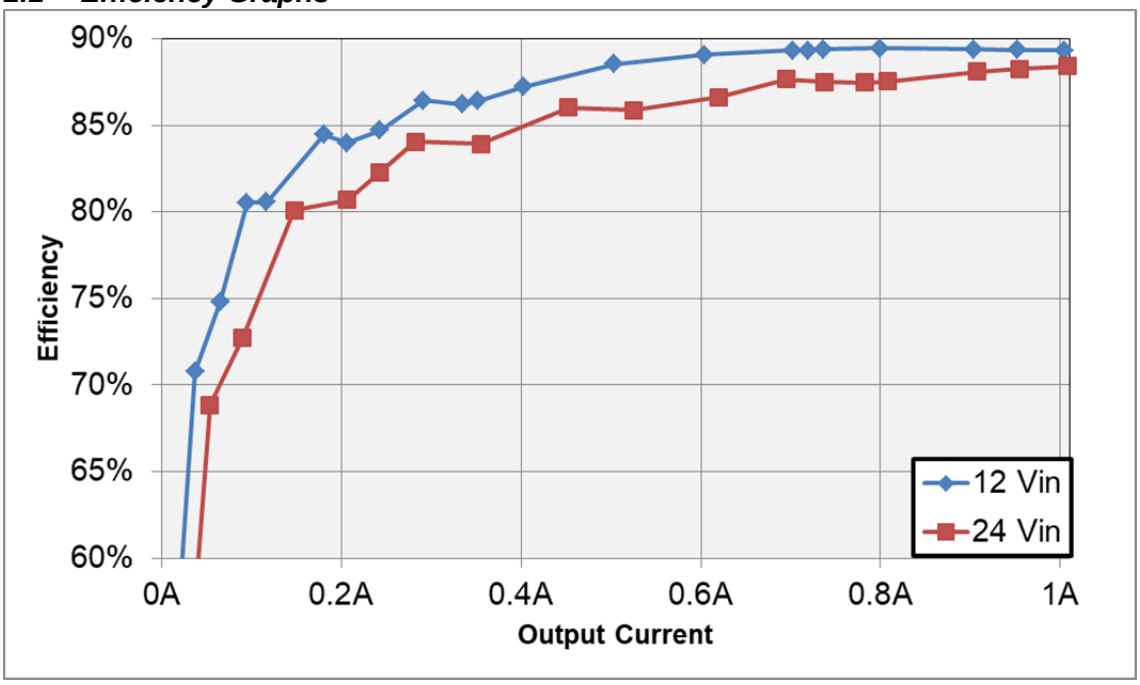


Figure 1 Efficiency vs Output Current

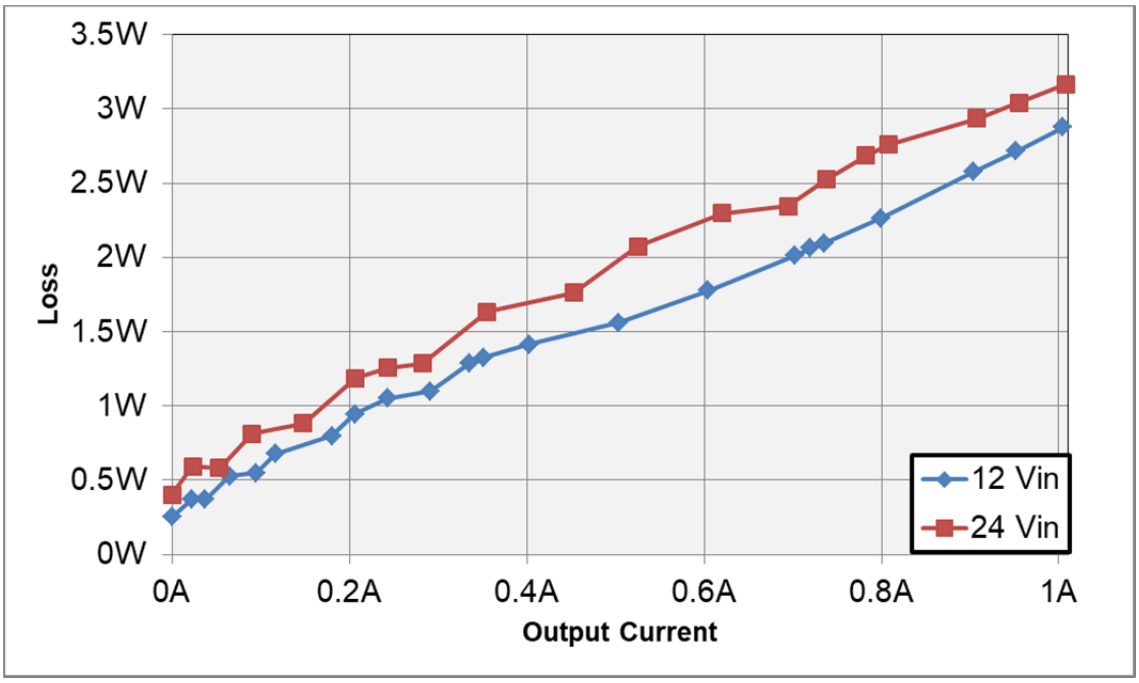


Figure 2 Loss vs Output Current

2.2 Load Regulation

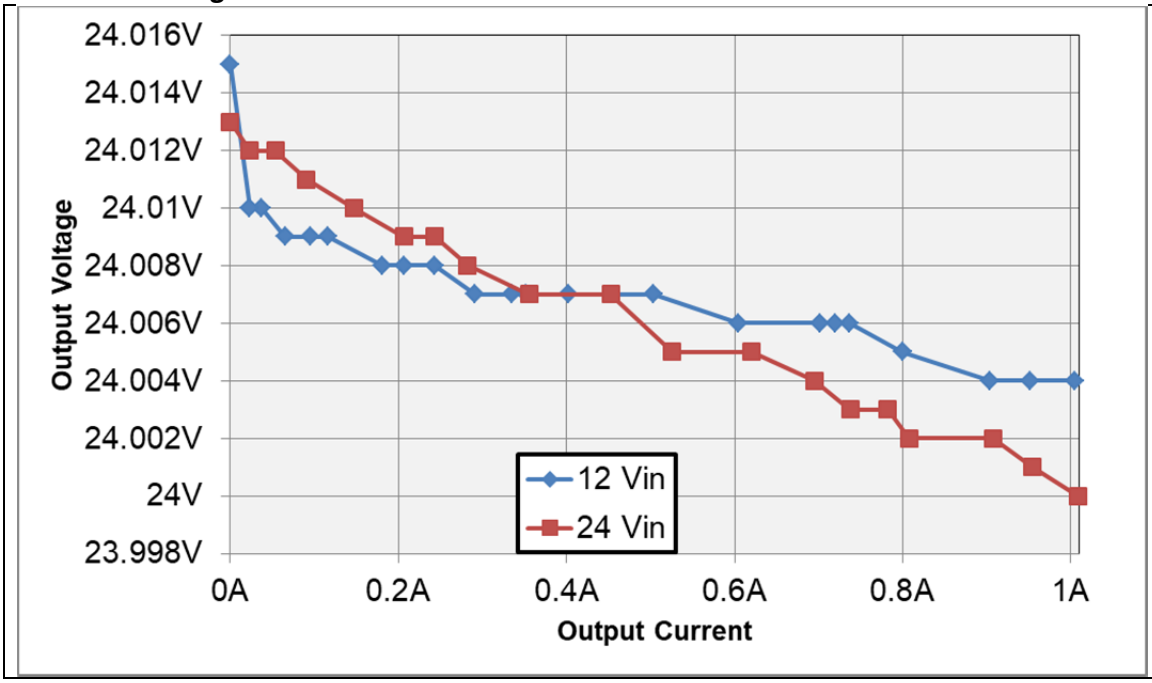


Figure 3 Load Regulation

2.3 Line Regulation

The output current was adjusted to 1A.

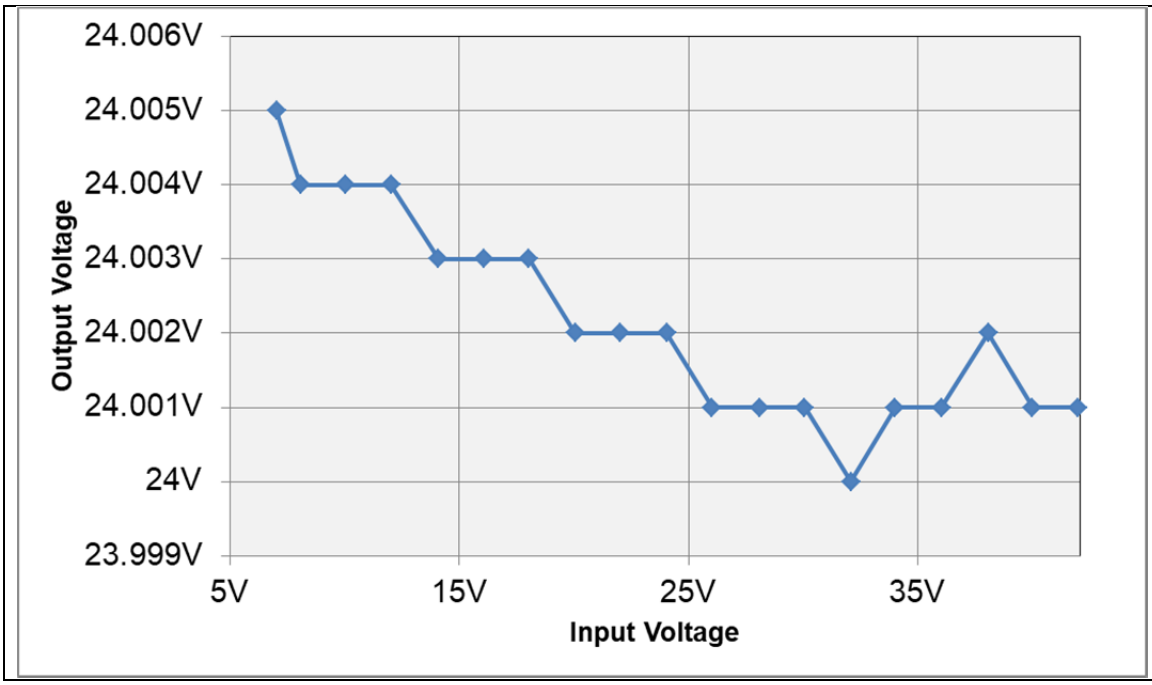


Figure 4 Line Regulation

With the same setup efficiency and loss were calculated.

