

# 200-W Automotive 2-Phase Synchronous Buck Converter Reference Design



## Description

This reference design provides power for automotive advanced driver assistance systems (ADAS), infotainment, and cluster applications. Operation is over the full automotive range including battery voltage surges to 32 V and dips to 6 V due to cold cranking. The peak conversion efficiency of 94% to 96% in the 10 V<sub>IN</sub> to 18 V<sub>IN</sub> range is shown. The output voltage undershoot and overshoot are 2% for 30-A step and dump. This test report includes operational data over the full input range and includes Bode plots to verify stability with good margins, internal waveforms, and thermal images.

## Features

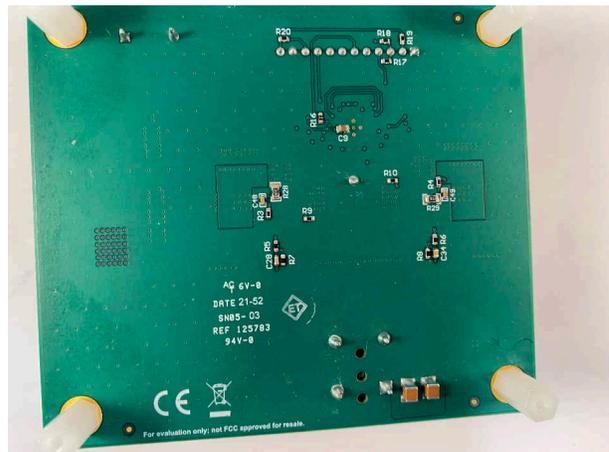
- High current for advanced driver assistance systems (ADAS), infotainment, and cluster applications
- Operation over the full automotive battery range including cold cranking and surges
- Peak conversion efficiency of 94% to 96% in the 10- to 18-V<sub>IN</sub> range
- LM25143-Q1 provides two-phase control and gate drive in a single IC
- Output voltage undershoot and overshoot 2% for 30-A step and dump

## Applications

- [Driver monitoring](#)
- [Surround view system ECU](#)
- [Radar ECU](#)
- [ADAS domain controller](#)
- [Drive assist ECU](#)
- [Hybrid instrument cluster](#)
- [Digital cockpit processing unit](#)



Top Photo



Bottom Photo

## 1 Test Prerequisites

This section provides the testing guide used in the detailed testing of the 3.3-V, 60-A power supply.

### 1.1 Voltage and Current Requirements

**Table 1-1. Voltage and Current Requirements**

Parameter	Specifications
Input Power	6-V to 18-V steady-state with surges to 32 V Use J2 on board (Phoenix Contact 1714971 Receptacle, 9.52 mm, 2 × 1, TH)
3.3-V output	Load up to 60 A Use J3 Terminal Block Eaton EM292902-UL
Various signals: J4	See the schematic (available from <a href="#">PMP23262</a> ) for details; connect a conductor (jumper) from the J4 pin 7 (DEMB) to pin 6 (VDDA) for two-phase operation.

### 1.2 Required Equipment

- $V_{IN}$  power supply 6 V to 32 V, at least 240 W at the input voltage under test, or 40 A for the full load off a 6-V input
- Electronic load to step for efficiency graphs, and for dynamic load testing such as Kikusui PLZ334WL
- Low inductance dynamic load for the 3.3-V output if the load slew rates  $> 3 \text{ A} / \mu\text{s}$  needed
- Oscilloscope such as Tektronix MDO34 with TPP0500B 10 × voltage probes and 30-A TCP0030A current probe
- Digital multimeters such as Fluke 87iii or 87V
- For Bode plots: Vector Network Analyzer such as Bode 100 from OMICRON Lab
- Thermal camera such as FLIR E75
- Keysight 34970 data acquisition, switch unit along with calibrated 100-A and 50-A current shunts for efficiency measurements

### 1.3 Considerations

When testing for steady-state loads above 45 A or input surges in the 18-V to 32-V range for more than a few seconds, use a fan blowing on the board.

### 1.4 Dimensions

Board dimensions: 4 in by 3.5 in.

## 1.5 Test Setup

Figure 1-1 illustrates the test setup showing input power and output load connections, and output voltage being monitored with a digital volt meter (DVM).

