Test Report: PMP23262

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

TEXAS INSTRUMENTS

Description

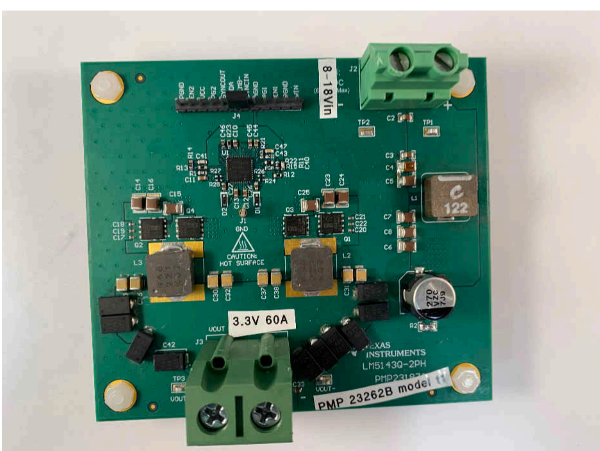
This reference design provides power for automotive advanced driver assistance systems (ADAS), infotainment, and cluster applications. Operation is over the full automotive range including battery voltage surges to 32 V and dips to 6 V due to cold cranking. The peak conversion efficiency of 94% to 96% in the 10 V_{IN} to 18 V_{IN} 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

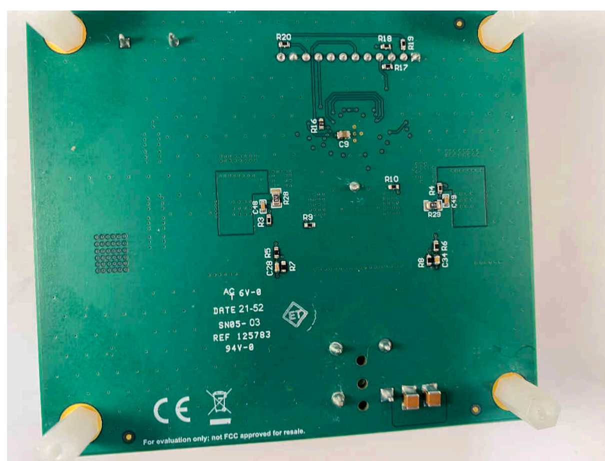
- High current for advanced driver assistance systems (ADAS), infotainment, and cluster applications
- Operation over the full automotive battery range including cold cranking and surges
- Peak conversion efficiency of 94% to 96% in the 10- to 18-V_{IN} range
- LM25143-Q1 provides two-phase control and 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 PMP23262) 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 A / µs 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).