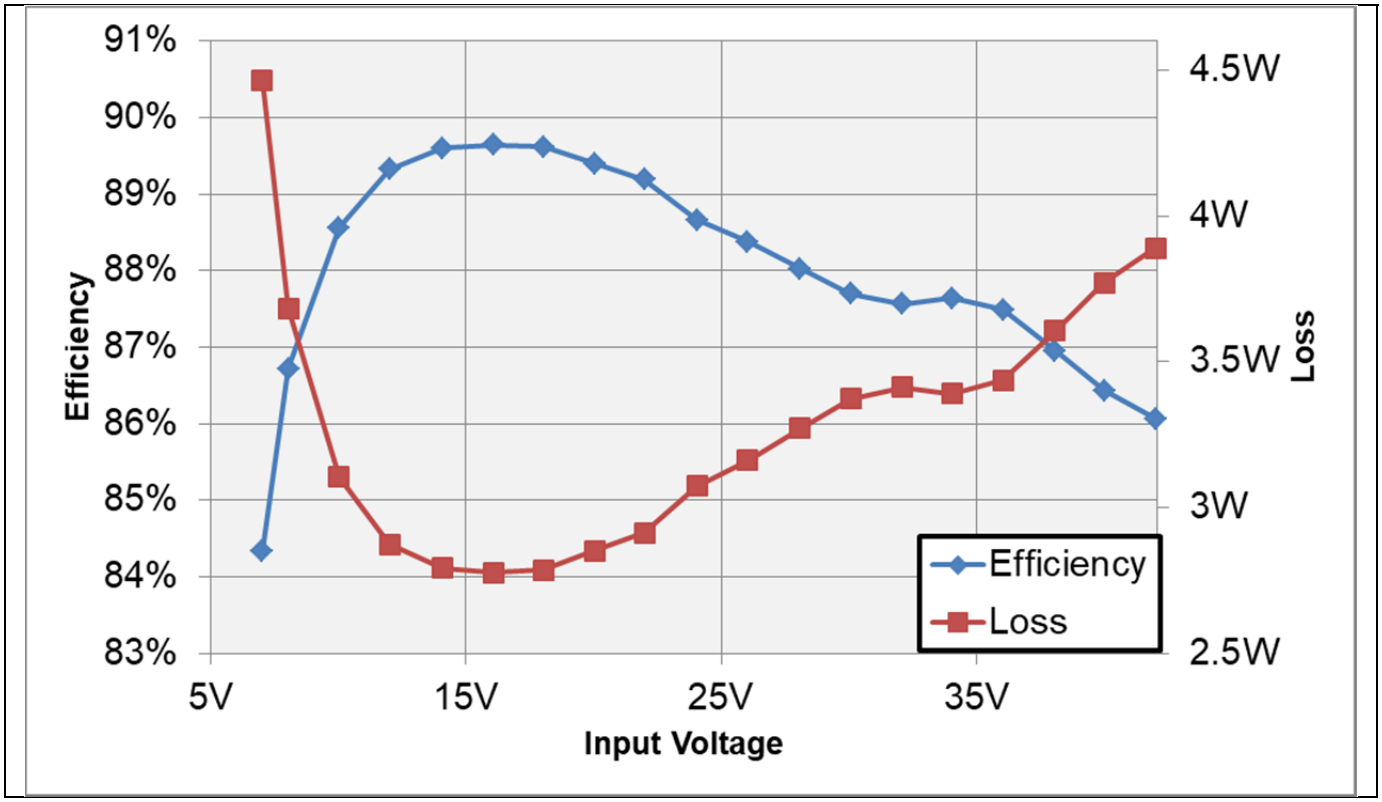


Figure 5 Efficiency and Loss vs Input Voltage

2.4 Thermal Images

2.4.1 12 V Input Voltage - full load 1A

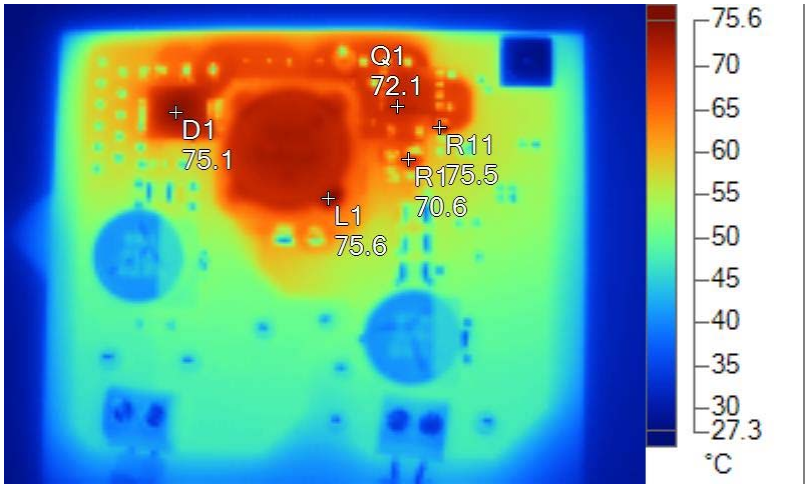


Figure 6 IR Photo for 12 V Input Voltage

Name	Temperature
D1	75.1°C
L1	75.6°C
Q1	72.1°C
R1	70.6°C
R11	75.5°C

2.4.2 24 V Input Voltage - full load 1A

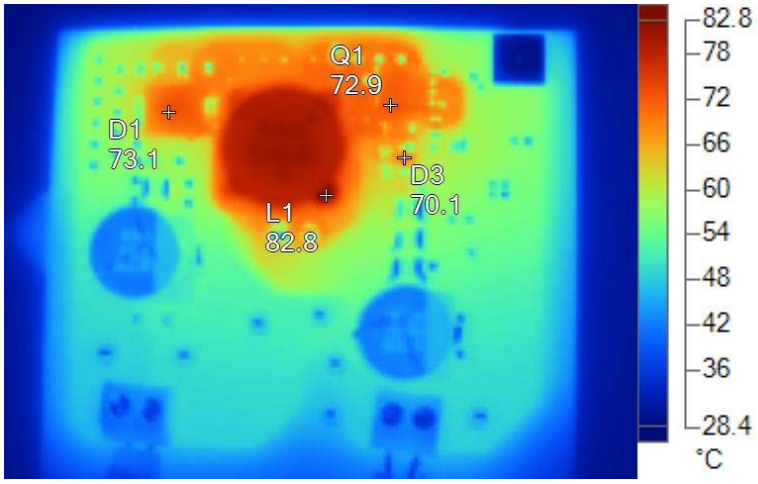


Figure 7 IR Photo for 24 V Input Voltage

Name	Temperature
D1	73.1°C
D3	70.1°C
L1	82.8°C
Q1	72.9°C

2.4.3 24V Input Voltage and 700mA Output Current

