

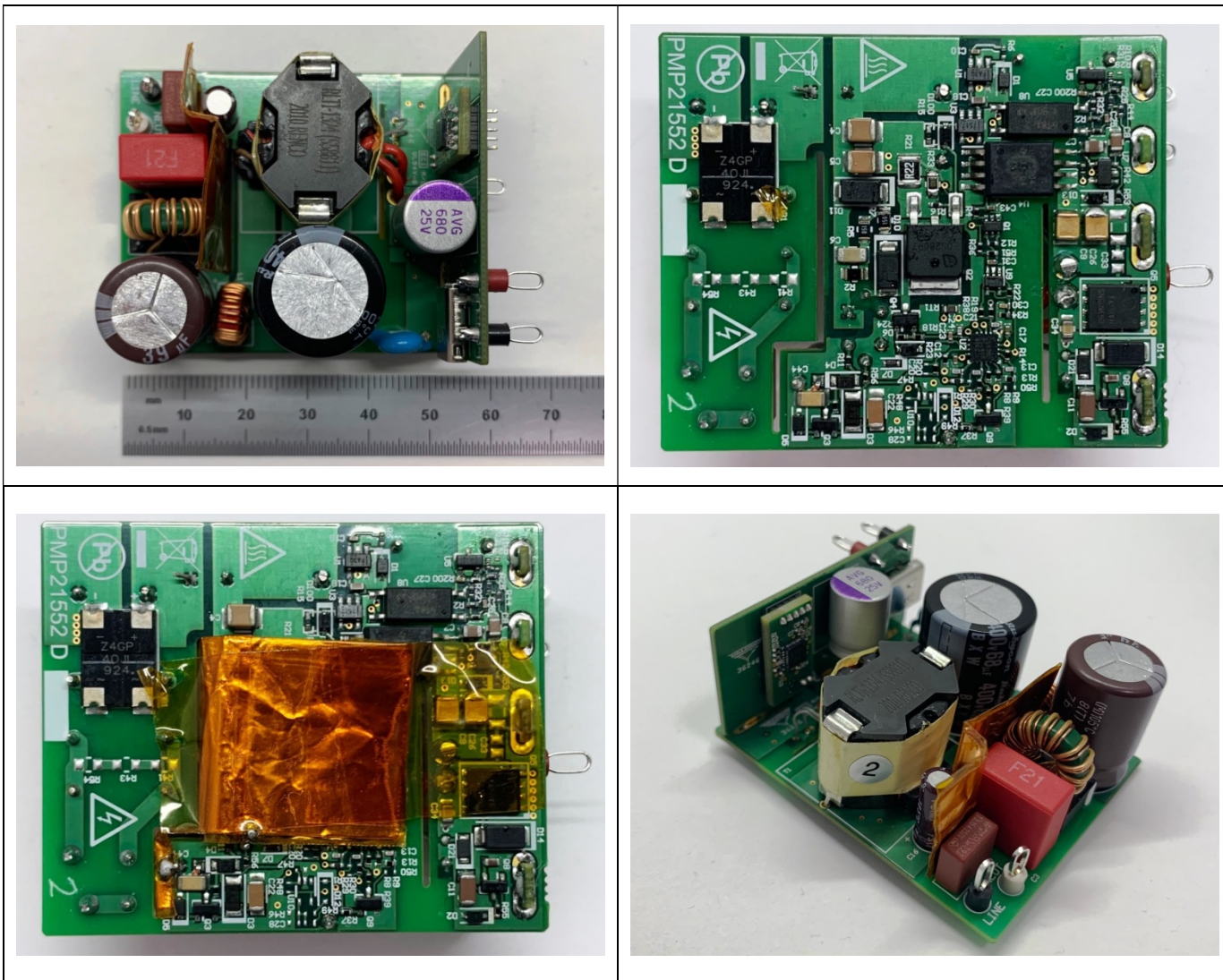
Test Report: PMP21552


65-W USB Type-C ZVS-Flyback Reference Design



Description

This reference design is a low-cost, high-density USB adapter that uses the UCC28780 active-clamp flyback controller and UCC5304 isolated driver in a ZVS-flyback topology. The maximum power rating is 65 W at 20-V output but is adjustable for 20-V/15-V/9-V/5-V output voltage and 3 A. This design reaches a peak efficiency of 93.2%. The average efficiency and standby power levels are designed to meet DoE level VI and CoC Tier 2 limits. The compact design has dimensions of 45 mm by 55 mm by 25mm (62cc).