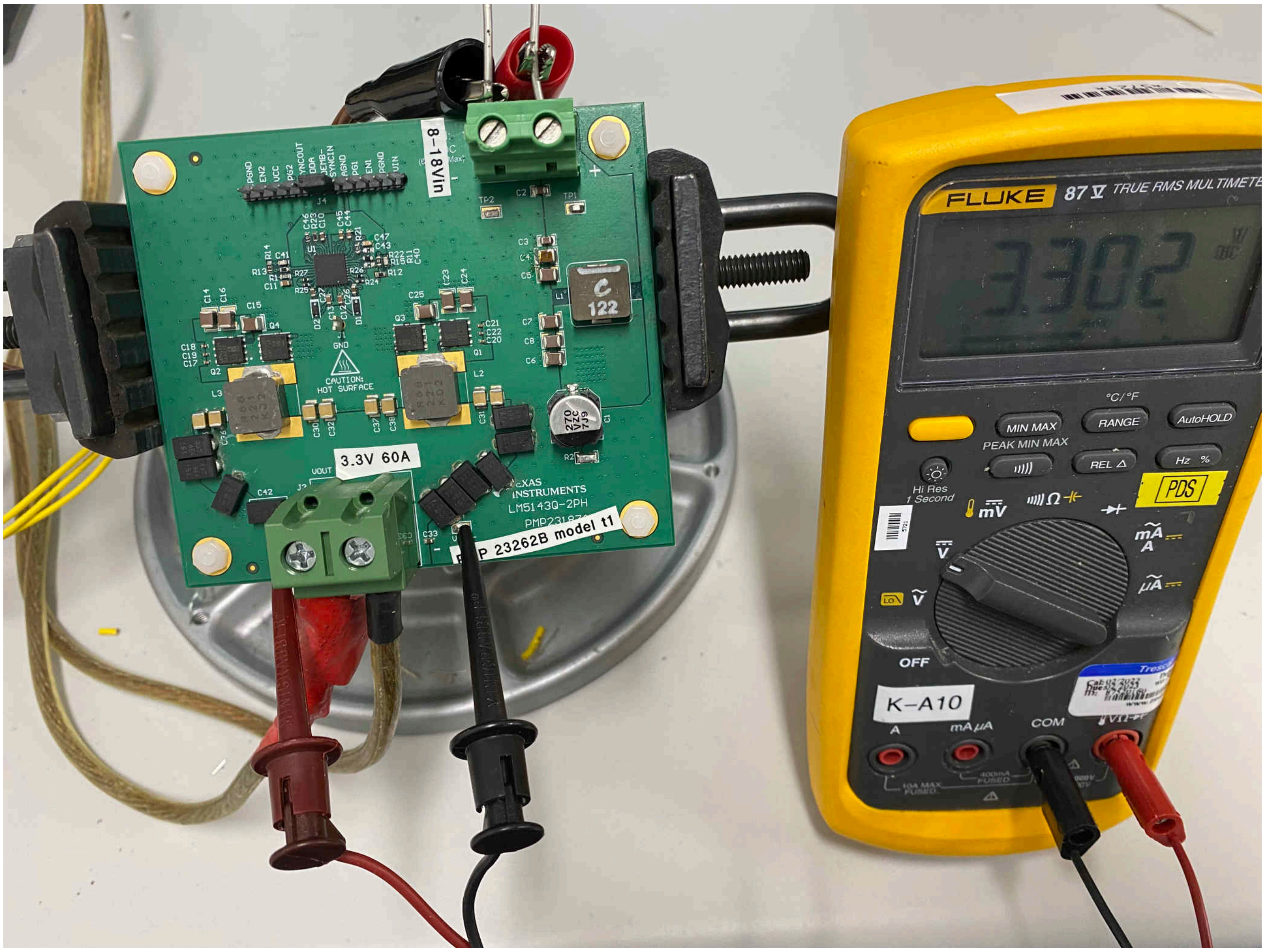


Figure 1-1. Test Setup

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.