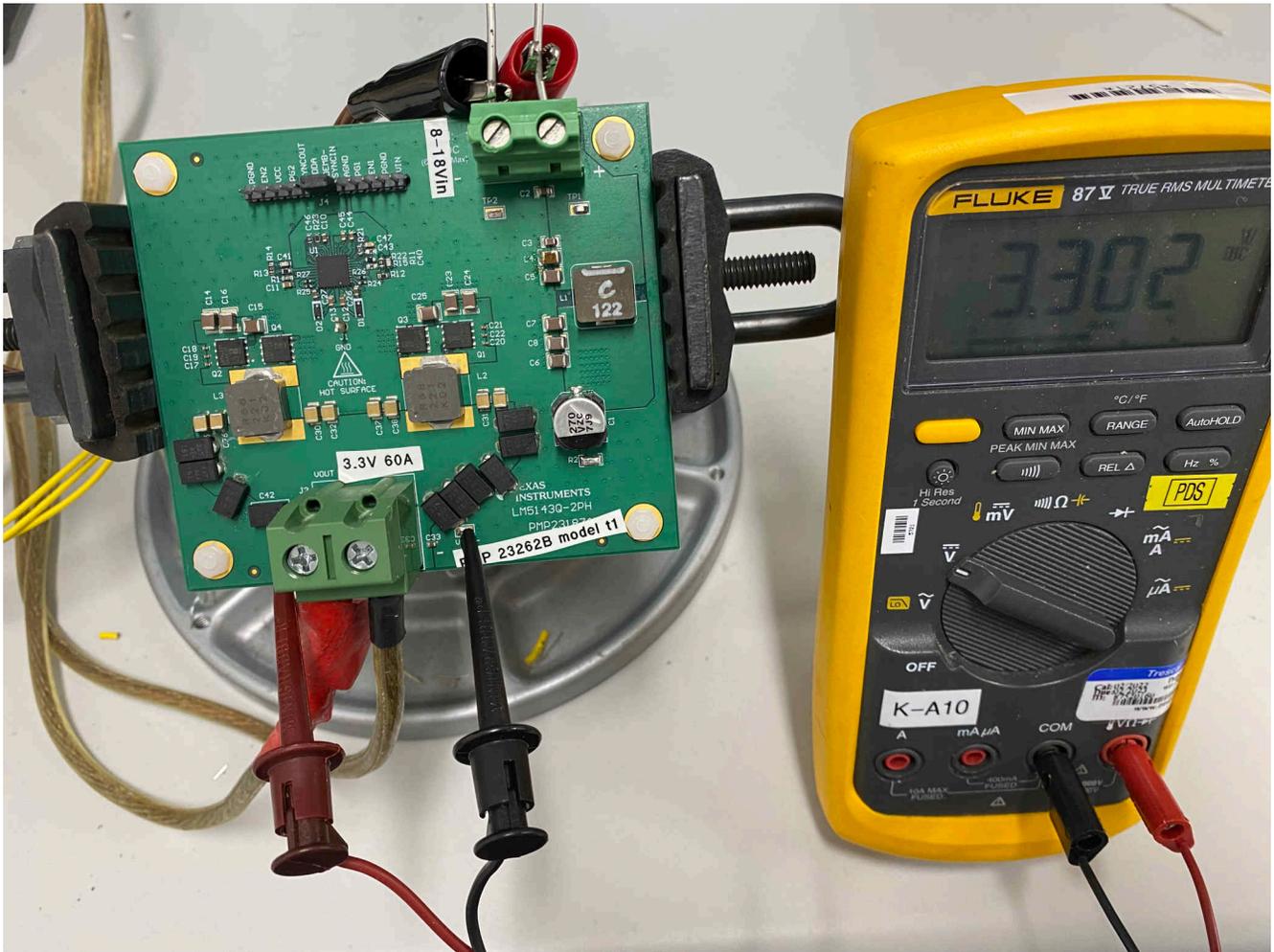


Figure 1-1. Test Setup



### CAUTION

Hot surface.  
Contact can cause burns.  
Do not touch!

## 2 Testing and Results

### 2.1 Efficiency Graphs

Efficiency is shown over the input voltage range of 6 V to 18 V.

Figure 2-1 illustrates that at full 60-A load, efficiency is in the 92% to 93% range. At 30 A, loading efficiency is in the 94% to 96 % range.

The efficiency graph is followed by the conversion loss vs load current graph (Figure 2-2) over the same 6-V to 18-V input range. No load loss varies from under 1 W at 6-V and 8-V input to just under 2 W at 18-V input. The full load loss range is 15.3 W at 8-V input to 17.7 W at 18-V input.

