

Test Report: PMP23126

3-kW Phase-Shifted Full Bridge With Active Clamp Reference Design With > 270 W/in³ Power Density



Description

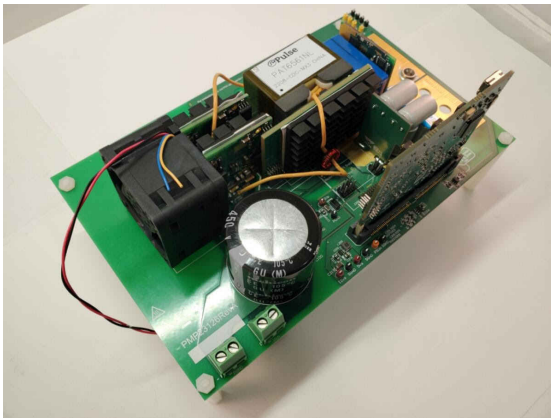
This reference design is a GaN-based 3-kW, phase-shifted full bridge (PSFB) targeting high-power density of 279 W/in³. The design employs an active clamp to minimize voltage stress on the secondary synchronous rectifier MOSFETs, enabling use of lower voltage rating MOSFETs with better figure-of-merit (FoM). PMP23126 uses 30-mΩ TI GaN on the primary side and silicon MOSFETs on the secondary side. The LMG3522 top side cooled GaN device with integrated driver and protection enables higher efficiency by maintaining ZVS over a wider range of operation compared to Si MOSFET. The PSFB operates at 100 kHz and achieves 80 plus Titanium when paired with the [PMP23069](#).

Features

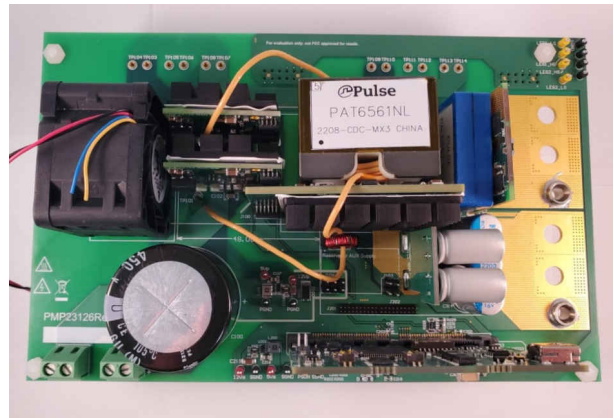
- 279 W/in³ power density in an x-y dimension of less than 68-mm × 102-mm space and maximum height of 32 mm
- Active clamp for minimizing voltage stress on SR MOSFET enabling use of lower FoM devices
- Adaptive SR scheme to enable SR during freewheeling period for improved efficiency
- GaN optimized with driver integration

Application

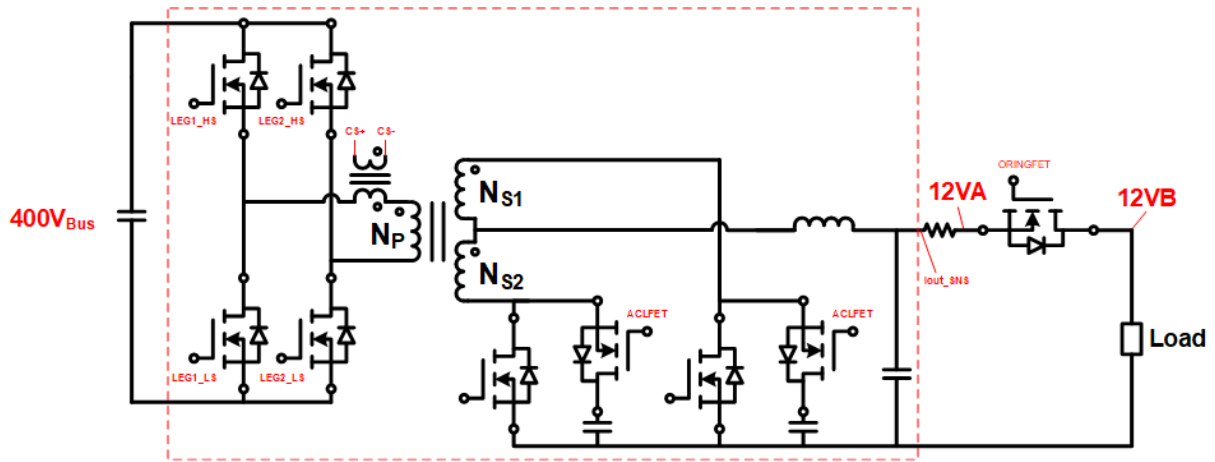
- [Merchant network and server PSU](#)
- [Merchant telecom rectifiers](#)