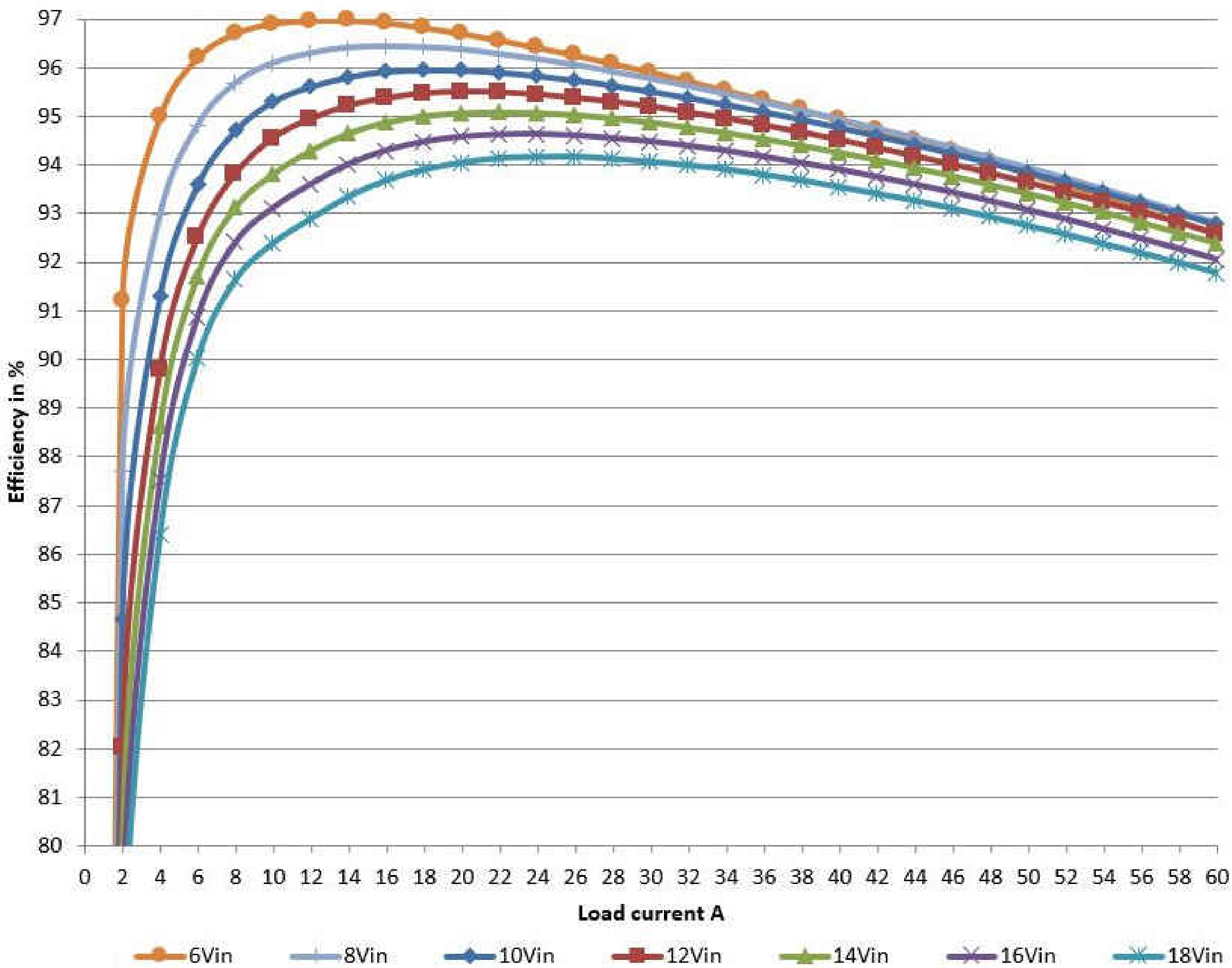


Figure 2-1. 3.3-V, 2-Phase Conversion Efficiency

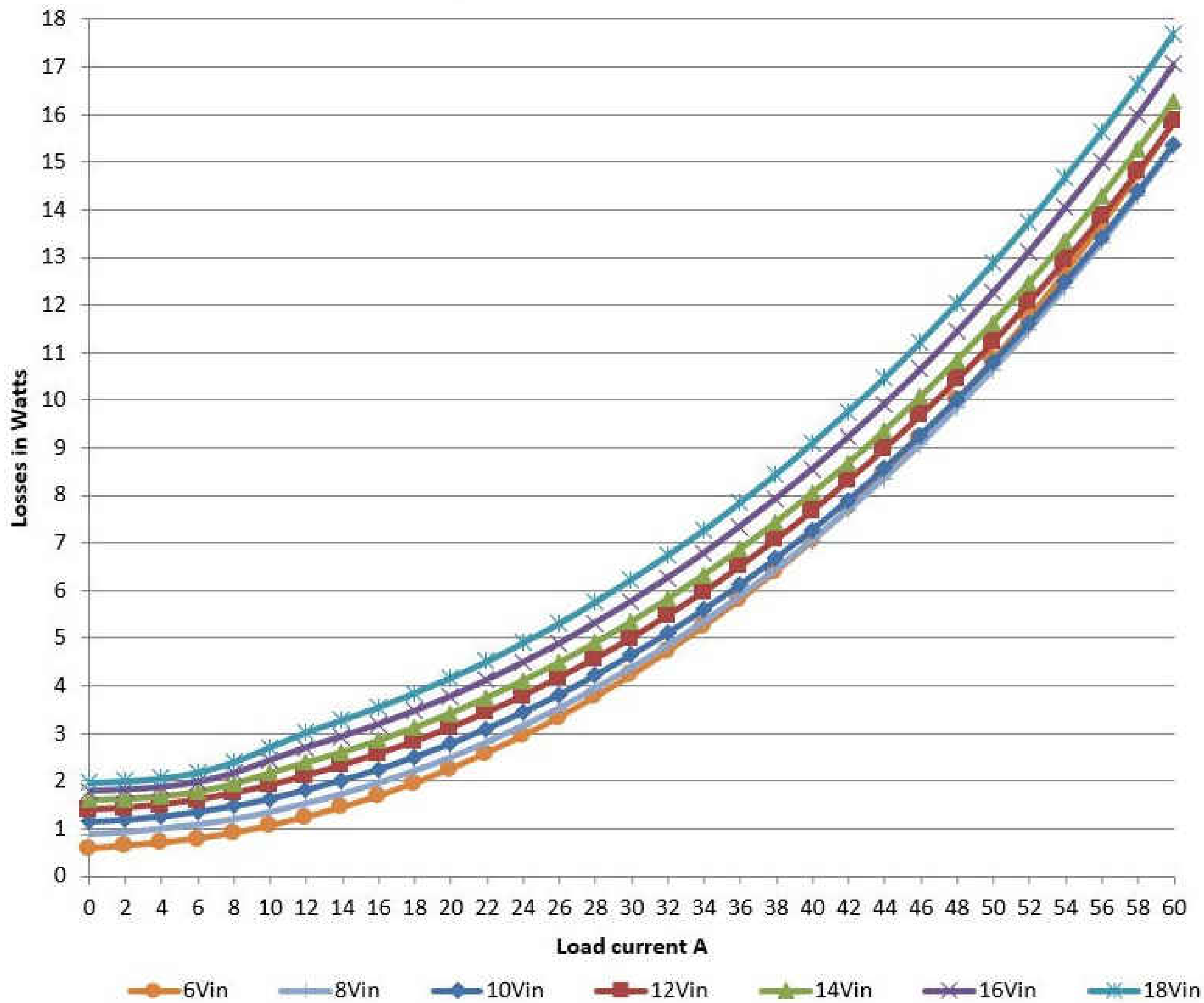


Figure 2-2. 3.3-V, 2-Phase Conversion Losses

2.2 Thermal Images

The first two thermal images in this section were taken with a load of 60 A, 14 V_{IN} 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.