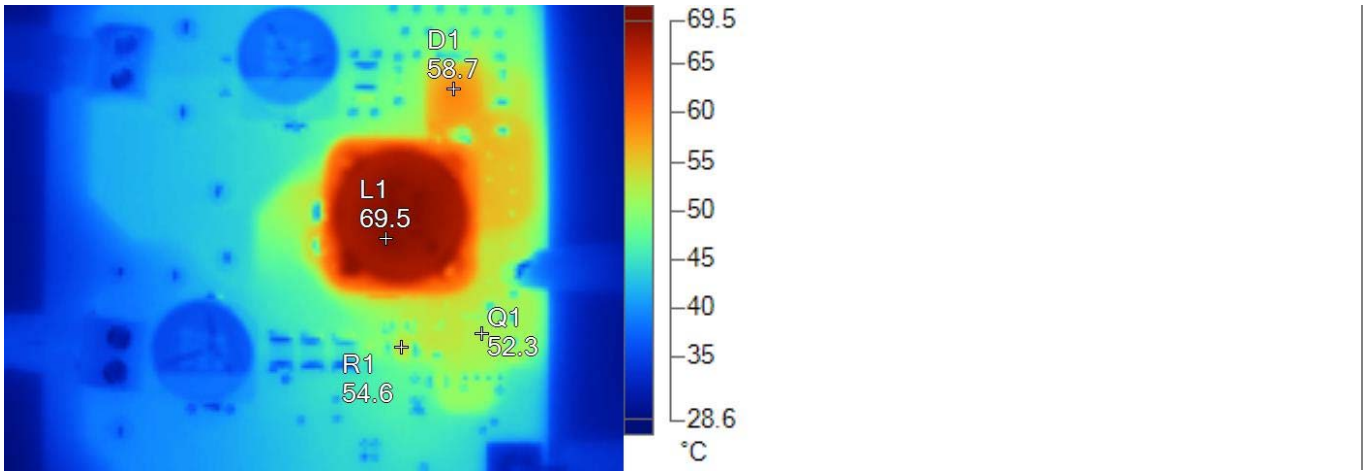


Figure 8 IR Photo for 24 V Input Voltage and 0.7 A Output Current

Name	Temperature
D1	58.7°C
L1	69.5°C
Q1	52.3°C
R1	54.6°C

3 Waveforms

3.1 Switching

3.1.1 Transistor Q1, 100V FET (Drain-Source)

3.1.1.1 12 V Input Voltage

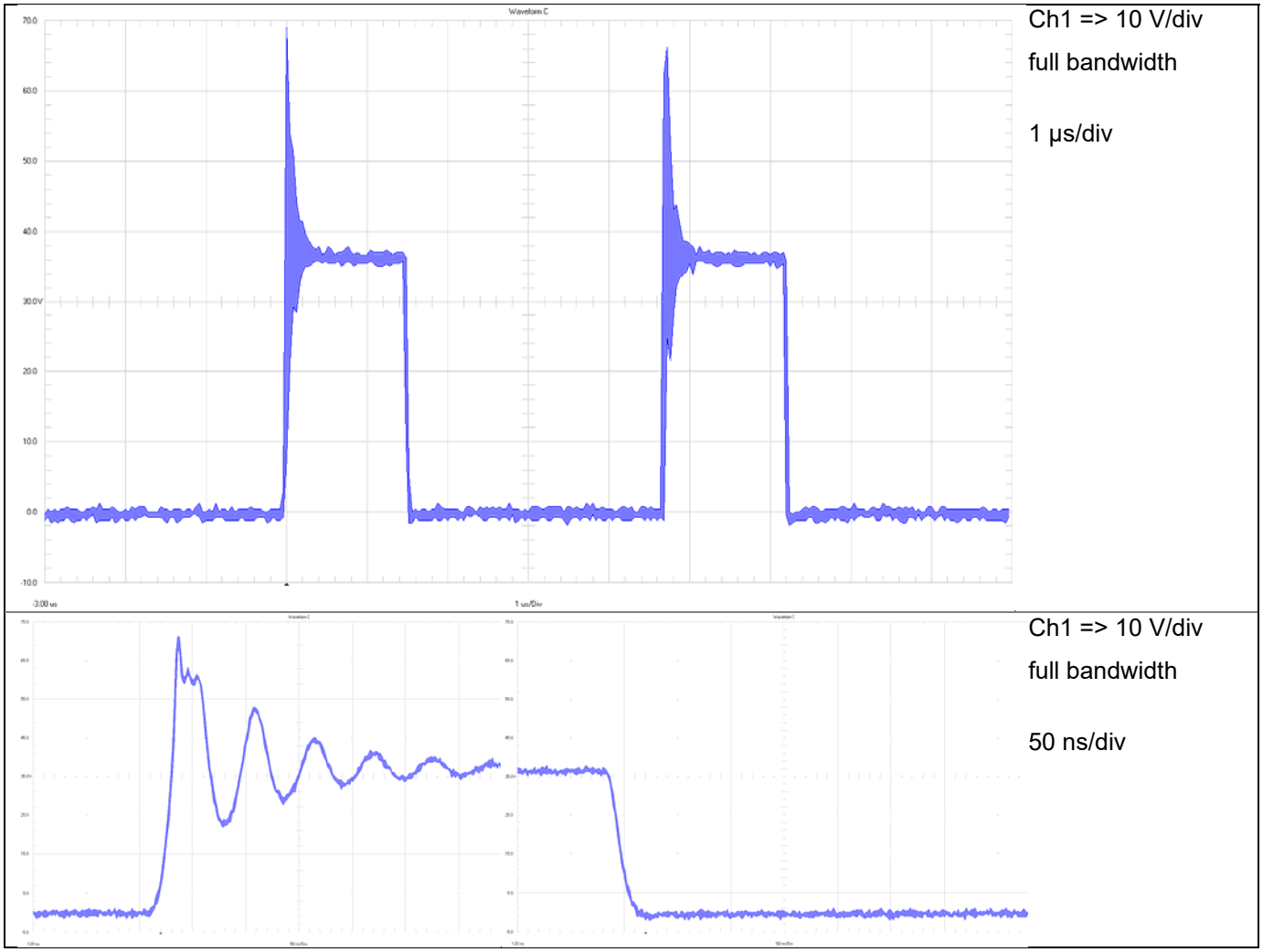


Figure 9 Switchnode Q1 at 12 V Input Voltage

3.1.1.2 24 V Input Voltage

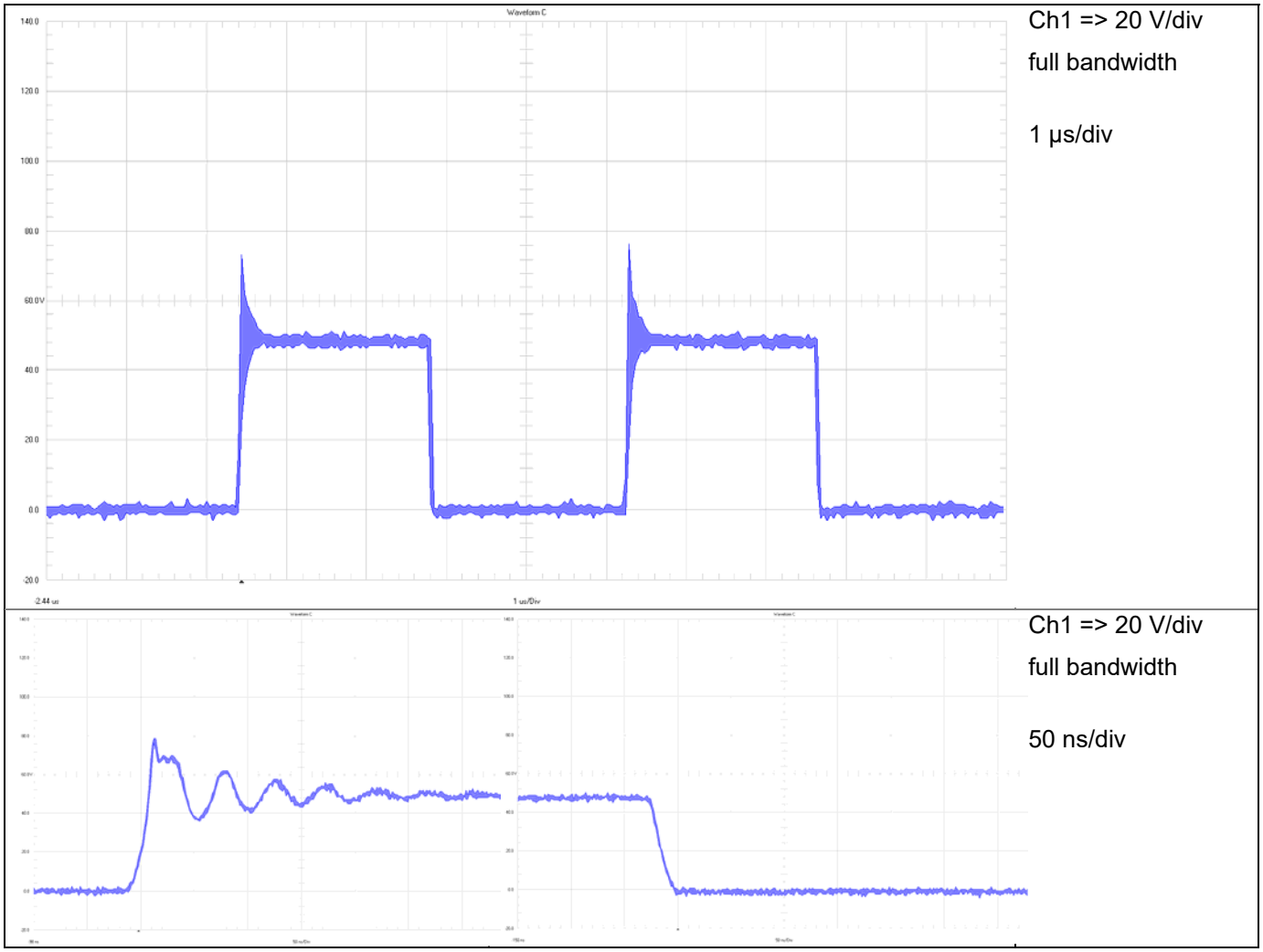


Figure 10 Switchnode Q1 at 24 V Input Voltage

(at maximum input 42V Vds is clamped to less than 90Vpk)