 An IMPORTANT NOTICE at the end of this TI reference design addresses authorized use, intellectual property matters and other important disclaimers and information.

CONTENTS

1	Test Prerequisites	3
1.1	Voltage and Current Requirements	3
2	Testing and Results	4
2.1	Efficiency.....	4
2.2	Thermal Images	7
2.3	Switching Frequency with 20Vout.....	11
2.4	Switching Waveforms	12
2.5	Output Voltage Ripple at Maximum Load Current.....	13
2.6	Bode Plot.....	17
2.7	5V Output Load Transients.....	19
2.8	9V Output Load Transients.....	23
2.9	15V Output Load Transients.....	27
2.10	20V Output Load Transients.....	31
2.11	Startup.....	35
2.12	Voltage Transitions.....	36
2.13	Conducted EMI.....	48
2.14	Radiated EMI	49

1 Test Prerequisites

1.1 Voltage and Current Requirements

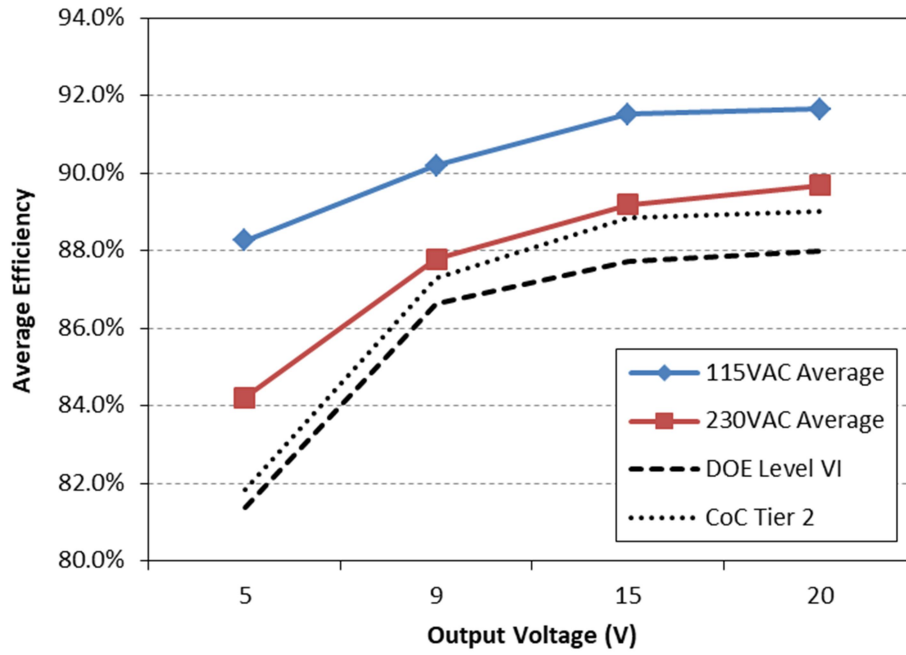
Table 1. Voltage and Current Requirements

PARAMETER	SPECIFICATIONS
Line Input Voltage Range	90VACrms – 265VACrms
Line Input Frequency	50Hz/60Hz
Output Voltage/Current	5V/3A, 9V/3A, 15V/3A, 20V/3.25A