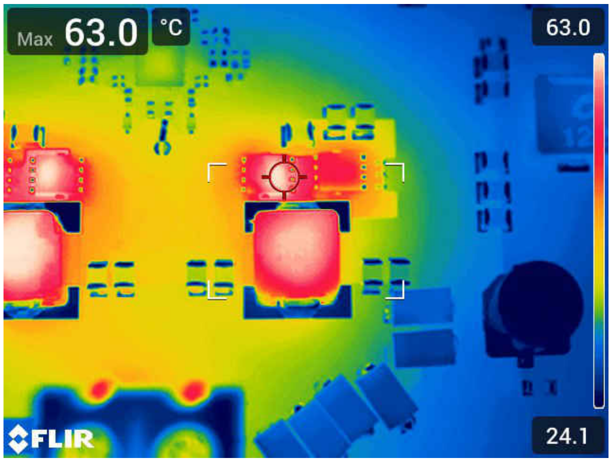


Figure 2-3. Phase 1 With Fan

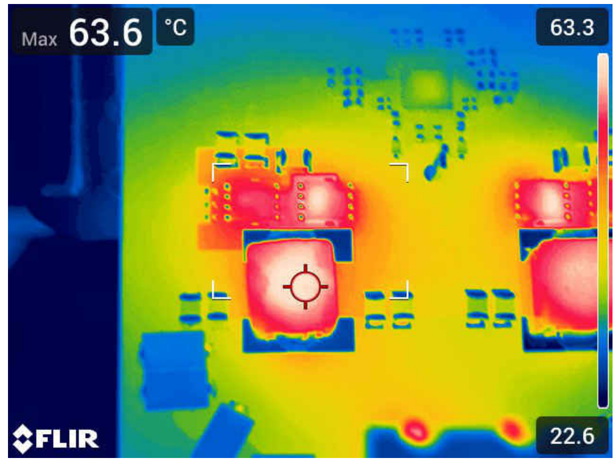


Figure 2-4. Phase 2 With Fan

The thermal images in Figure 2-5 and Figure 2-6 are for the same 14 V_{IN}, 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.

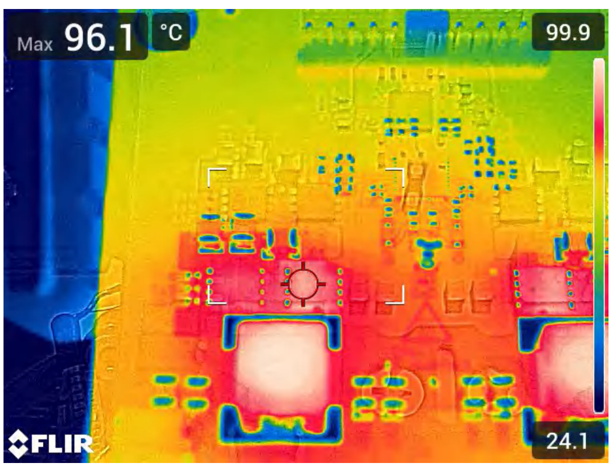


Figure 2-5. Phase 1 With No Fan

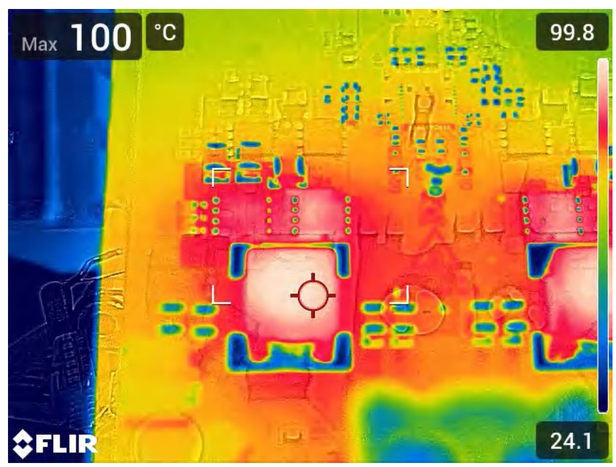


Figure 2-6. Phase 2 With No Fan

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.