3.1.2 Transistor Q1 Gate (Gate to Source)

3.1.2.1 12 V Input Voltage

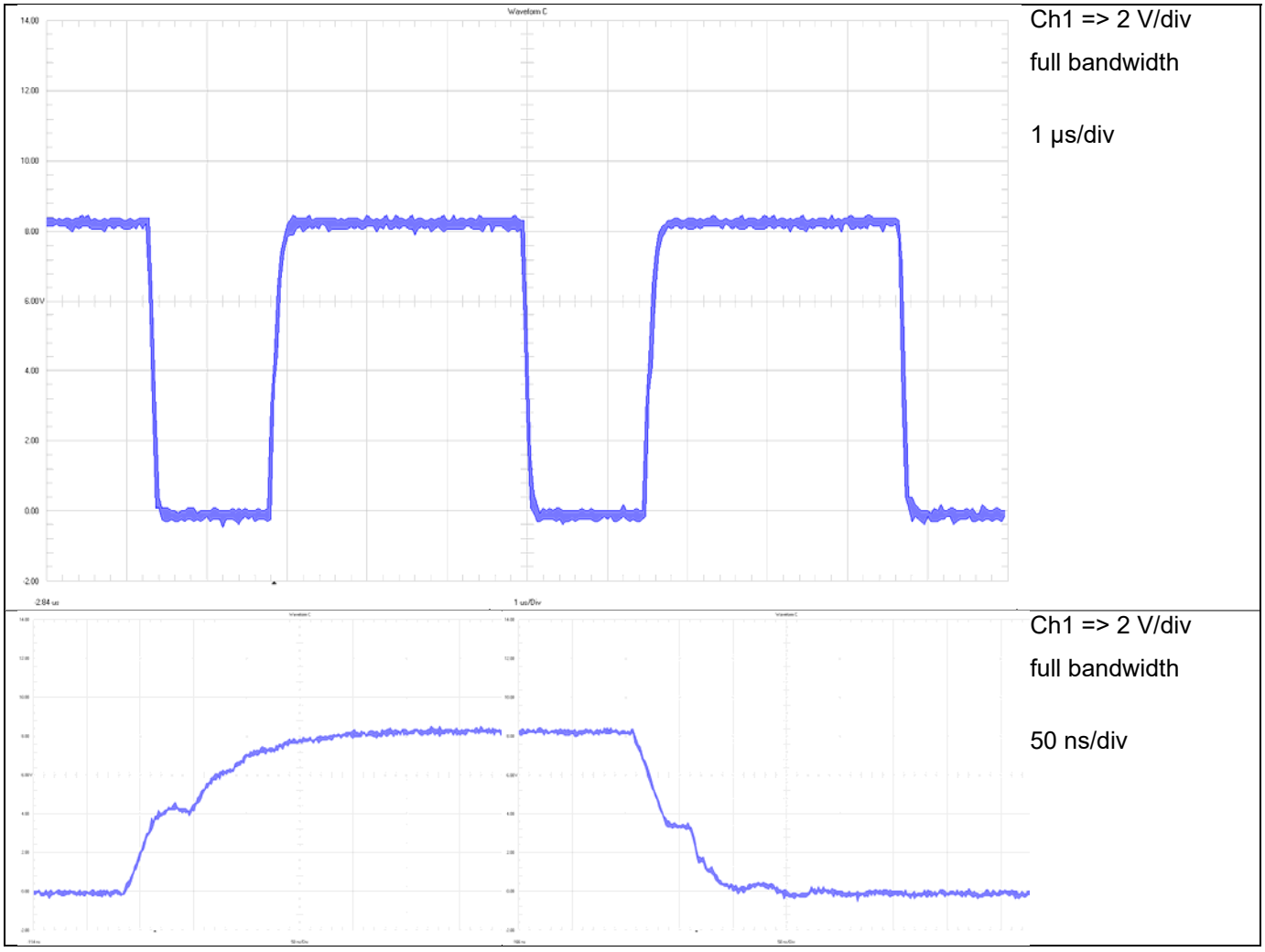


Figure 11 Q1 Gate at 12 V Input Voltage

3.1.2.2 24 V Input Voltage

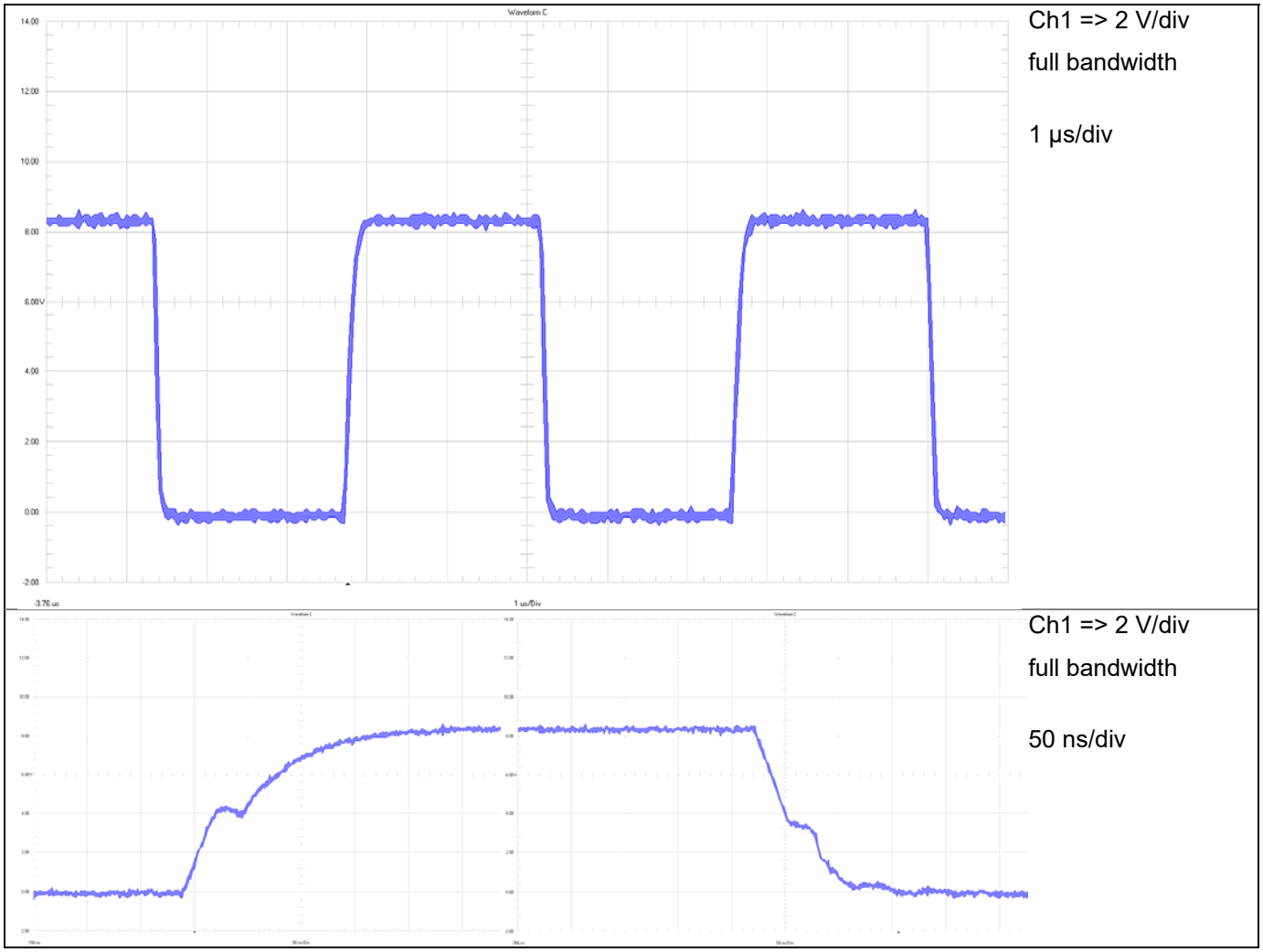


Figure 12 Q1 Gate at 12 V Input Voltage

3.1.3 Diode D1

These waveforms were measured with reference to output voltage.