Board Side View



Board Top View



Phase Shift Full Bridge Converter

PSFB With Active Clamp Block Diagram

1 Test Prerequisites

1.1 Voltage and Current Requirements

Table 1-1. Voltage and Current Requirements

Parameter	Specifications	Units
Input Voltage	350–410	VDC
Output Voltage	12	VDC
Output Current	250	A
Output Power	3	kW

1.2 Dimensions

The power supply as shown in [Figure 1-1](#) has a maximum component height of 32 mm.

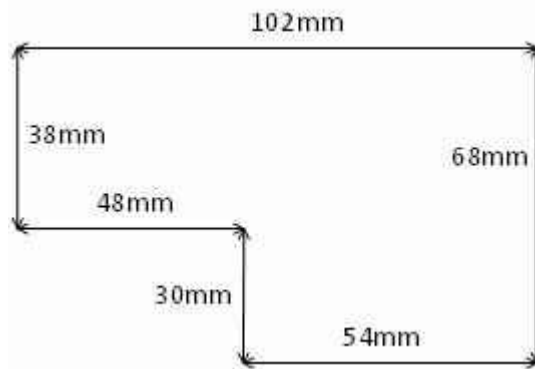


Figure 1-1. Power-Supply Dimensions

2 Testing and Results

2.1 Efficiency Graphs

The efficiency graph data in [Figure 2-1](#) was taken under the following conditions:

- Switching frequency: 100 kHz
- GaN slew rate: 20 V/ns
- Input voltage: 385 VDC
- Output voltage: 12 VDC
- Fan: FFB0412EN-00Y2E

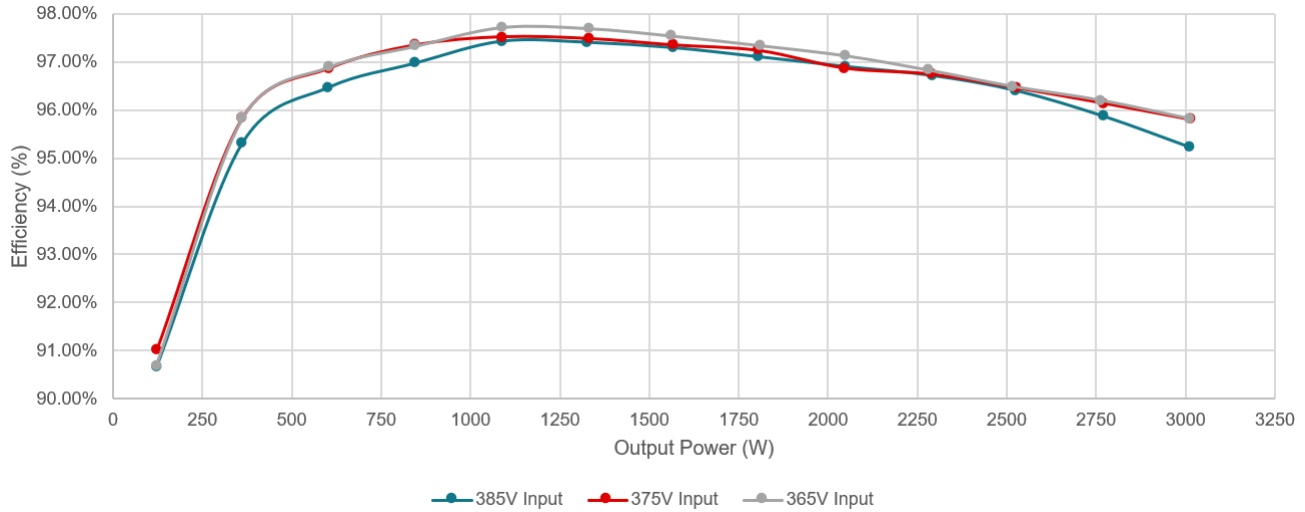


Figure 2-1. PMP23126 Efficiency Graph

2.2 Efficiency Data

[Table 2-1](#) displays the efficiency data.