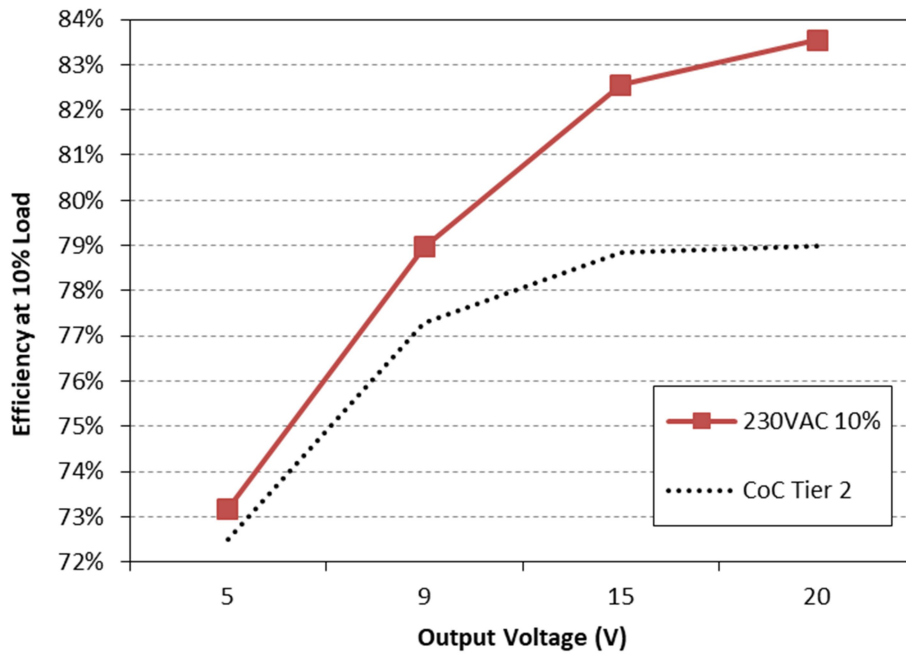
2 Testing and Results

2.1 Efficiency

2.1.1 Average Efficiency



2.1.2 Efficiency at 10% Load



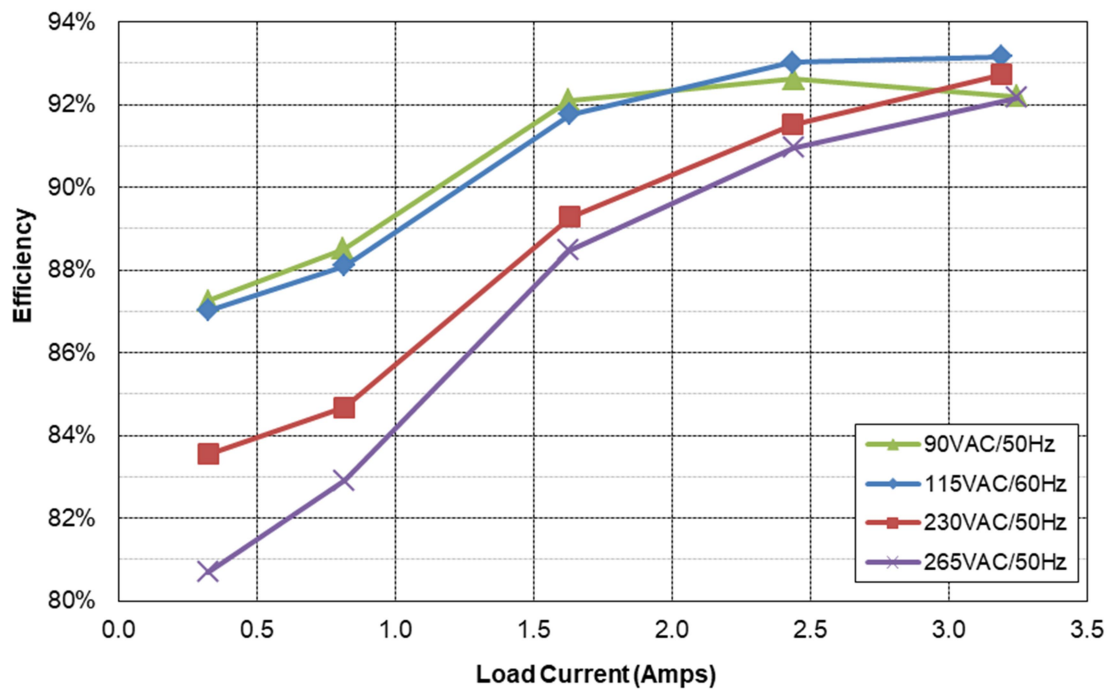
2.1.3 Standby (Output Cable Unplugged)