3.1.3.1 12 V Input Voltage

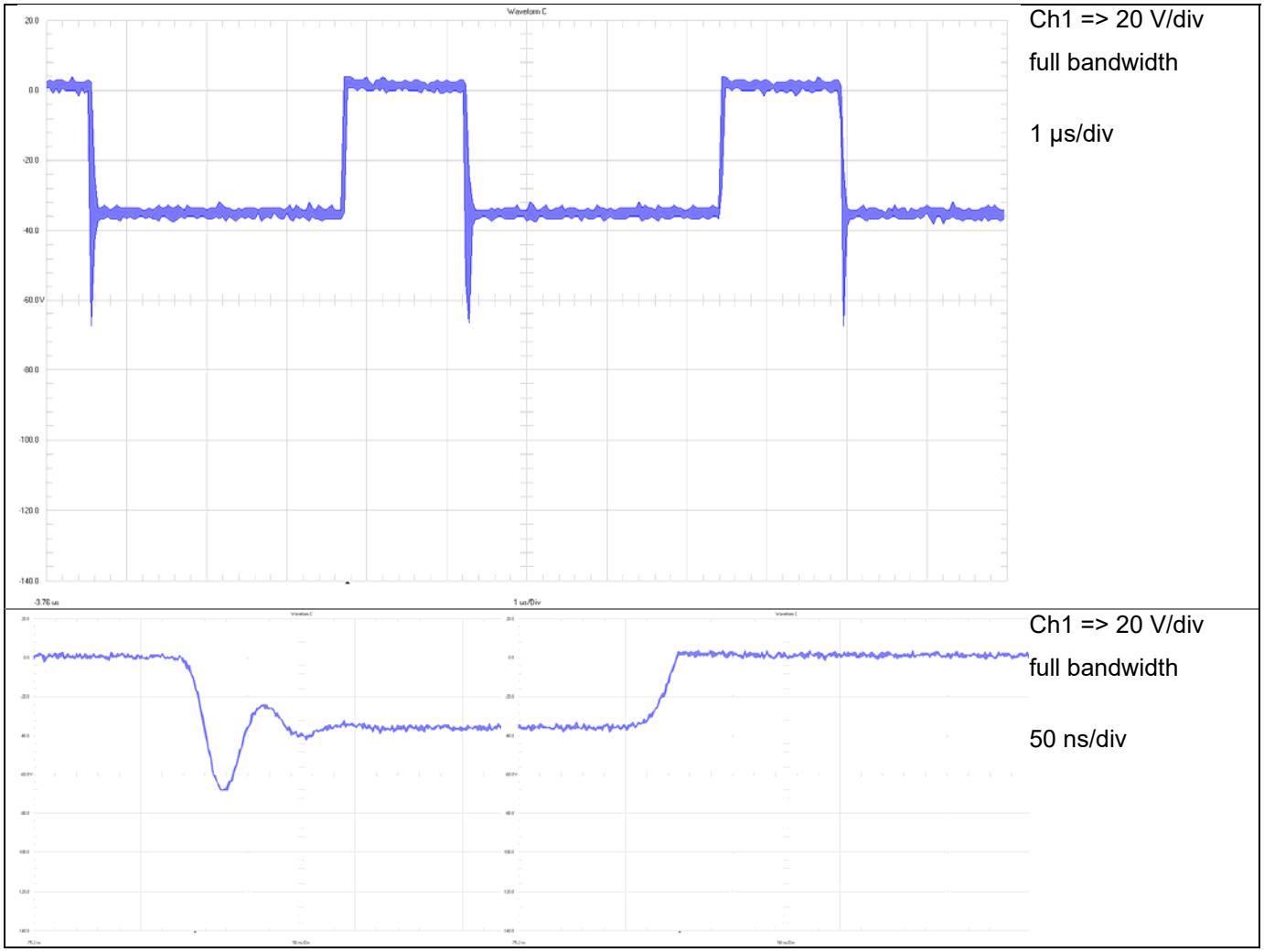


Figure 13 Diode D1 at 12 V Input Voltage

3.1.3.2 24 V Input Voltage

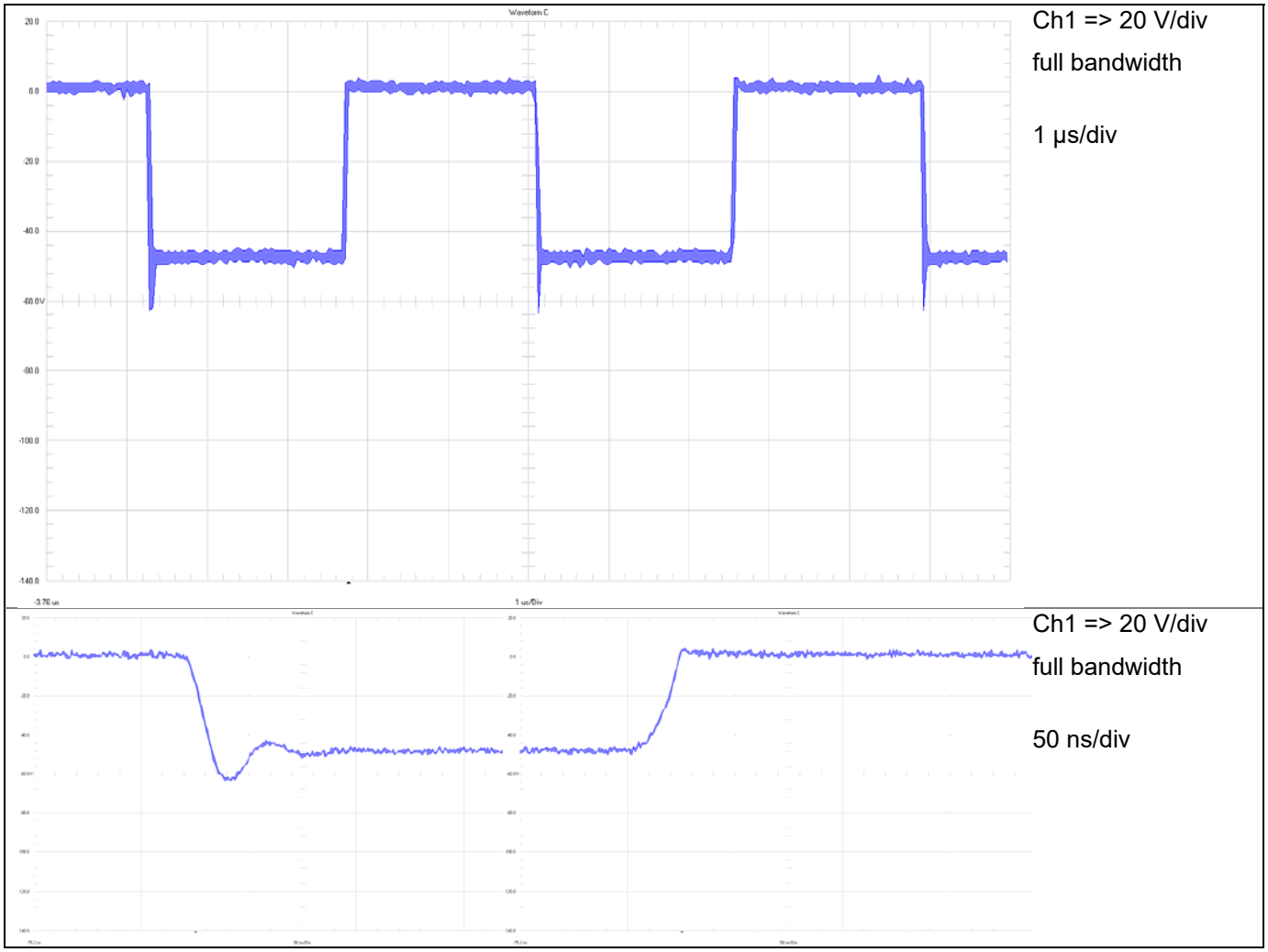
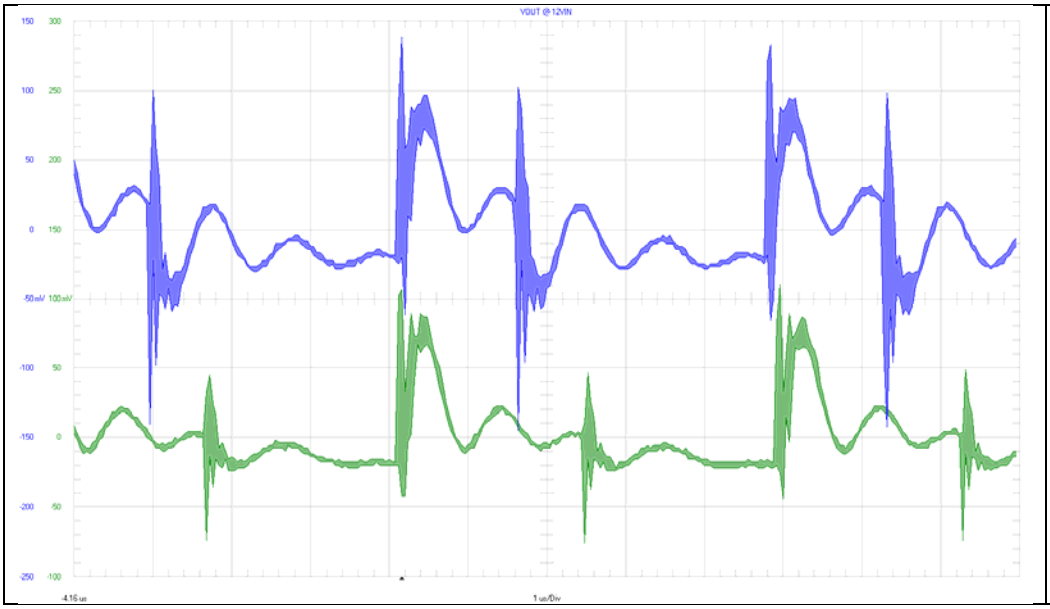