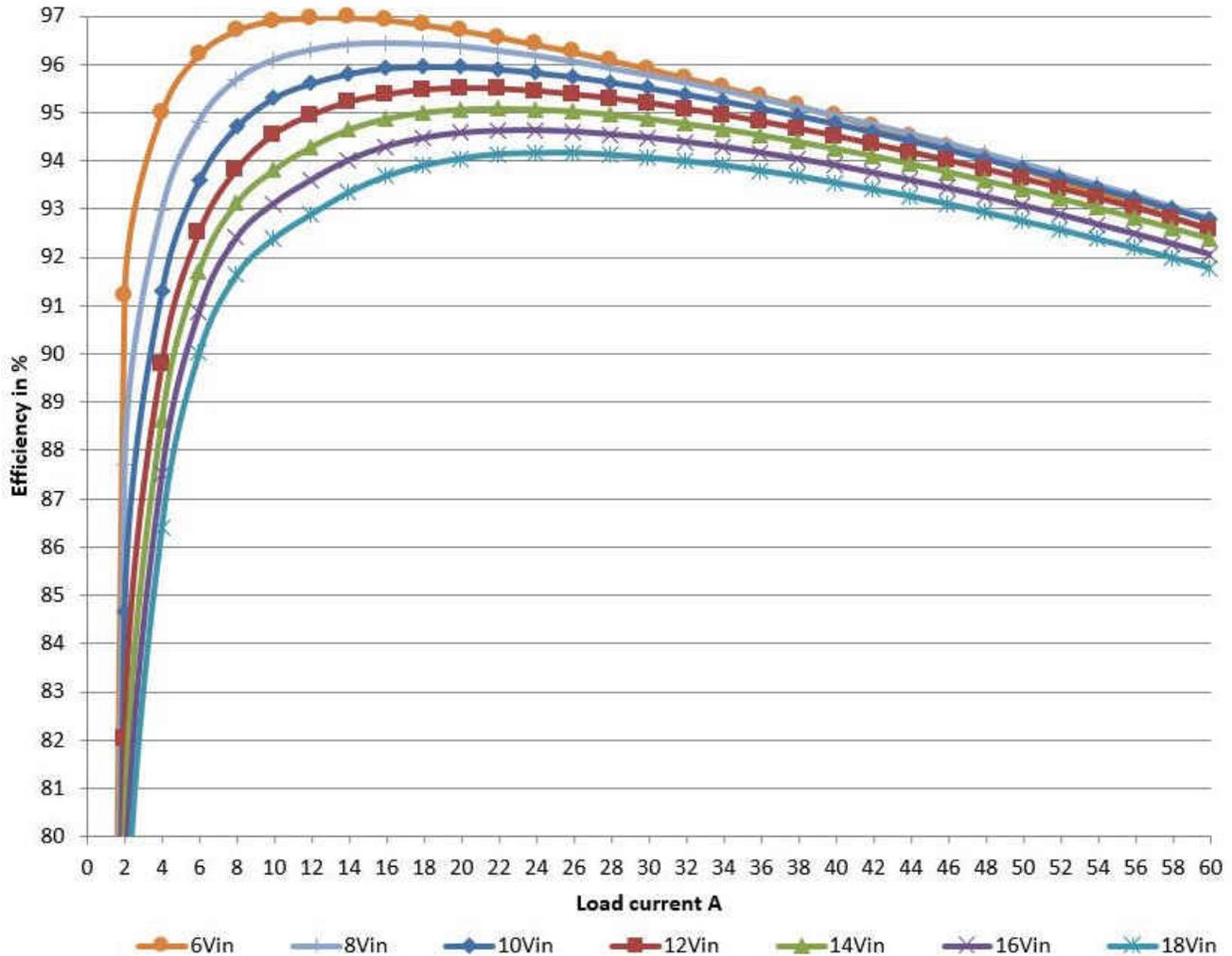


Figure 2-1. 3.3-V, 2-Phase Conversion Efficiency

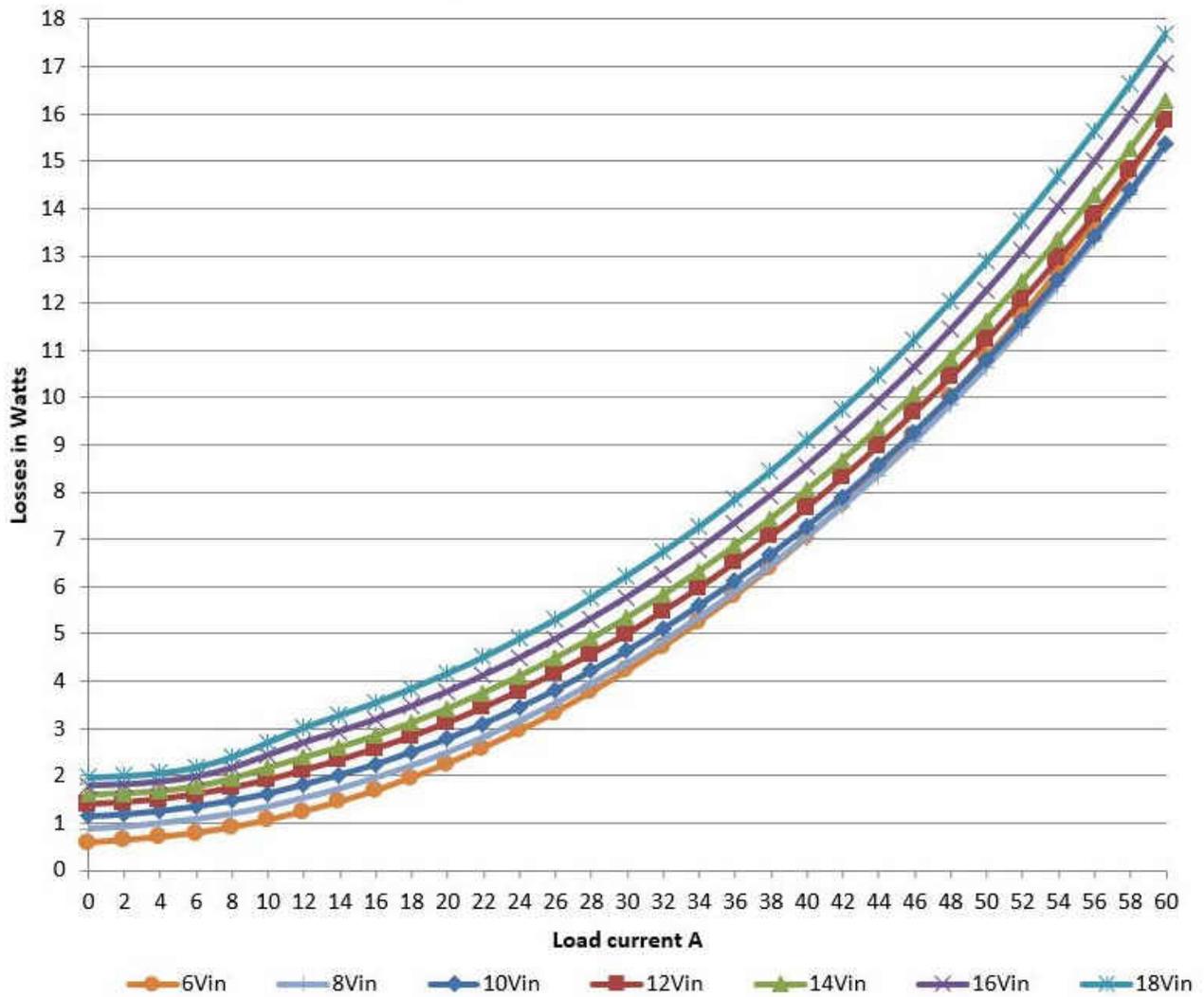


Figure 2-2. 3.3-V, 2-Phase Conversion Losses

## 2.2 Thermal Images

The first two thermal images in this section were taken with a load of 60 A, 14 V<sub>IN</sub> with a fan.