Vin RMS	Line Frequency	Input Power
115 V	60	33.1 mW
230 V	50	42.1 mW

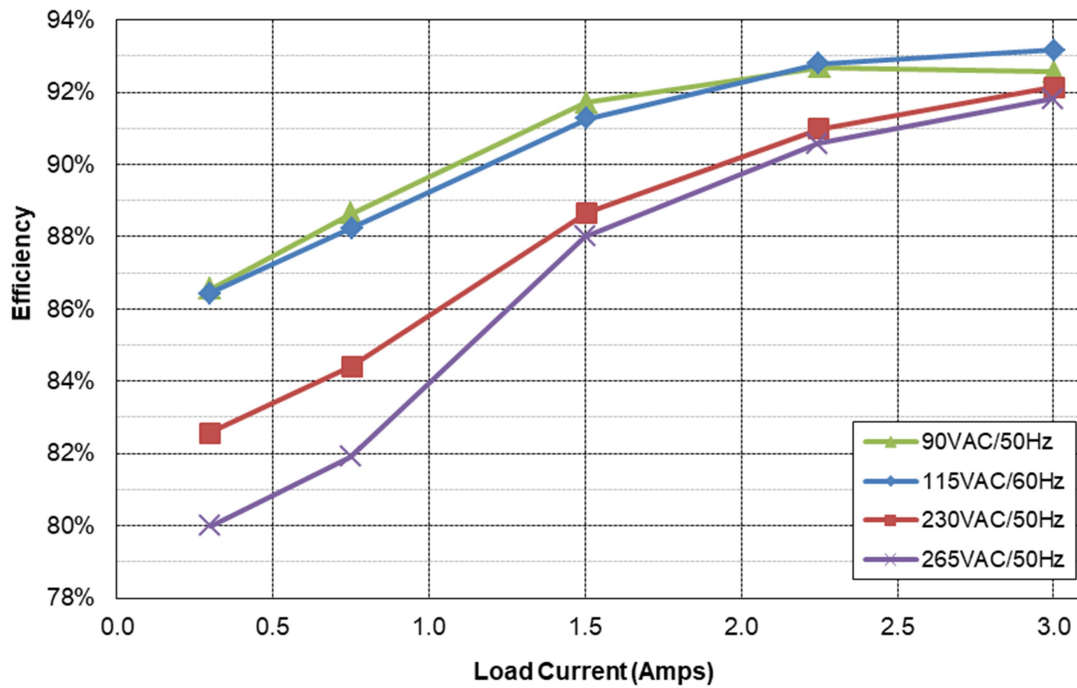
2.1.4 Tiny Load (20V Output at 250mw Load)

Vin RMS	Line Frequency	Input Power	Efficiency
115 V	60	424 mW	59%
230 V	50	444 mW	56%