Table 2-1. Efficiency

Input Voltage (V)	Input Current (A)	Input Power (W)	Output Voltage (V)	Output Current (A)	Output Power (W)	Efficiency (%)
385	0.345	132.825	12.046	9.997	120.424	90.66
385	0.985	379.225	12.051	29.997	361.494	95.32
385	1.622	324.47	12.049	49.997	602.414	96.47
384	2.258	869.330	12.043	69.997	842.974	96.97
384	2.904	1115.136	12.072	89.997	1086.444	97.43
384	3.550	1363.200	12.071	109.998	1327.786	97.40
384	4.189	1608.576	12.039	129.997	1565.034	97.29
384	4.841	1858.944	12.034	149.999	1805.088	97.10
384	5.513	2116.992	12.067	169.997	2051.354	96.90
383	6.172	2370.048	12.067	189.997	2292.124	96.71
384	6.840	2619.720	12.026	209.997	2525.424	96.40
384	7.530	289.520	12.052	229.997	2771.924	95.86
384	8.240	3164.16	12.052	249.997	3012.964	95.22
375	0.353	12.049	9.997	132.375	120.454	90.99
374	1.009	12.059	29.997	377.366	361.674	95.84

Table 2-1. Efficiency (continued)

Input Voltage (V)	Input Current (A)	Input Power (W)	Output Voltage (V)	Output Current (A)	Output Power (W)	Efficiency (%)
374	1.664	12.057	49.997	622.336	602.814	96.86
374	2.318	12.057	69.997	866.932	843.954	97.35
374	2.984	12.093	89.997	1116.016	1088.334	97.52
374	3.647	12.088	109.998	1363.978	1329.656	97.48
374	4.301	12.046	129.997	1608.574	1565.944	97.35
374	4.970	12.049	149.997	1858.780	1807.314	97.23
374	5.652	12.045	169.997	2113.848	2047.614	96.87
374	6.324	12.043	189.997	2365.176	2288.134	96.74
374	7.010	12.042	209.997	2621.740	2528.784	96.45
374	7.710	12.053	229.997	2883.540	2772.154	96.14
374	8.42	12.067	249.997	3149.080	3016.714	95.80
365	0.364	12.053	9.997	132.860	120.494	90.69
365	1.034	12.057	29.997	377.410	361.674	95.83
365	1.705	12.060	49.997	622.325	602.964	96.89
365	2.376	12.058	69.997	867.240	844.024	97.32
364	3.060	12.094	89.997	1113.840	1088.424	97.72
364	3.741	12.094	109.997	1361.724	1330.304	97.69
364	4.407	12.036	129.997	1604.148	1564.644	97.54
364	5.106	12.061	149.997	1858.584	1809.138	97.34
364	5.795	12.052	169.997	2109.380	2048.804	97.13
364	6.473	12.008	189.997	2356.172	2281.484	96.83
364	7.170	11.992	209.997	2609.880	2518.284	96.49
364	7.890	12.013	229.997	2871.960	2762.954	96.20
364	8.640	12.054	249.997	3144.960	3013.464	95.82

2.3 Load Regulation

The load regulation graph data in [Figure 2-2](#) was taken under the following conditions:

- Input Voltage: 385 VDC
- Output Voltage: 12 VDC
- Switching Frequency: 100 kHz
- GaN Slew Rate: 20 V/ns
- Fan: FFB0412EN-00Y2E