Figure 2-3 and Figure 2-4 show the thermal images of the board in phase 1 (Figure 2-3), followed by phase 2 (Figure 2-4). In these images, both low-side FETs and main inductors each had about a 40°C rise from the ambient room temperature of 21°C to 23°C.

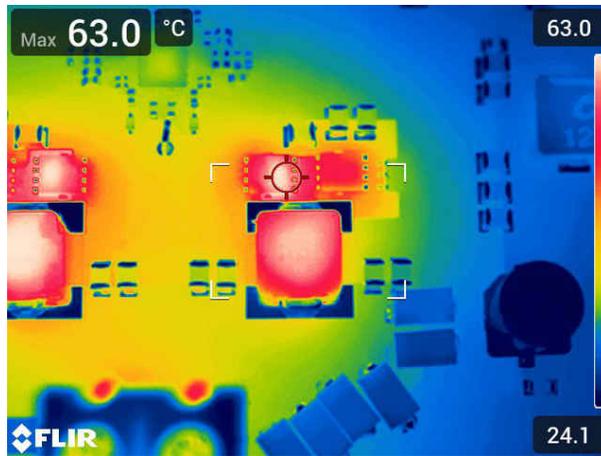


Figure 2-3. Phase 1 With Fan

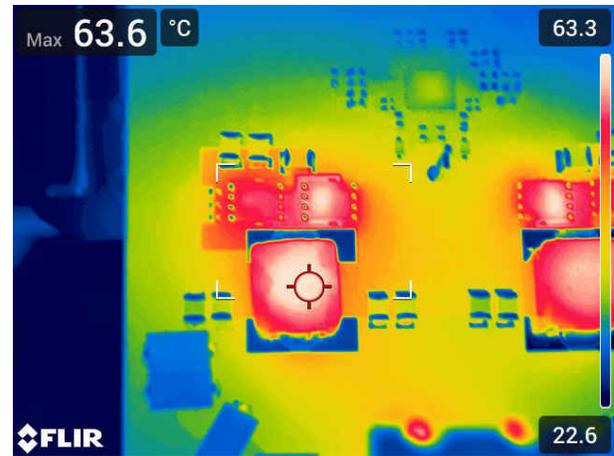


Figure 2-4. Phase 2 With Fan

The thermal images in Figure 2-5 and Figure 2-6 are for the same 14 V<sub>IN</sub>, but no fan was used and the load was 45 A. Here, phase 2 (Figure 2-6) was slightly hotter than phase 1 (Figure 2-5) with the inductor reaching 100°C, and the low-side FET reaching 96°C from the same ambient room temperature of 21°C to 23°C.

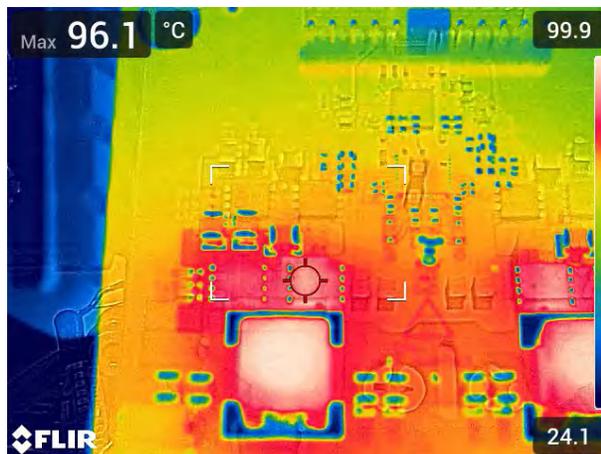


Figure 2-5. Phase 1 With No Fan

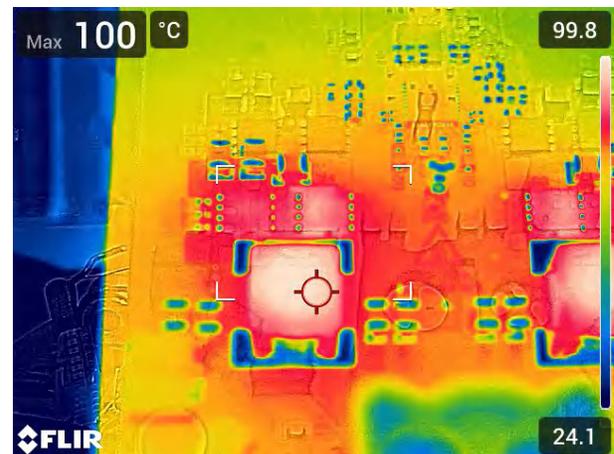


Figure 2-6. Phase 2 With No Fan

### 2.3 Bode Plots

All three Bode plots in this section are shown at 14-V input at 3.3-V output.

Figure 2-7 shows the Bode plot at 0-A load. The Bode plot in Figure 2-8 is created at a 30-A load and the Bode plot in Figure 2-9 was created at the maximum 60-A load.

Crossover increases with load from 30 kHz at no load to 46 kHz at the maximum 60-A load, but phase margin is always at least 96 degrees and gain margin is more than 10 dB.