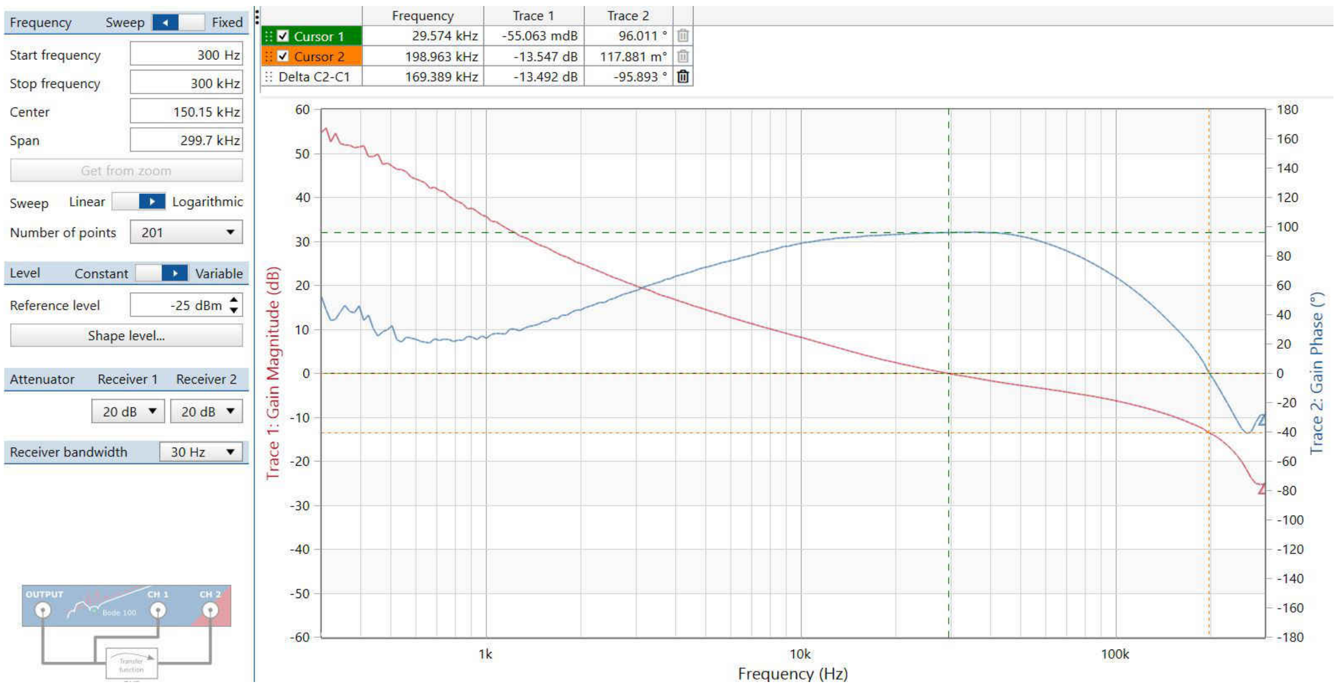


Figure 2-7. Bode Plot, 0-A Load

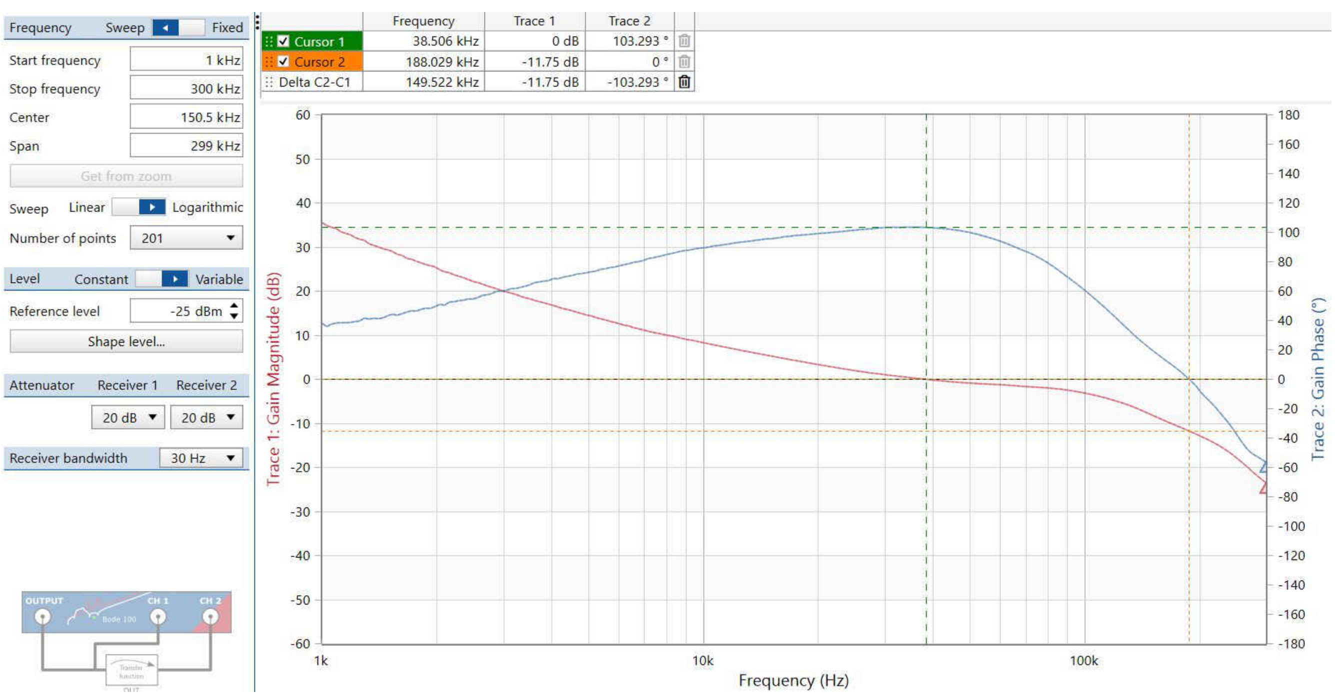


Figure 2-8. Bode Plot, 30-A Load

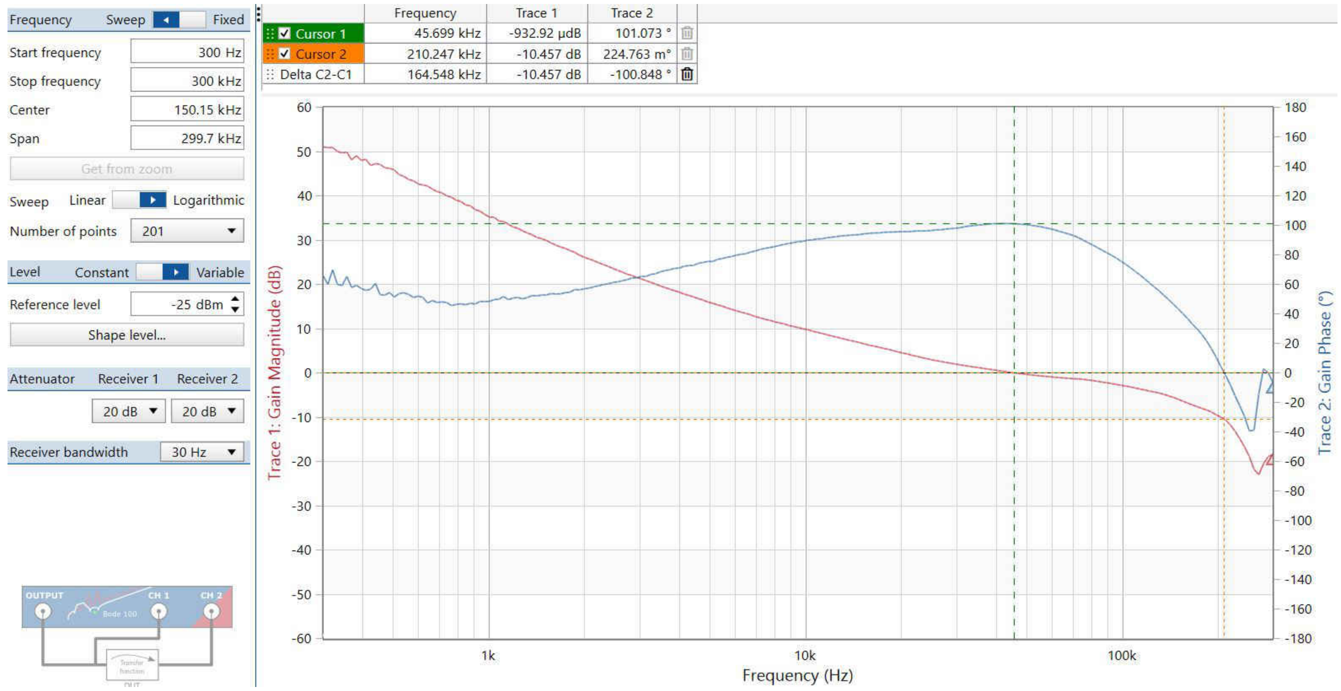


Figure 2-9. Bode Plot at Maximum 60-A Load

3 Waveforms

3.1 Switching

Figure 3-1 shows the main switching waveform.

The waveform in Figure 3-1 is taken at 32 V_{IN} 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.