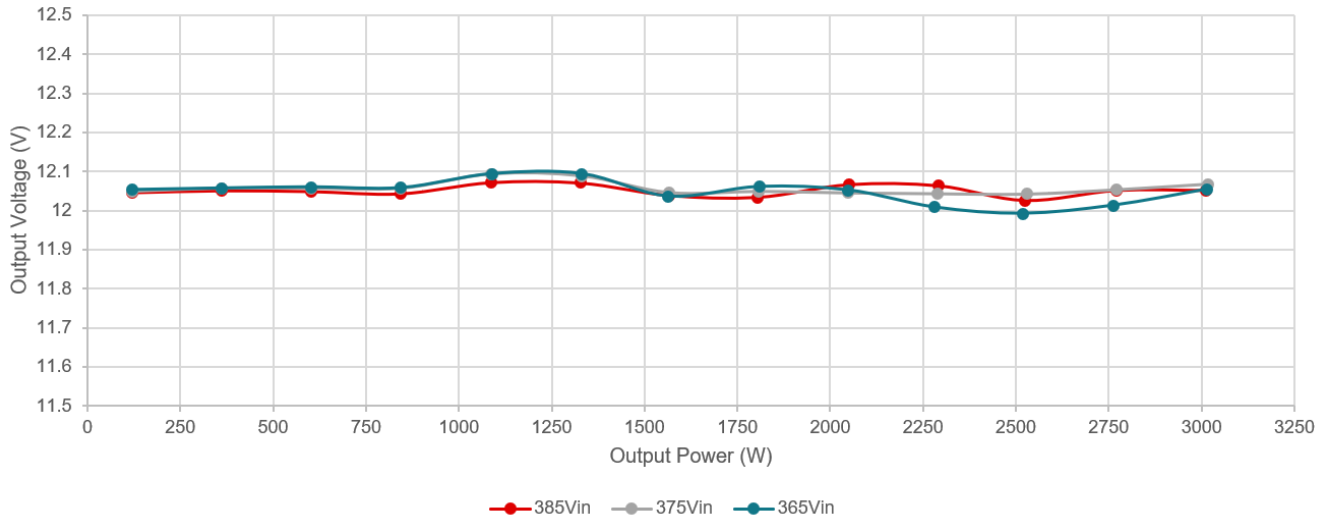


Figure 2-2. PMP23126 Load Regulation Graph

3 Waveforms

3.1 Steady State

The channels for [Figure 3-1](#) through [Figure 3-6](#) have the following values: C1 (yellow) = SR Vds, C2 (magenta) = transformer primary current, C3 (cyan) = Leg1_LS PWM signal, C4 (green) = output voltage.