Figure 14 Diode D1 at 24 V Input Voltage

3.2 Output Voltage Ripple



Ch1=> output voltage @ 12 V input voltage

Ch2=> output voltage @ 24V input voltage

50 mV/div

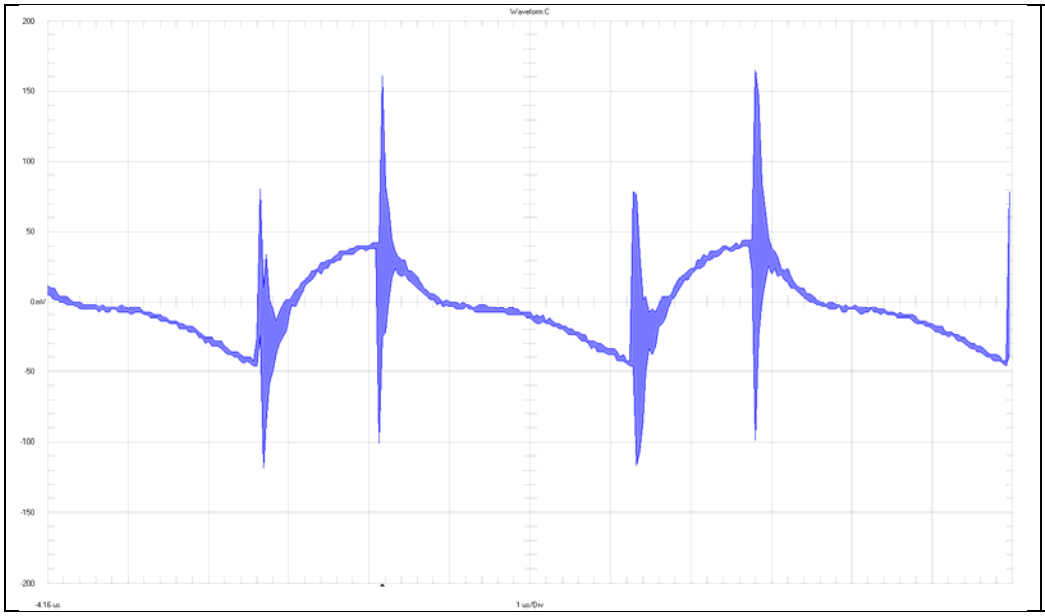
20MHz bandwidth

1 µs/div

Figure 15 Output Ripple Voltage

3.3 Input Ripple Voltage

3.3.1 12 V Input Voltage



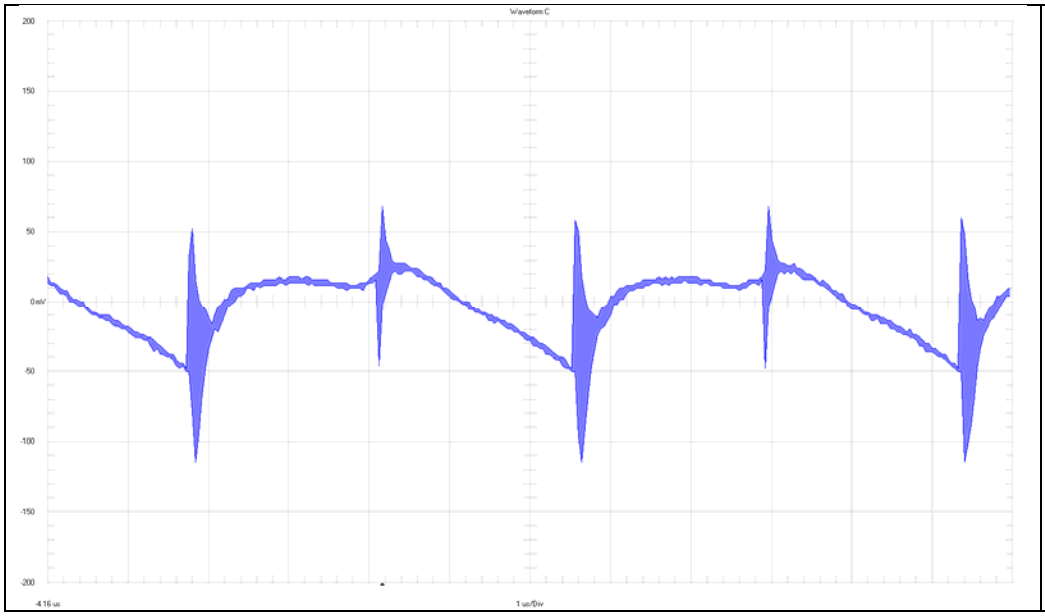
Ch1=> input voltage 12 V
50 mV/div

20MHz bandwidth

1 µs/div

Figure 16 Input Ripple Voltage (12V Input Voltage)

3.3.2 24 V Input Voltage



Ch1=> input voltage 24 V
50 mV/div

20MHz bandwidth

1 µs/div

Figure 17 Input Ripple Voltage (24 V Input Voltage)

3.4 Bode Plot

Table 1 summarizes the results from Figure 18, Figure 19 and Figure 20. Bode box good for 100Hz to 10kHz were used.

	7 V	12 V	24 V
Bandwidth (Hz)	907	1300	1795
Phasemargin	83°	93°	98°
slope (20dB/decade)	-1.0	-0.87	-0.75
gain margin (dB)	18	21	20
slope (20dB/decade)	-0.7	-1.2	-1.6
freq (kHz)	10.9	16.2	17.3