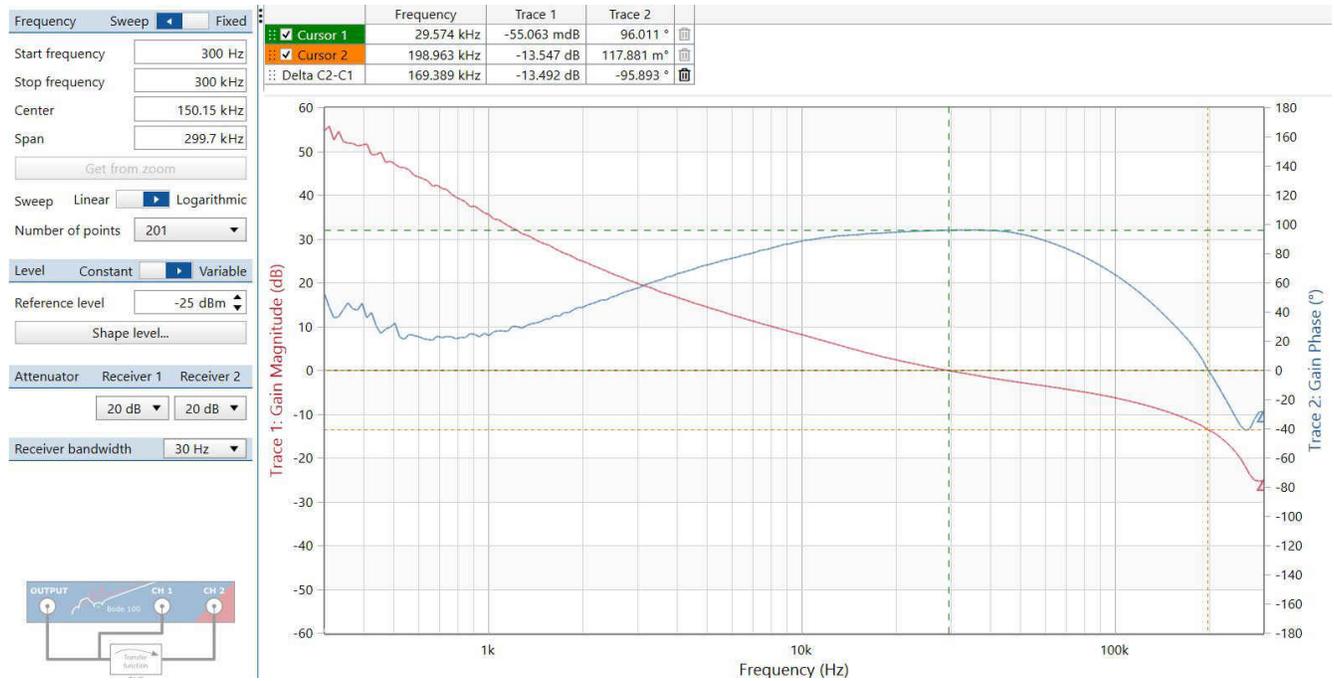


Figure 2-7. Bode Plot, 0-A Load

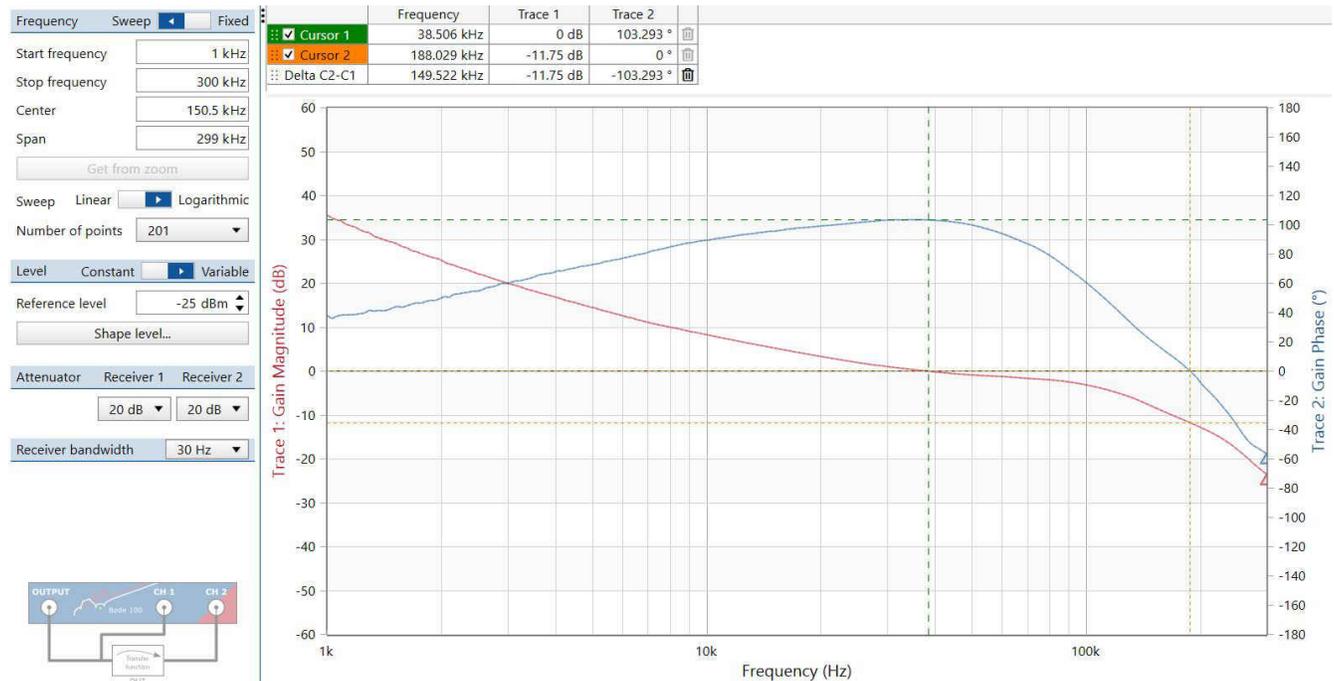


Figure 2-8. Bode Plot, 30-A Load

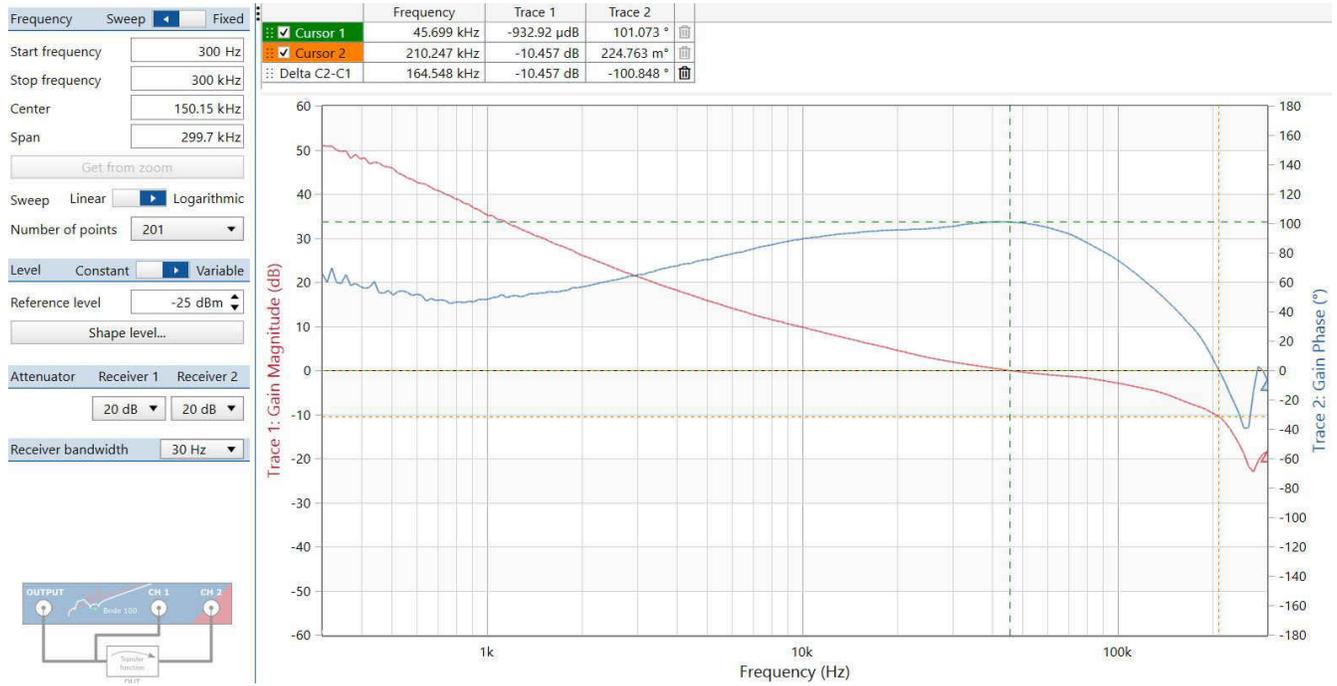


Figure 2-9. Bode Plot at Maximum 60-A Load

### 3 Waveforms

#### 3.1 Switching

Figure 3-1 shows the main switching waveform.

The waveform in Figure 3-1 is taken at 32 V<sub>IN</sub> with a maximum load of 30 A per phase. Other conditions include the following: 399-kHz switching, 8-V overshoot, rise time of 6 ns and a fall time of 3 ns.