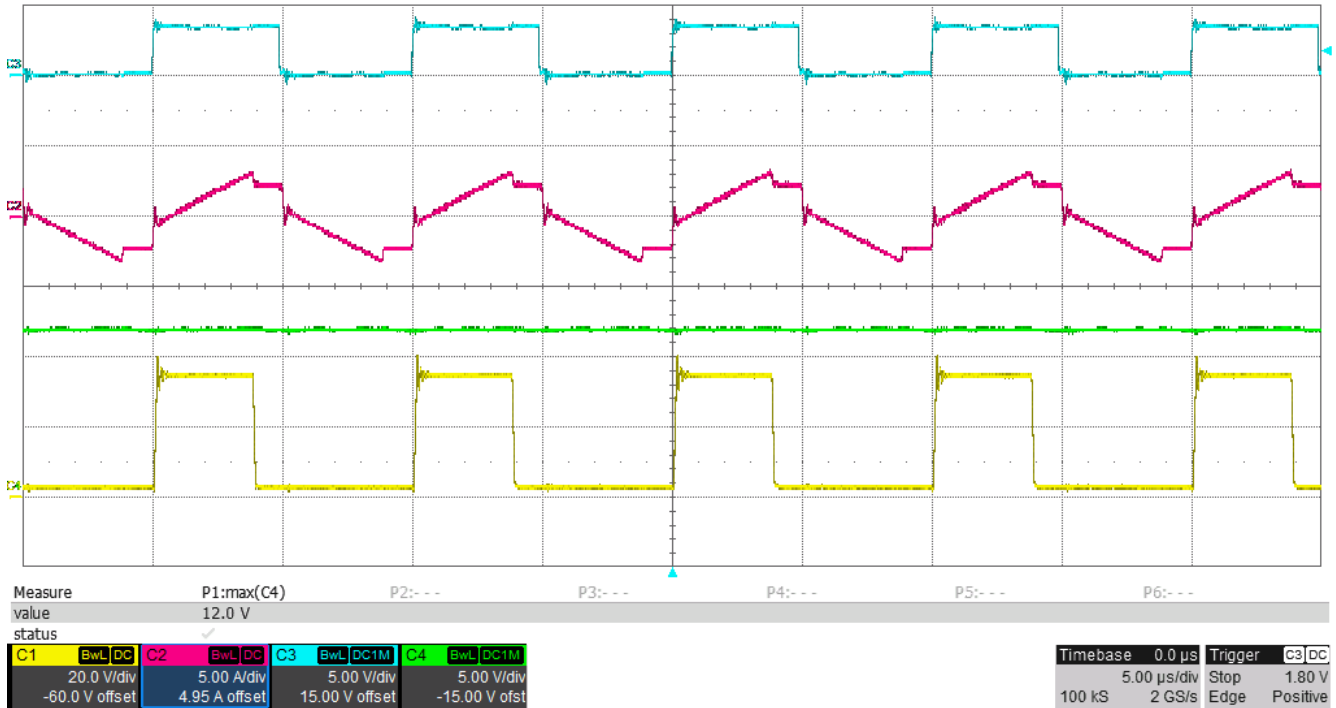


Figure 3-1. 30-A Load

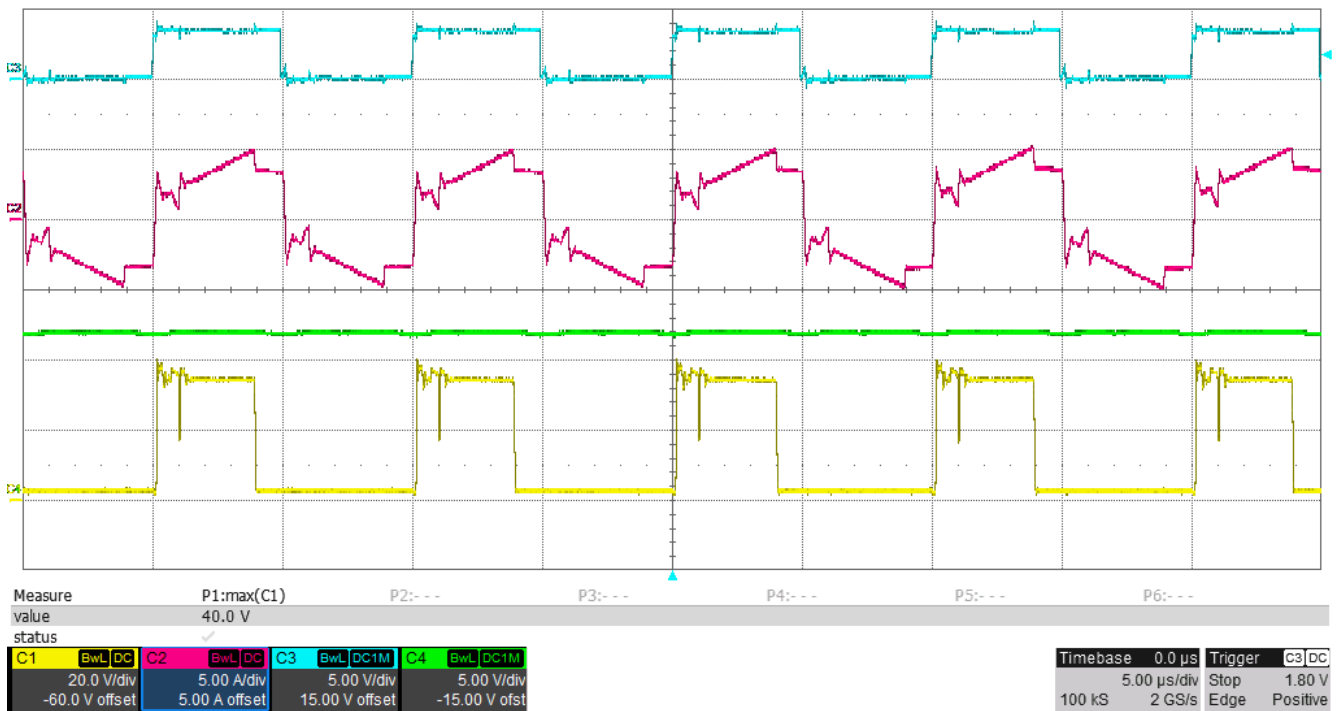


Figure 3-2. 50-A Load

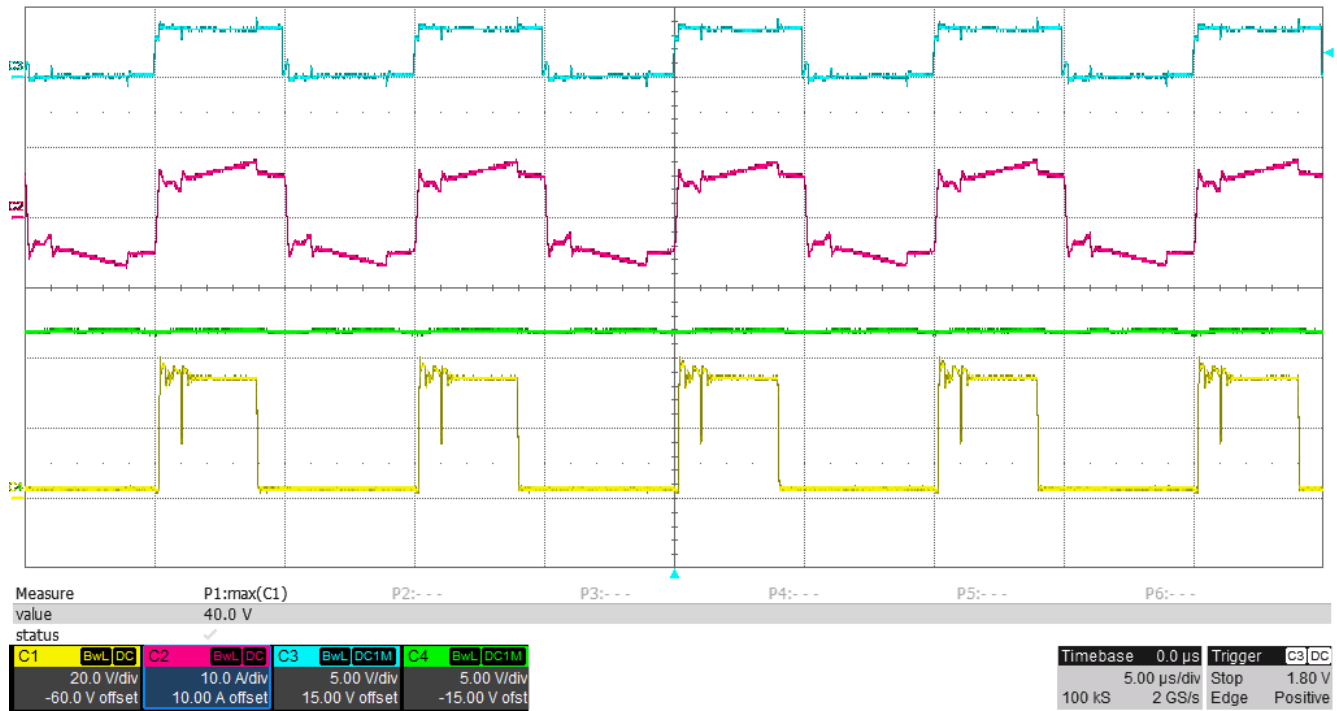


Figure 3-3. 90-A Load

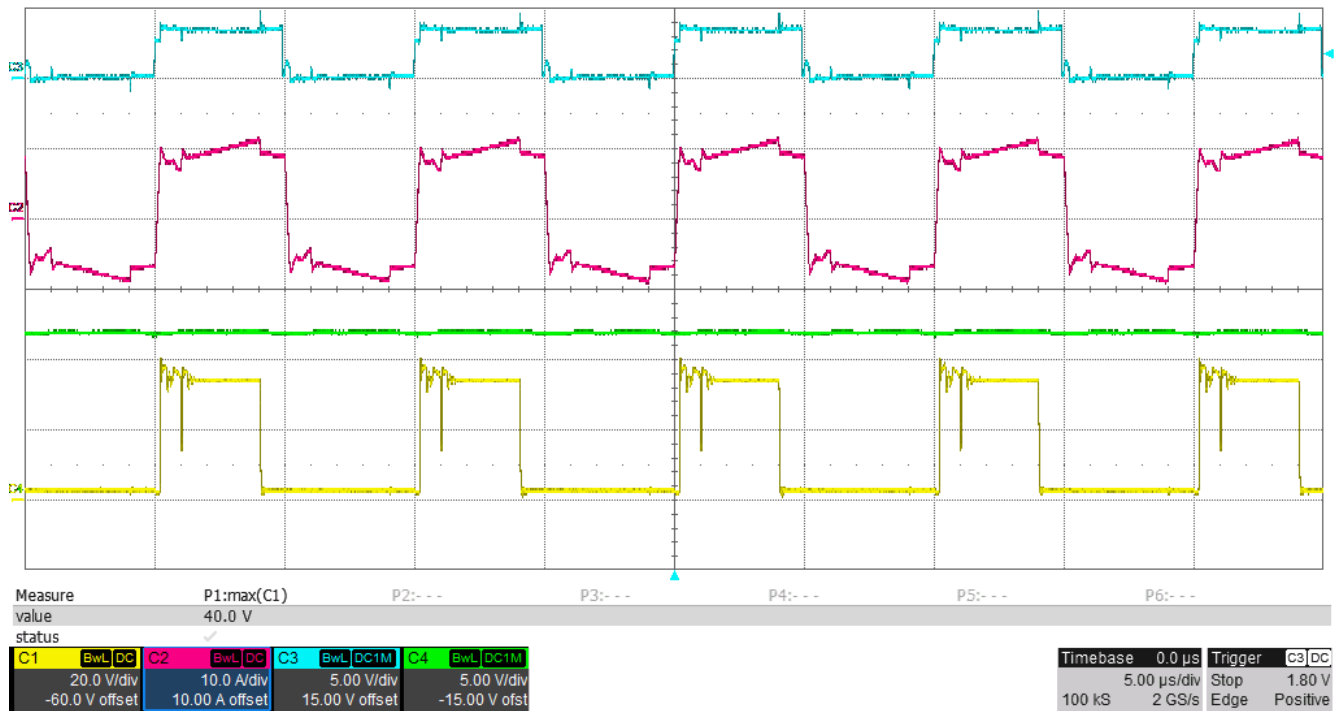


Figure 3-4. 150-A Load