Table 1 Summery of the Bodeplots

3.4.1 7 V Input Voltage

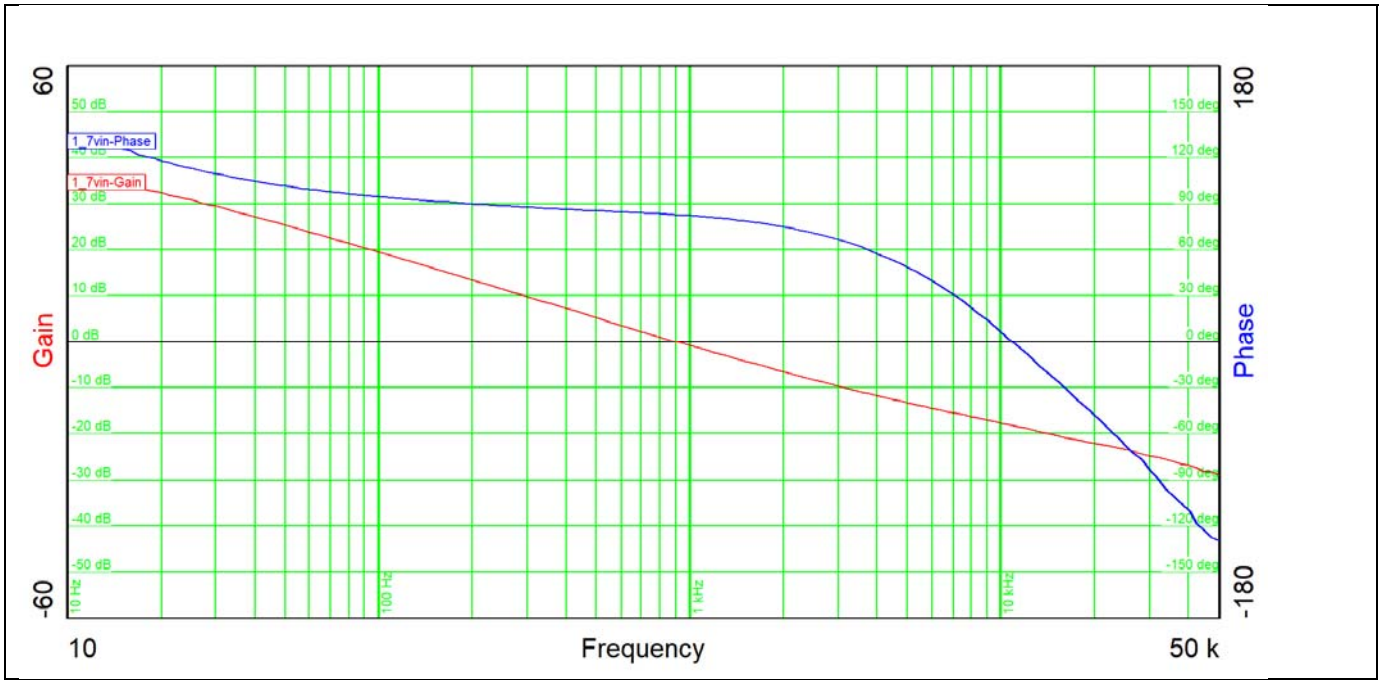


Figure 18 Bode Plot for 7 V Input Voltage

3.4.2 12 V Input Voltage

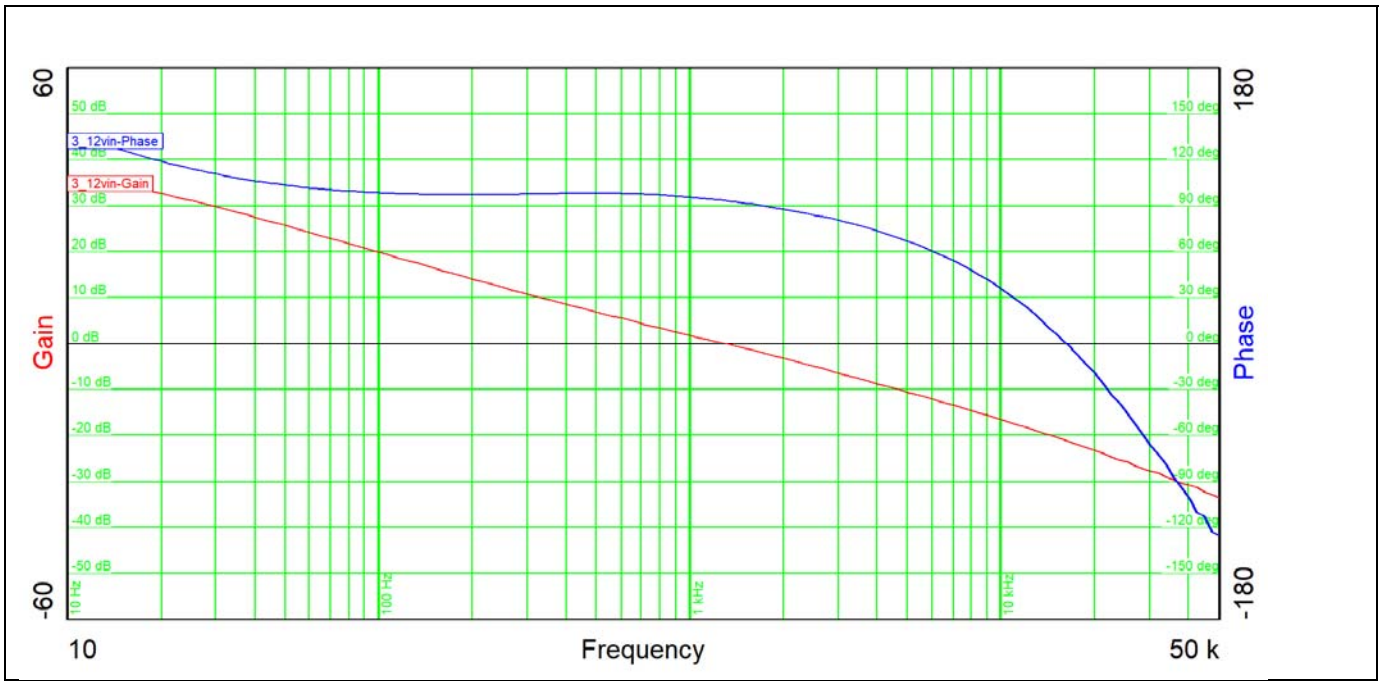


Figure 19 Bode Plot for 12 V Input Voltage

3.4.3 24 V Input Voltage

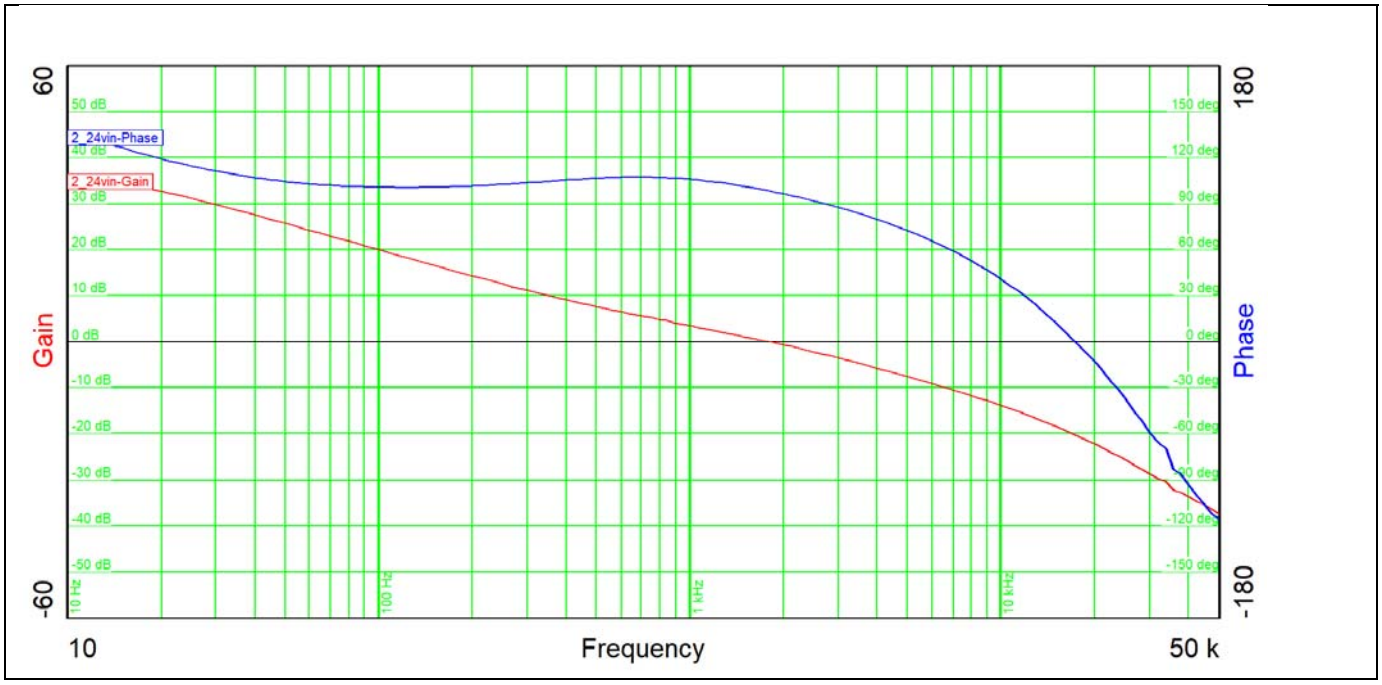
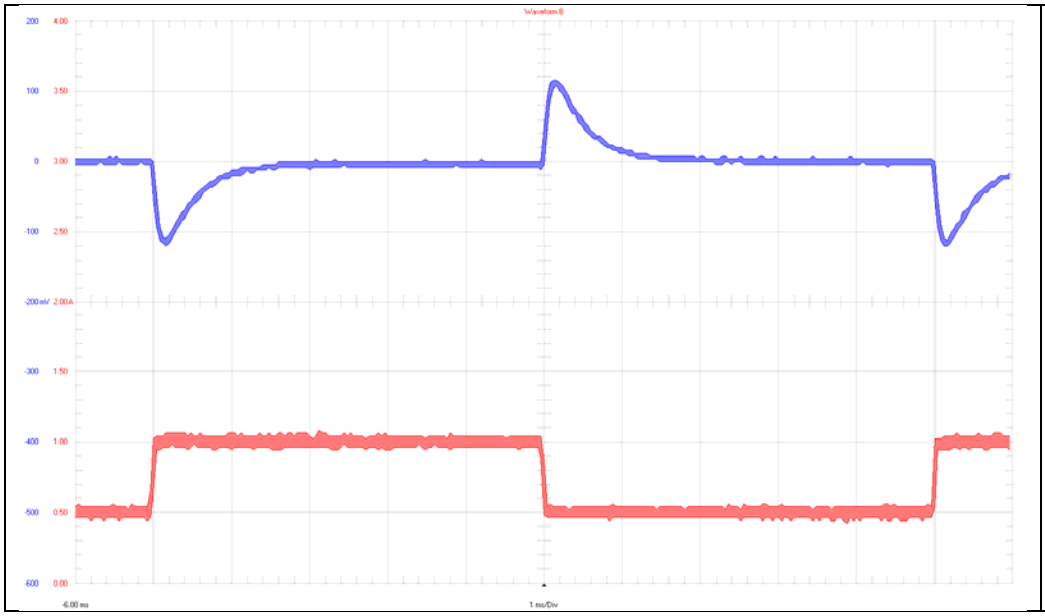


Figure 20 Bode Plot for 24 V Input Voltage

3.5 Load Transients

Electronic load has been used to create the load steps of 0.5 A to 1 A (100 Hz);
The deviation is only around 1% Vout !

3.5.1 12V Input Voltage



Ch1=> output voltage
100 mV/div
10 kHz bandwidth

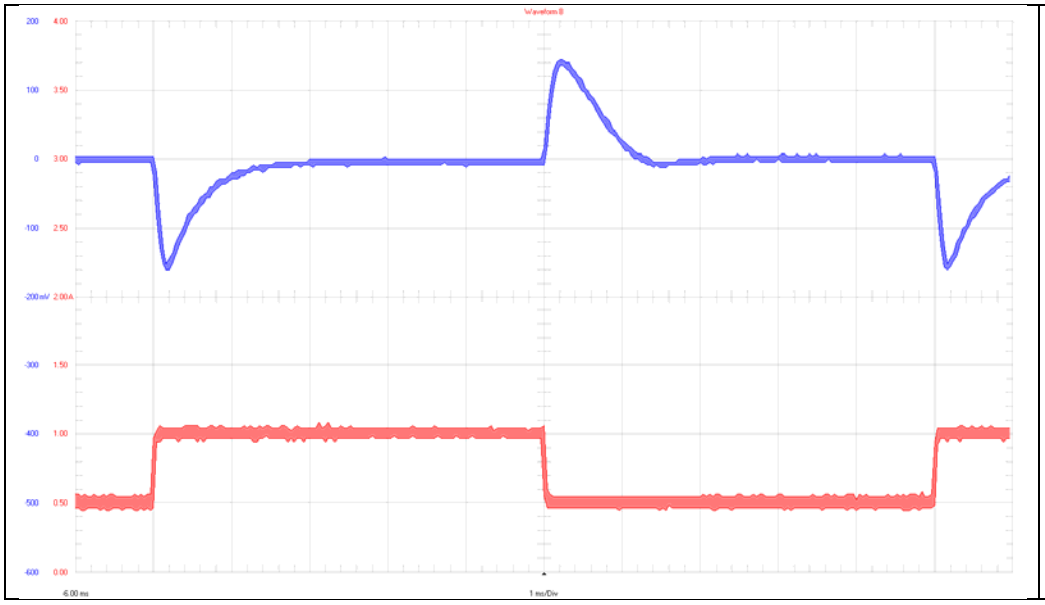
Ch2=> output current
0.5 A/div
20 MHz bandwidth