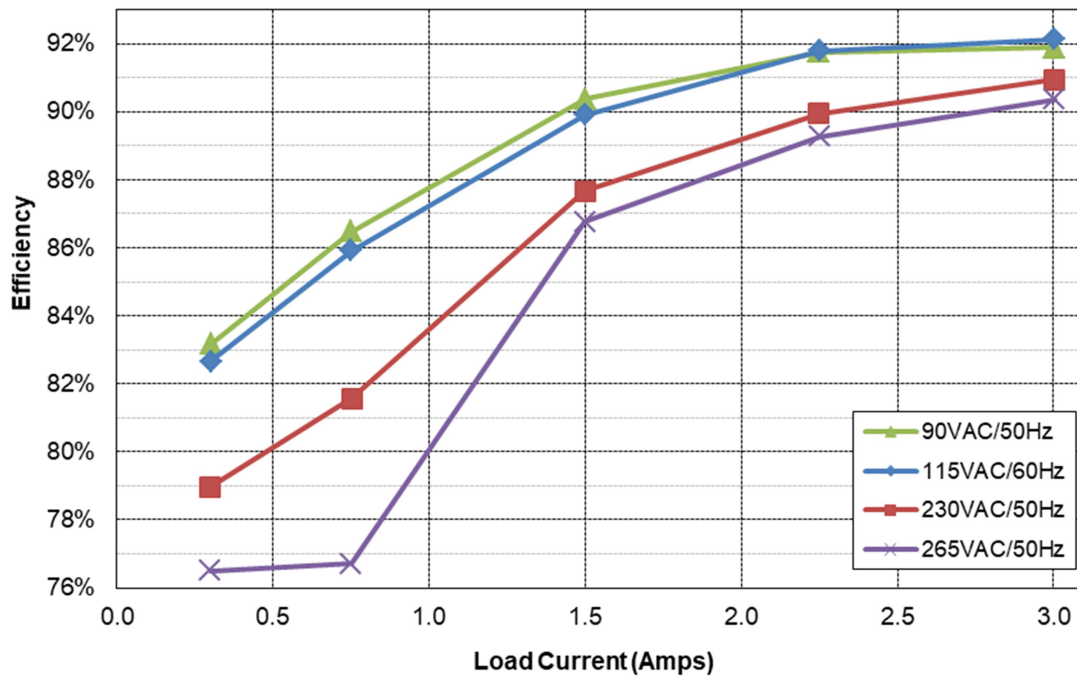
2.1.5 20V Output



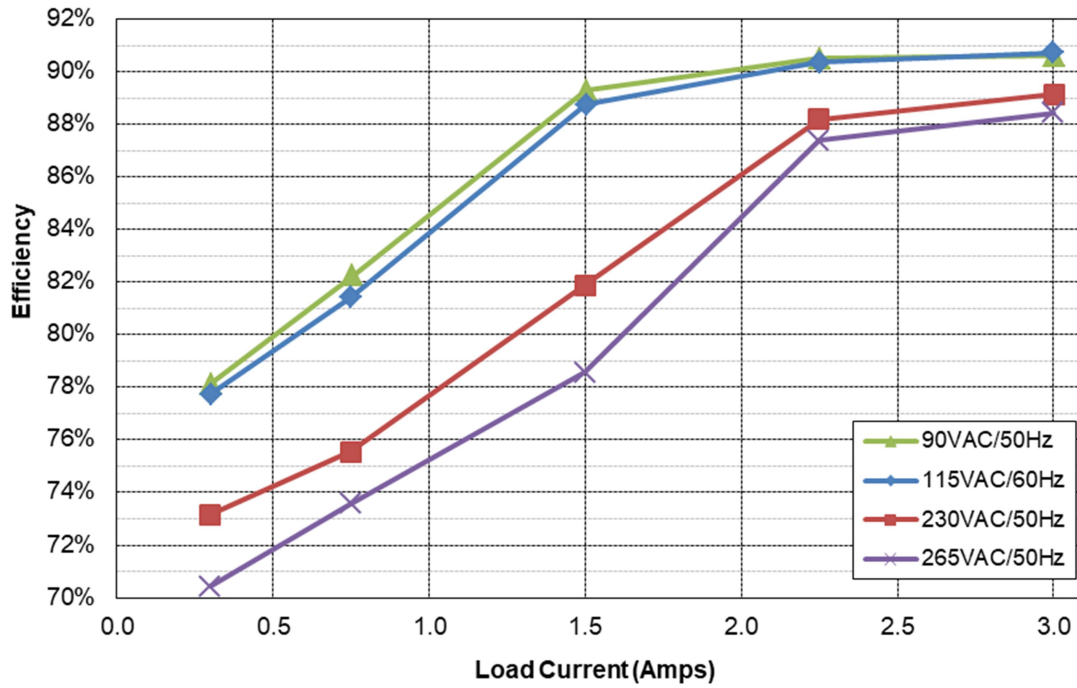
2.1.6 15V Output



2.1.7 9V Output



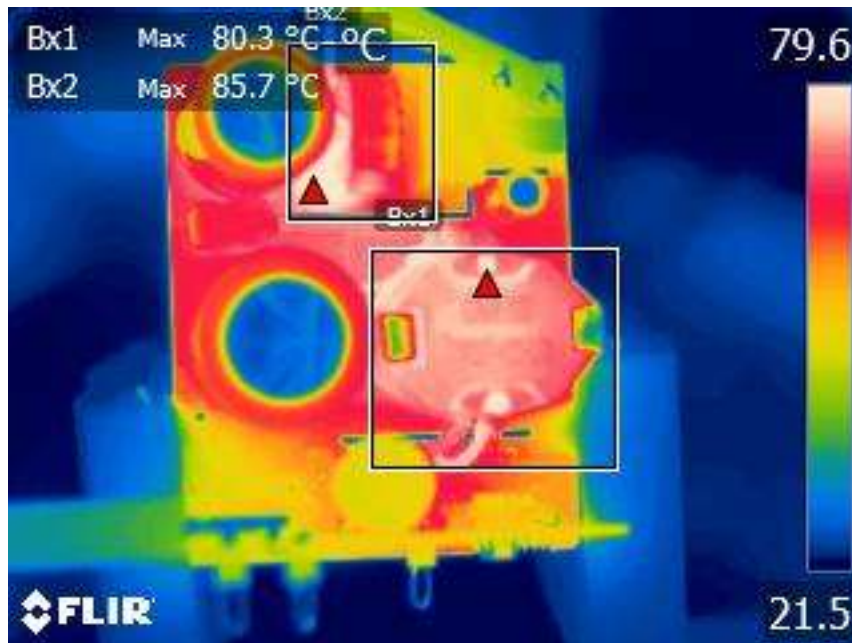
2.1.8 5V Output