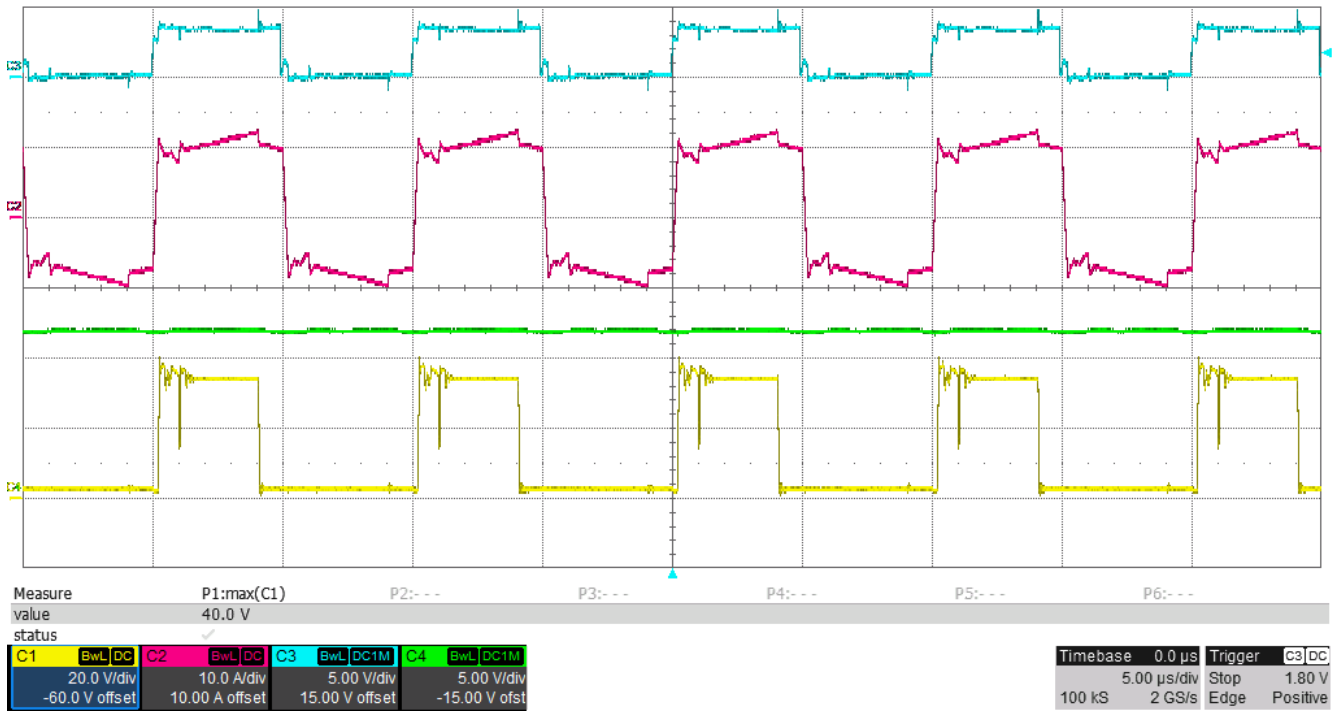


Figure 3-5. 210-A Load

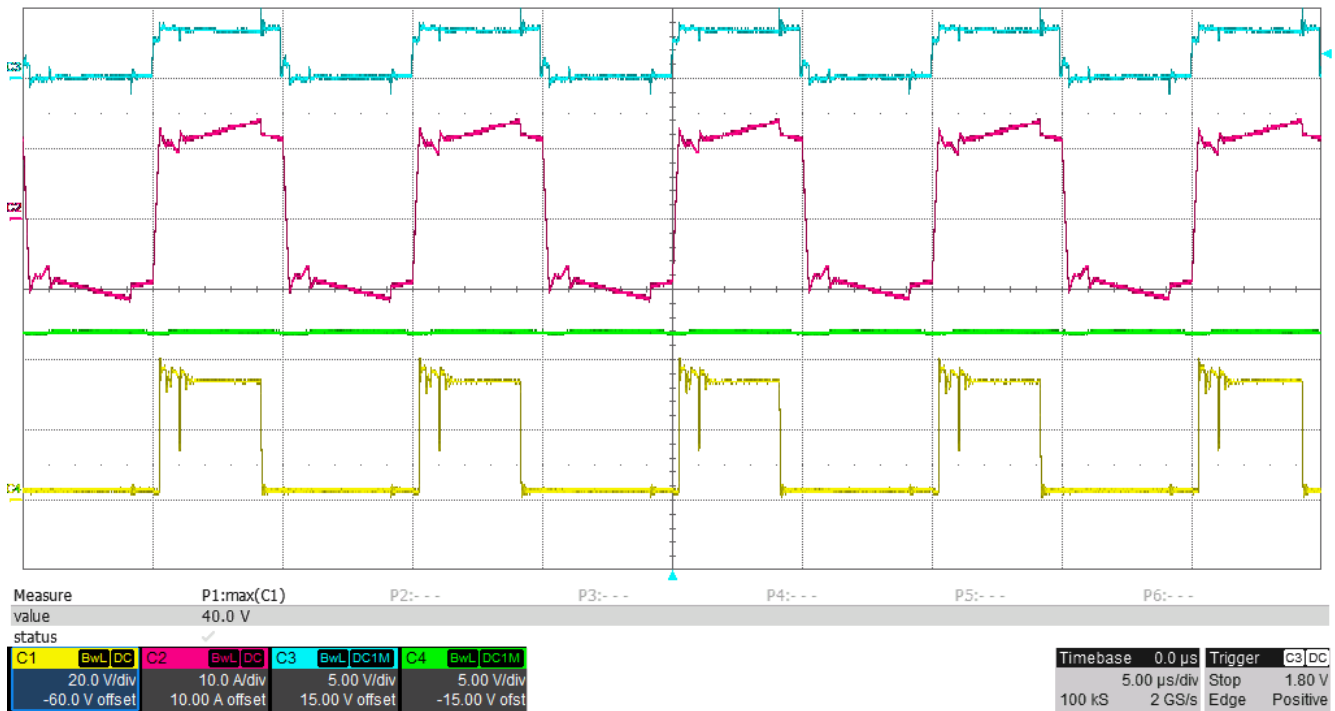


Figure 3-6. 250-A Load

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATA SHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES "AS IS" AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI's products are provided subject to [TI's Terms of Sale](#) or other applicable terms available either on ti.com or provided in conjunction with such TI products. TI's provision of these resources does not expand or otherwise alter TI's applicable warranties or warranty disclaimers for TI products.

TI objects to and rejects any additional or different terms you may have proposed.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2022, Texas Instruments Incorporated