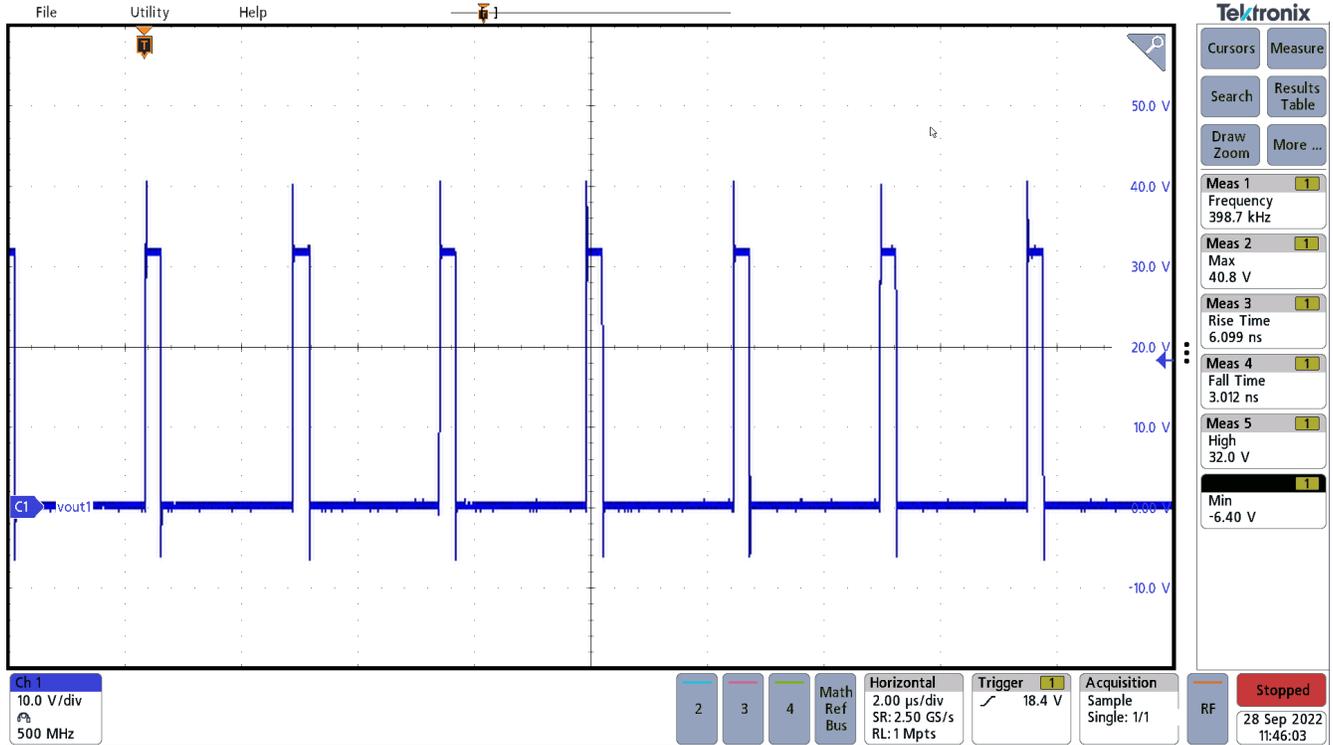


Figure 3-1. Main Switching Waveform

### 3.2 Load Transients

Figure 3-2 and Figure 3-3 show load transient 1 at 14 V<sub>IN</sub>. Load transient 1 shows a step response for load step from 30 A to 60 A (Figure 3-2), followed by a load dump from 60 A to 30 A (Figure 3-3). Load change time is about 2 μs. The undershoot and overshoot for each is about 2% or 66 mV. In both images, the blue trace is V<sub>OUT</sub> and the green trace is I<sub>OUT</sub>, but 30-A static load is not shown.