50 mV/div

1 ms/div

Figure 21 Load Transient with 12V Input Voltage

3.5.2 24V Input Voltage



Ch1=> output voltage
100 mV/div
10 kHz bandwidth

Ch2=> output current
0.5 A/div
20 MHz bandwidth

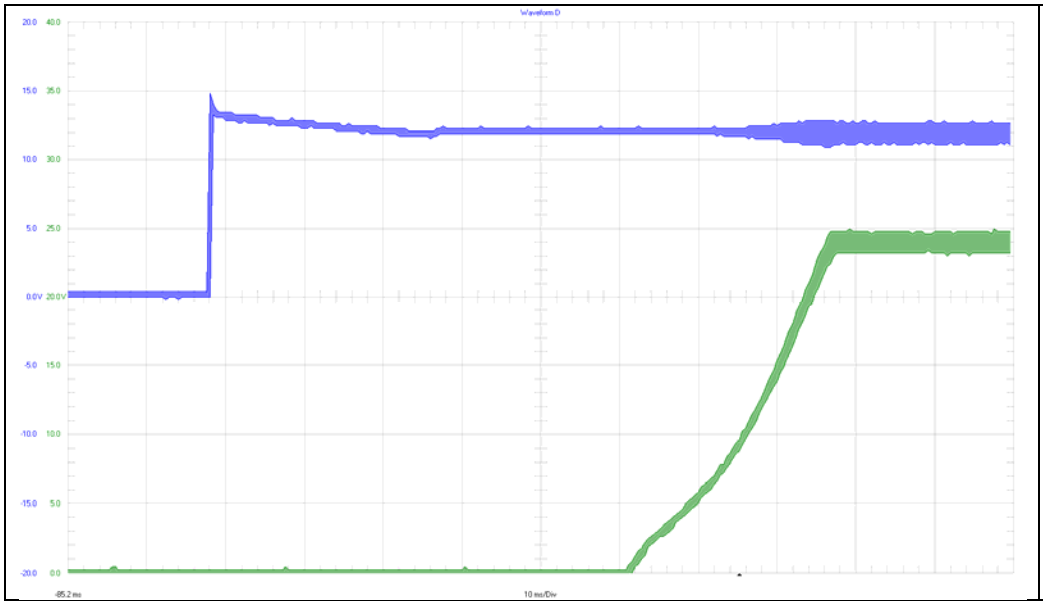
1 ms/div

Figure 22

3.6 Start-up Sequence

Oscilloscope with isolated channels was used. The power supply was plugged in.

3.6.1 12 V Input Voltage



Ch1=> input voltage
5 V/div

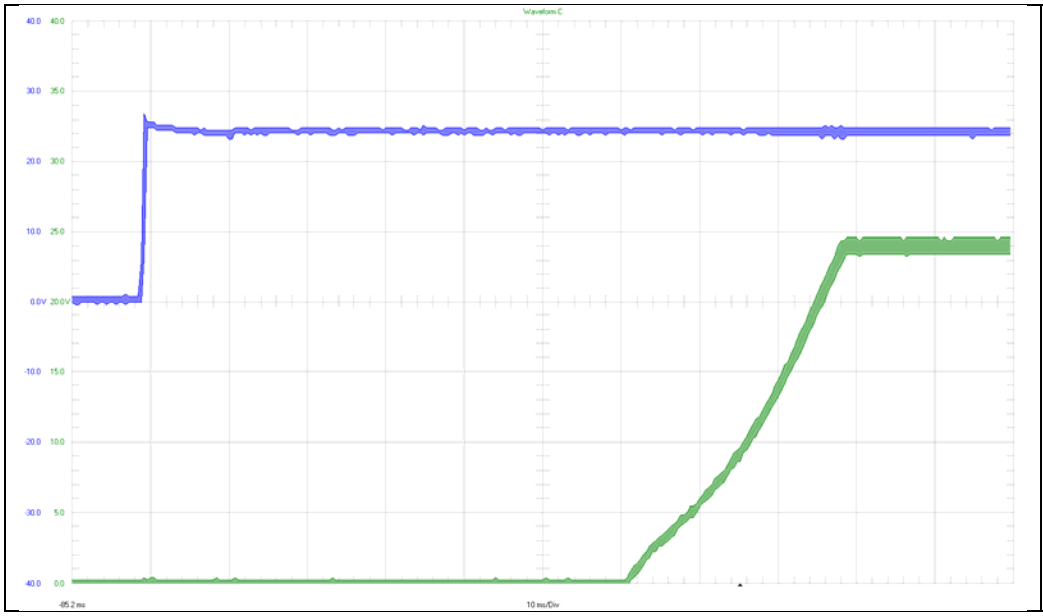
Ch2=> output voltage
5 V/div

20 MHz bandwidth

10 ms/div

Figure 23 Start-Up with 12 V Input Voltage

3.6.2 24 V Input Voltage



Ch1=> input voltage
10 V/div

Ch2=> output voltage
5 V/div

20 MHz bandwidth

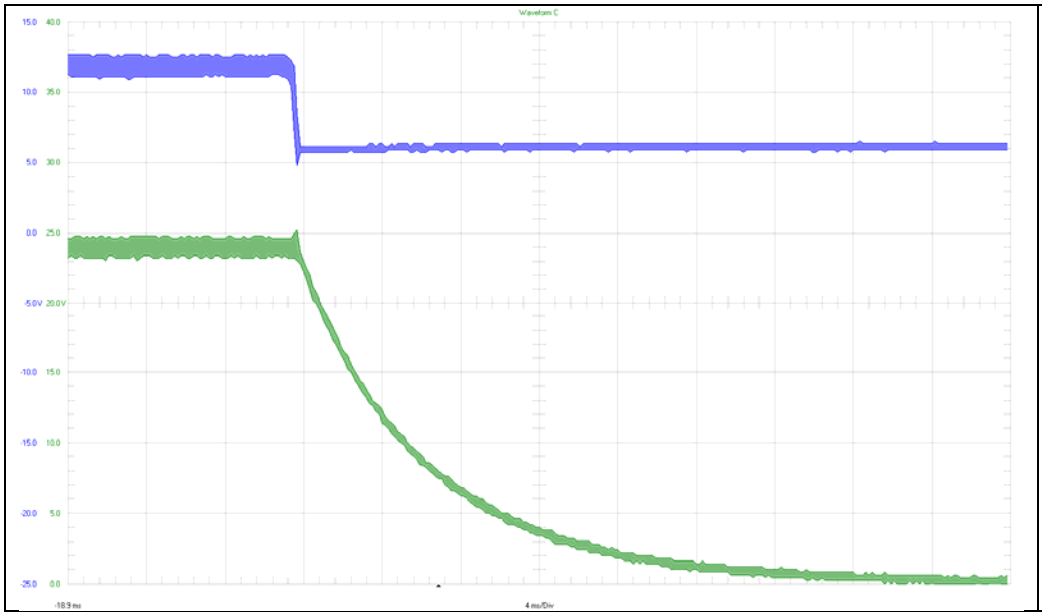
10 ms/div

Figure 24 Start-Up with 24 V Input Voltage

3.7 Shutdown Sequence

Oscilloscope with isolated channels was used. The power supply was disconnected.

3.7.1 12 V Input Voltage



Ch1=> input voltage
5 V/div

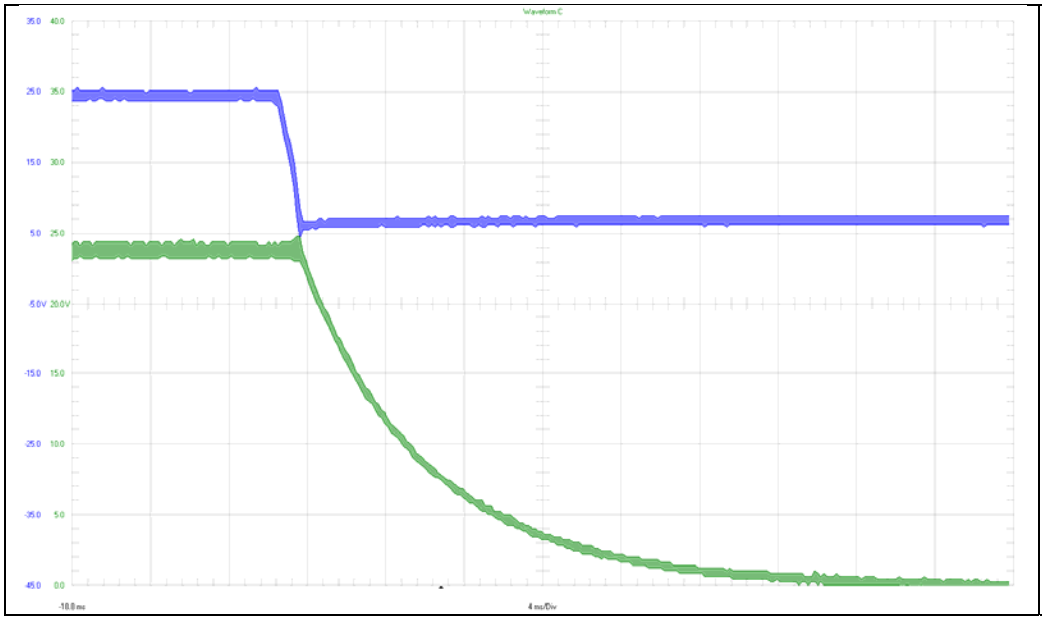
Ch2=> output voltage
5 V/div

20MHz bandwidth

4 ms/div

Figure 25 Shutdown with 12 V Input Voltage

3.7.2 24 V Input Voltage



Ch1=> input voltage
10 V/div

Ch2=> output voltage
5 V/div

20MHz bandwidth

4 ms/div

Figure 26 Shutdown with 24 V Input Voltage

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