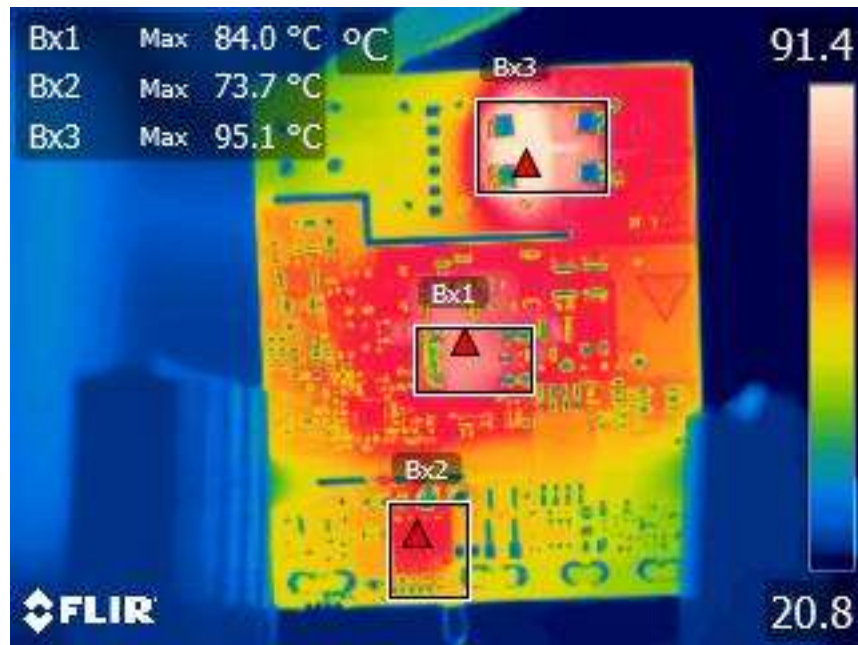


2.2 Thermal Images

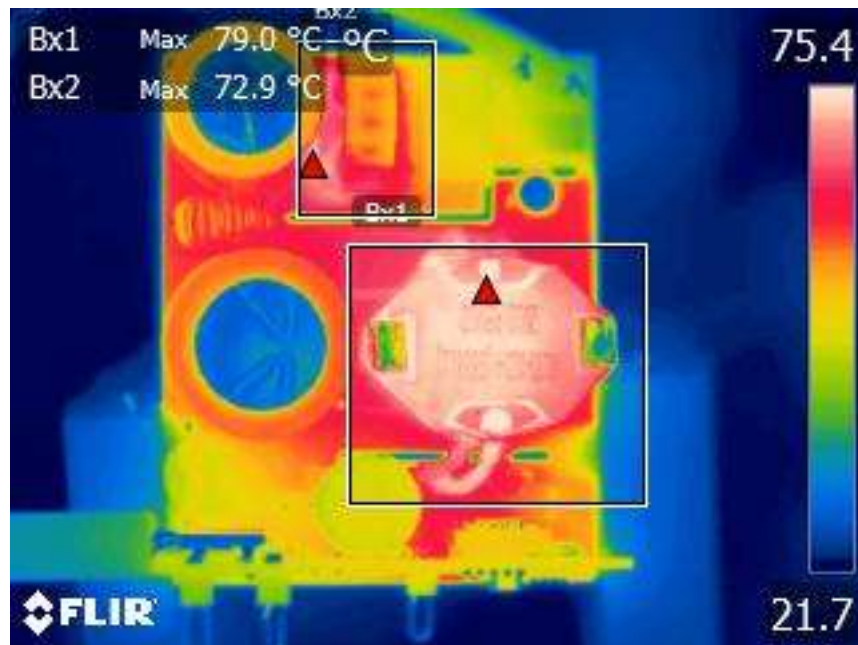
All images captured open frame, 25°C ambient, after a 30-minute warm up period.