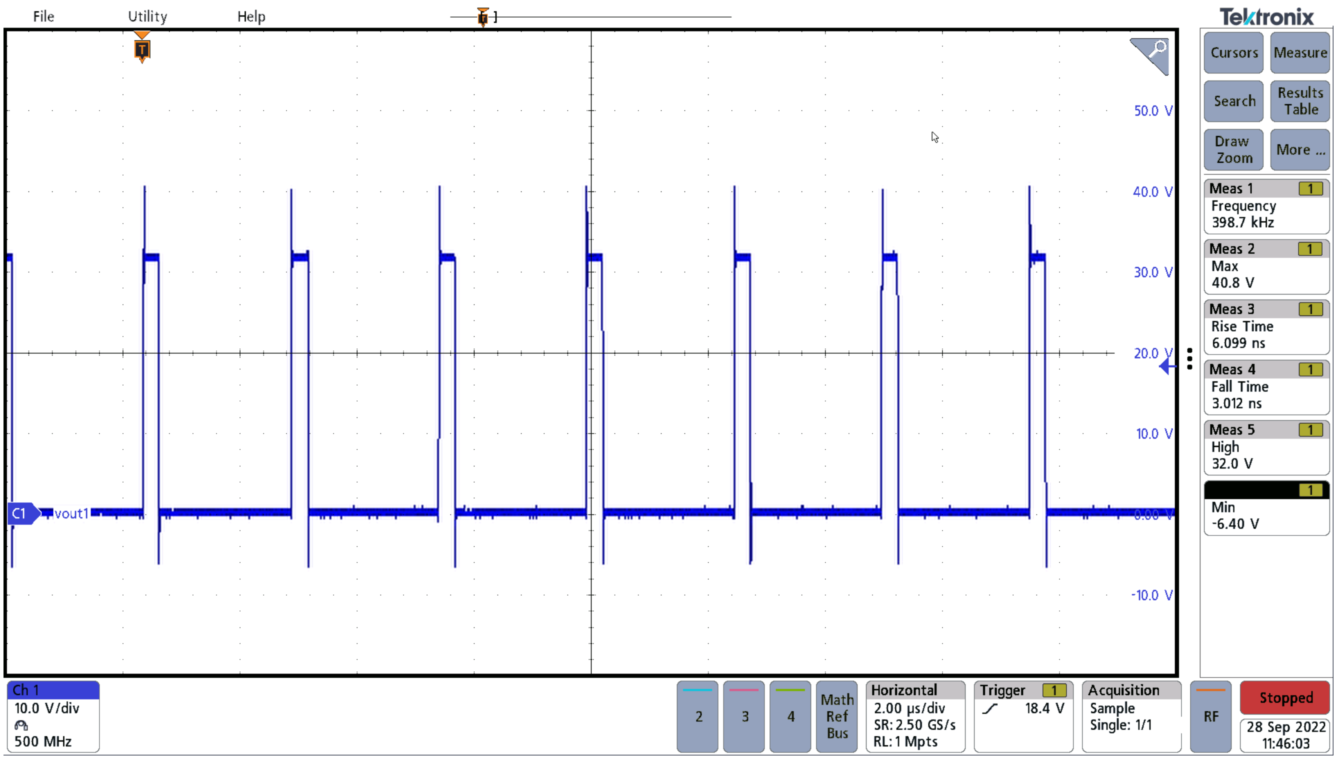


Figure 3-1. Main Switching Waveform

3.2 Load Transients

Figure 3-2 and Figure 3-3 show load transient 1 at 14 V_{IN}. 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_{OUT} and the green trace is I_{OUT}, but 30-A static load is not shown.