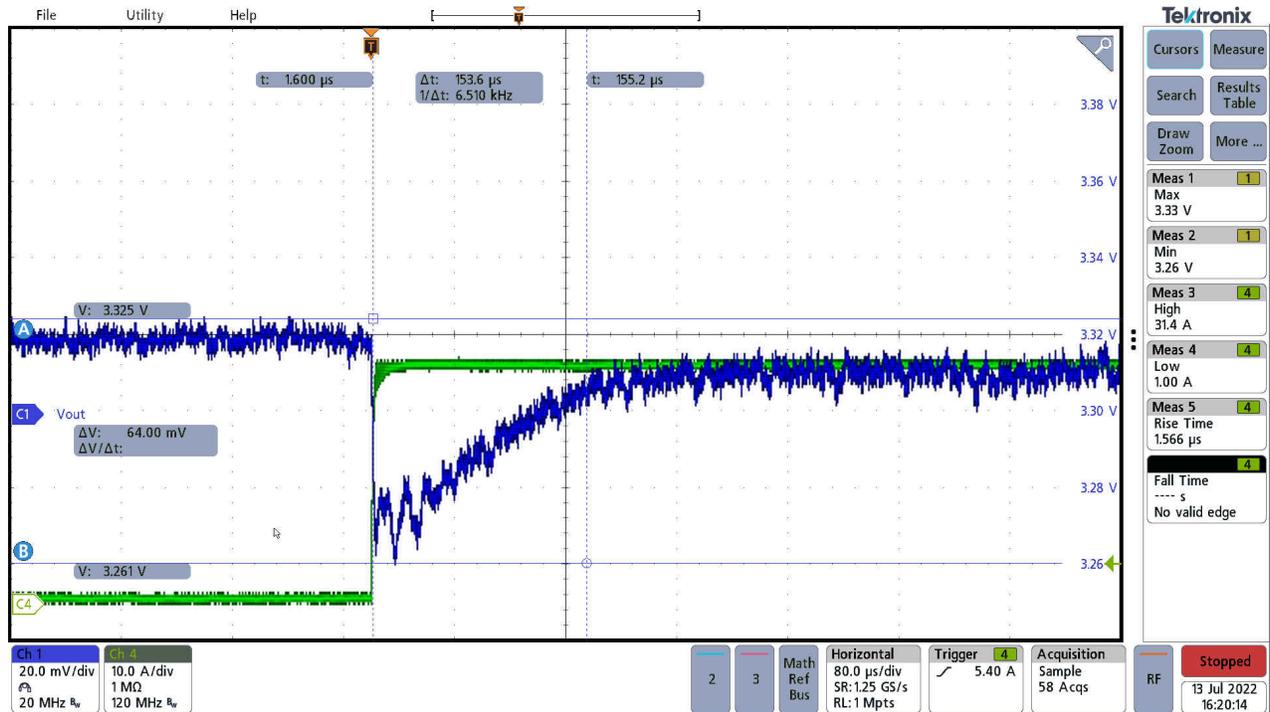


Figure 3-2. Load Transient 1, Load Step

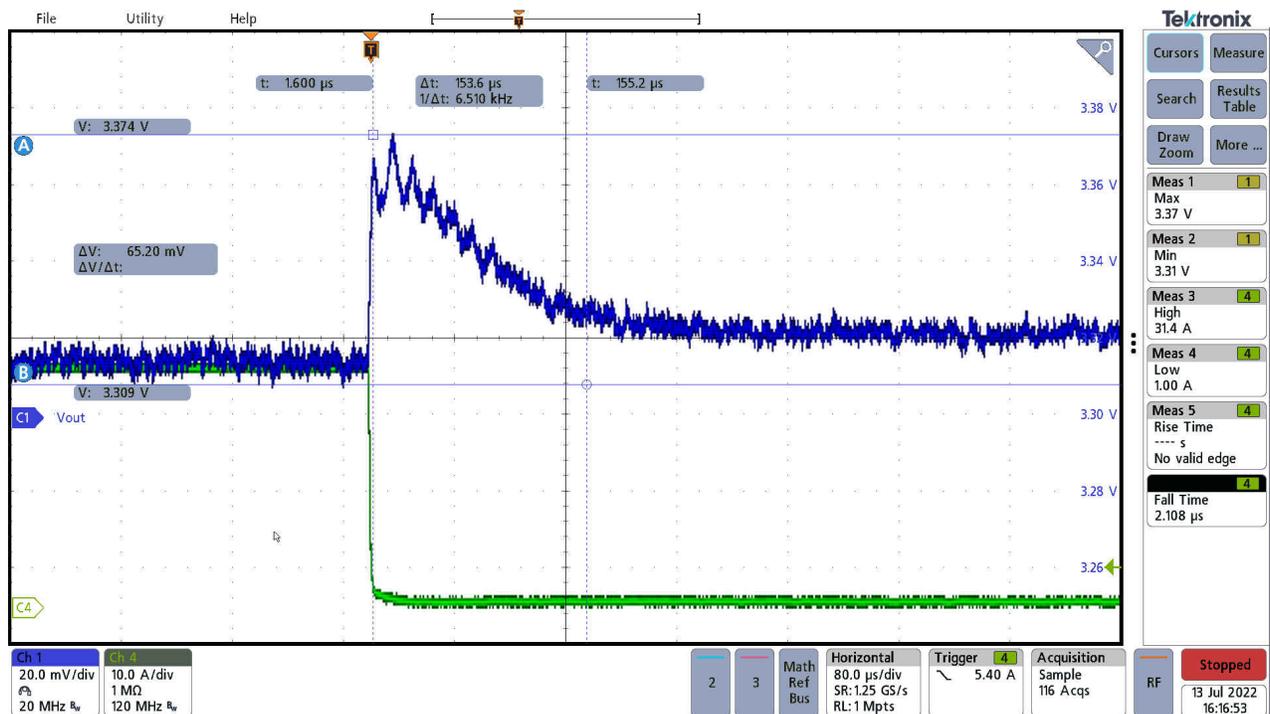


Figure 3-3. Load Transient 1, Load Dump

Figure 3-4 shows the load transient at 32 V<sub>IN</sub>. The load step response is for a load step from 0.8 A to 30.8 A, followed by load dump back to 0.8 A. The load change time is about 2 μs. Undershoot and overshoot are each about 60 mV.

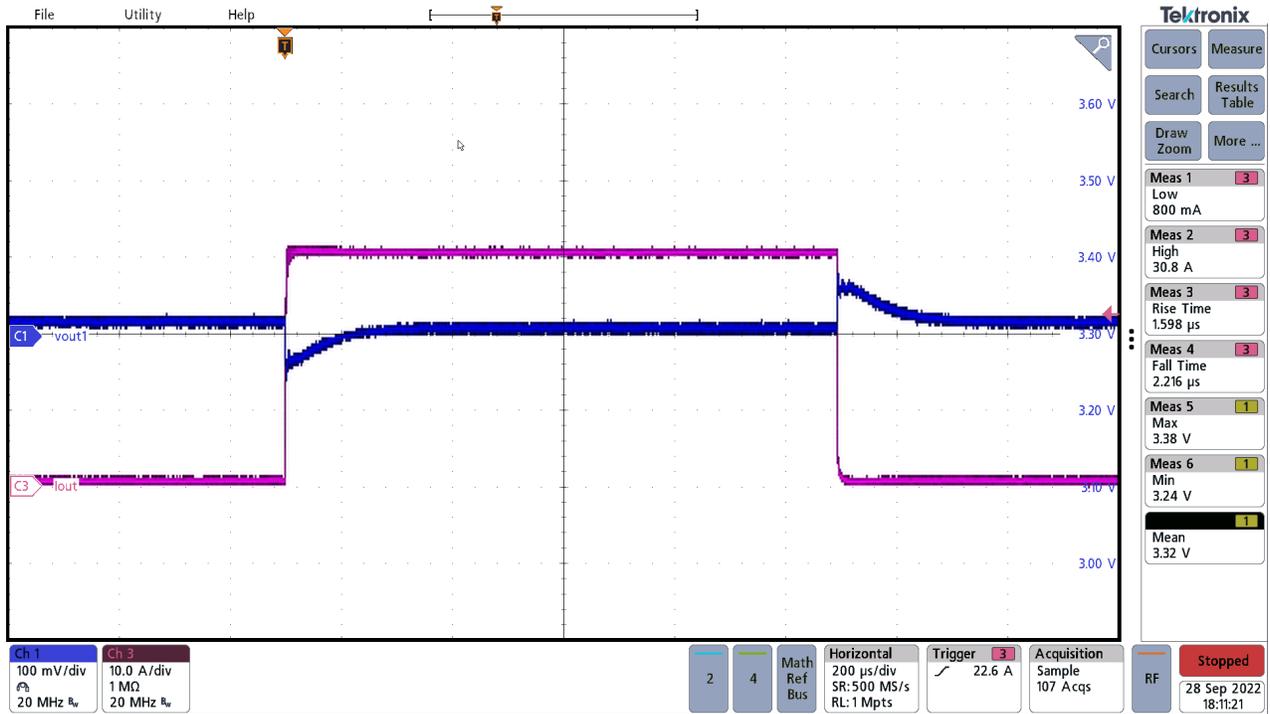


Figure 3-4. Load Transient 2

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