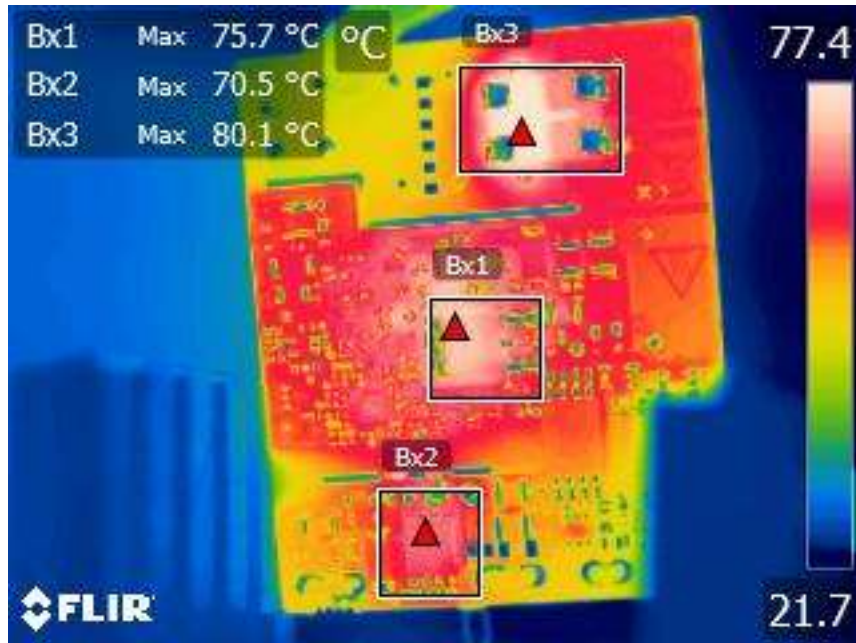
2.2.1 90VAC/50Hz Input, 20V/3.25A Output



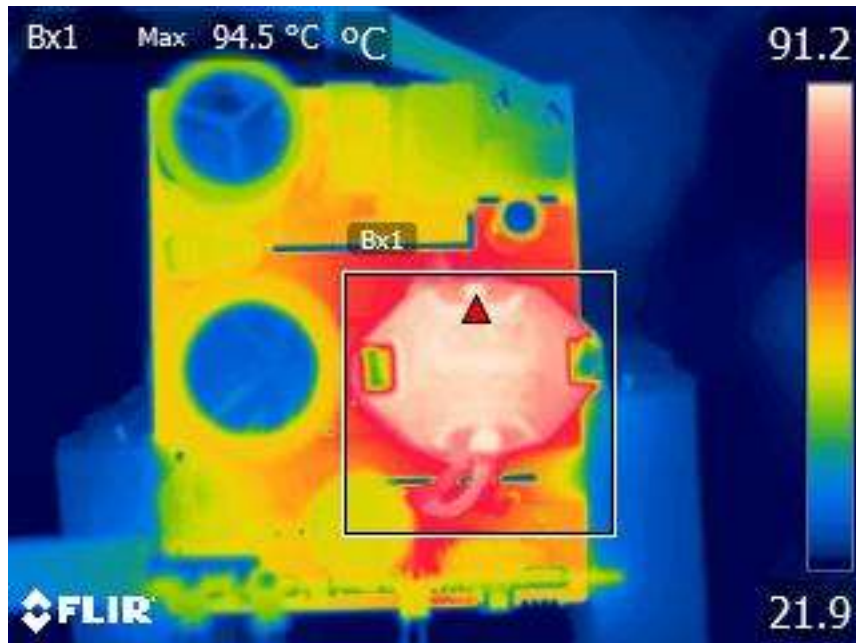


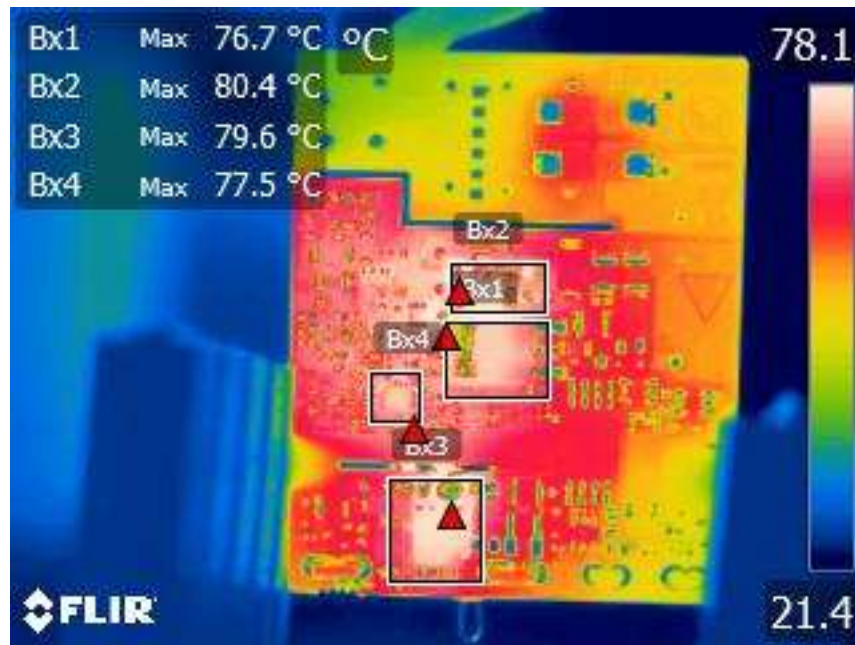
2.2.2 115VAC/60Hz Input, 20V/3.25A Output