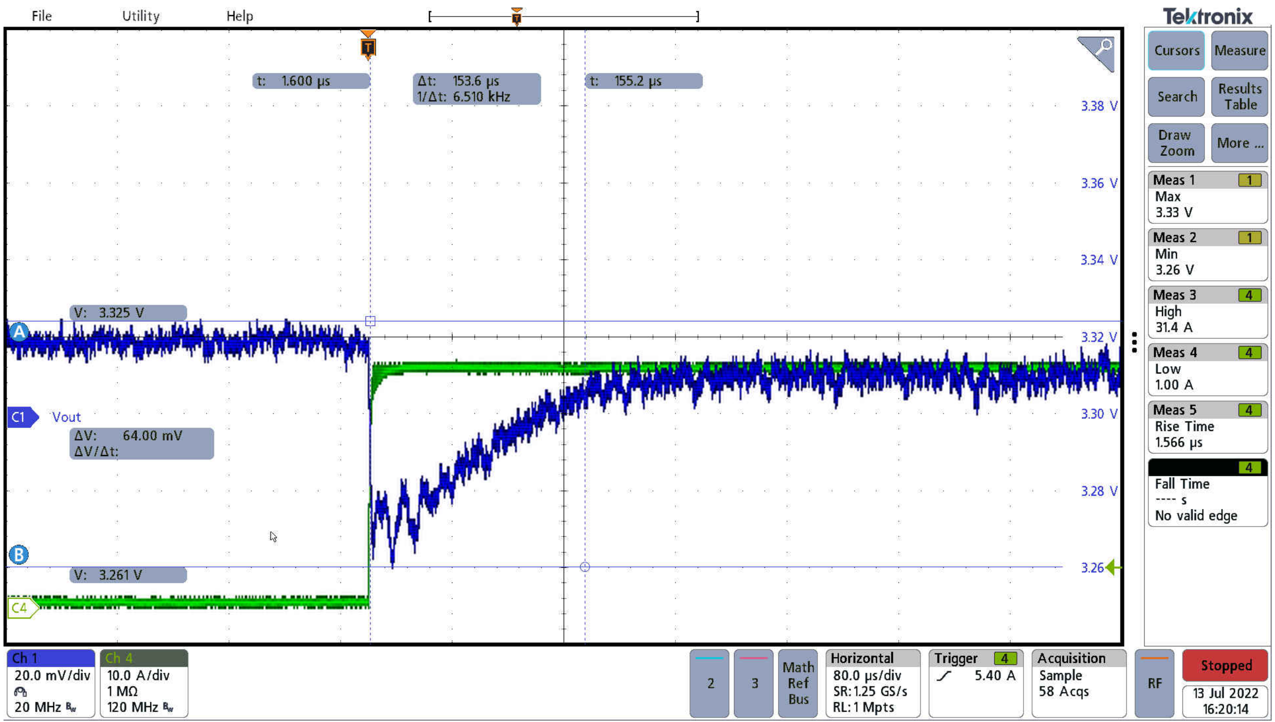


Figure 3-2. Load Transient 1, Load Step

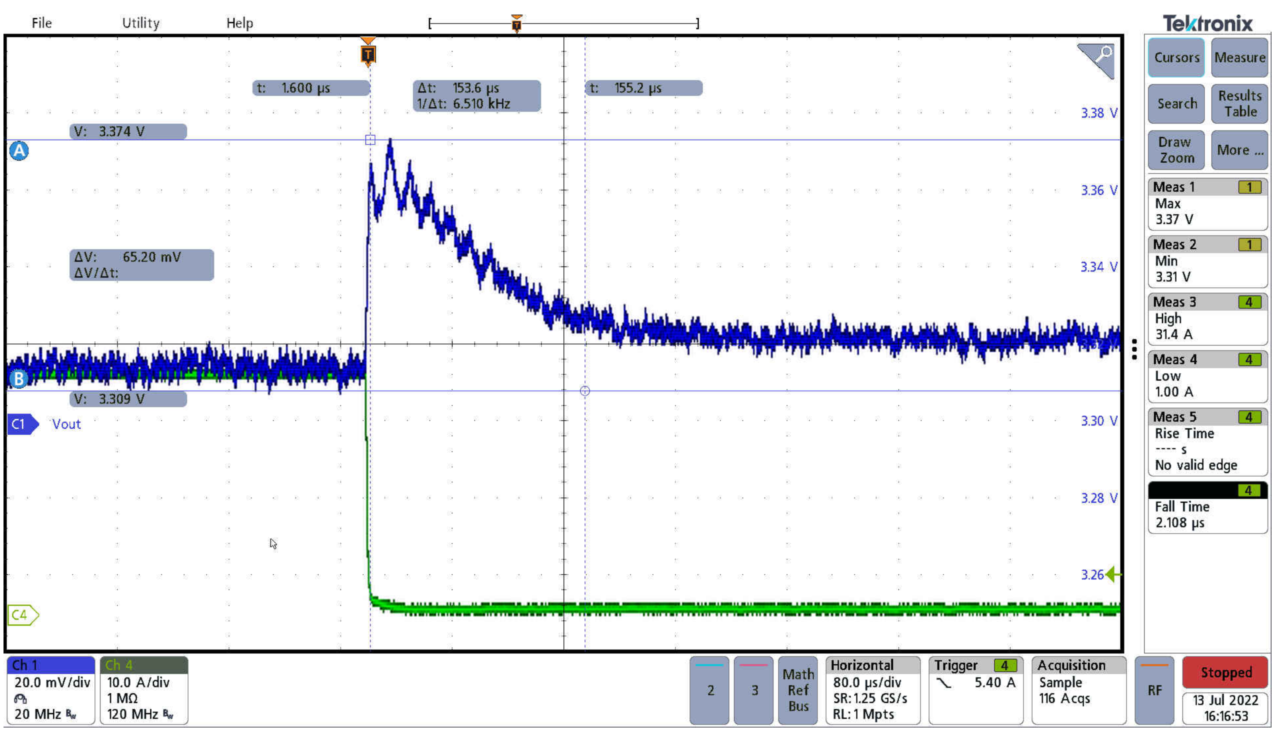


Figure 3-3. Load Transient 1, Load Dump

Figure 3-4 shows the load transient at 32 V_{IN}. 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.

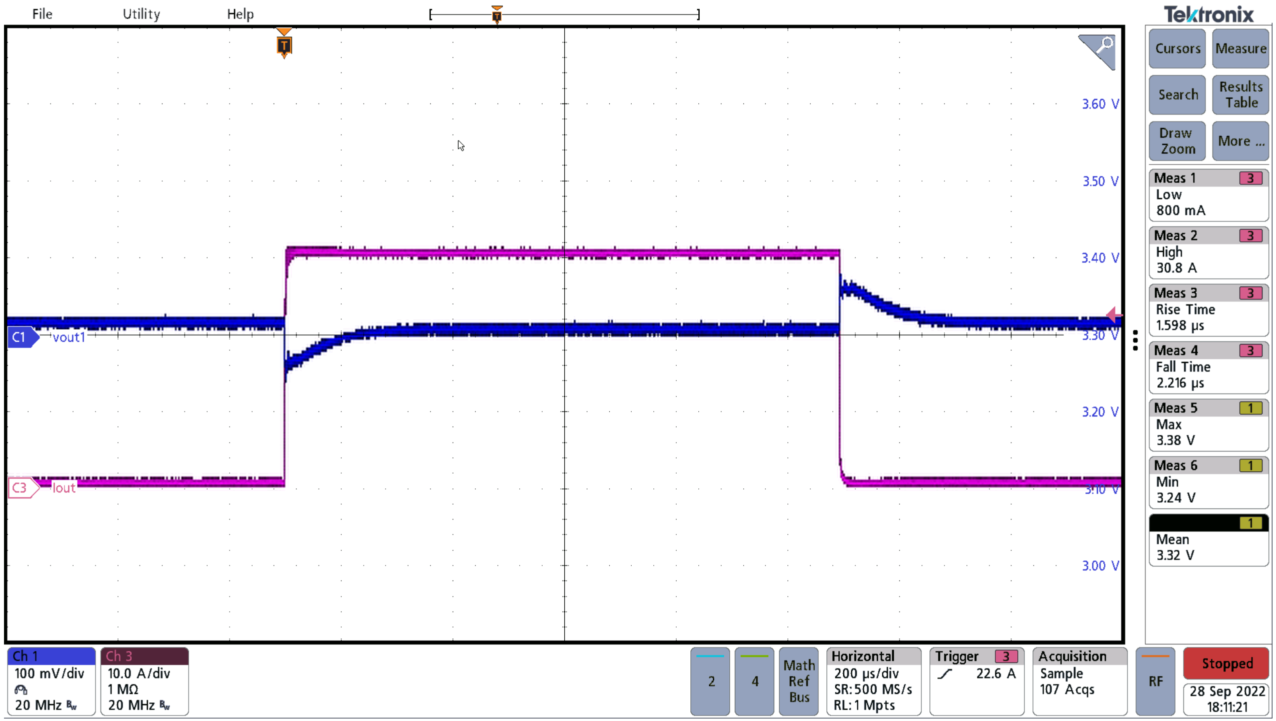


Figure 3-4. Load Transient 2