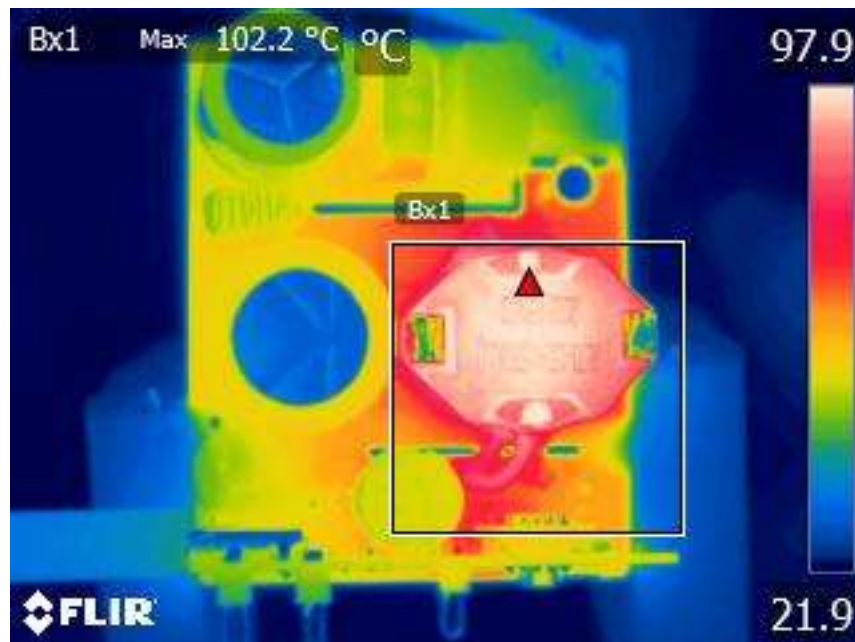


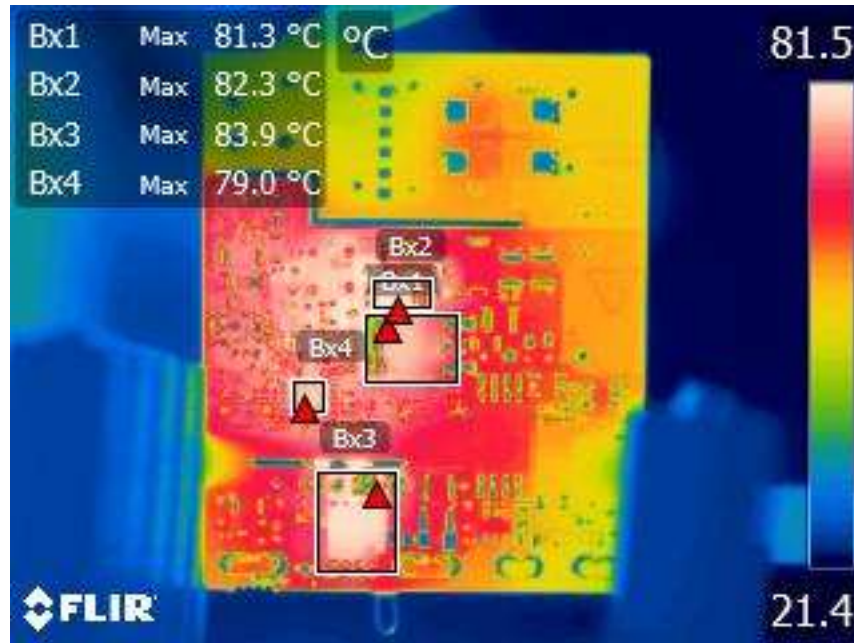
2.2.3 230VAC/50Hz Input, 20V/3.25A Output



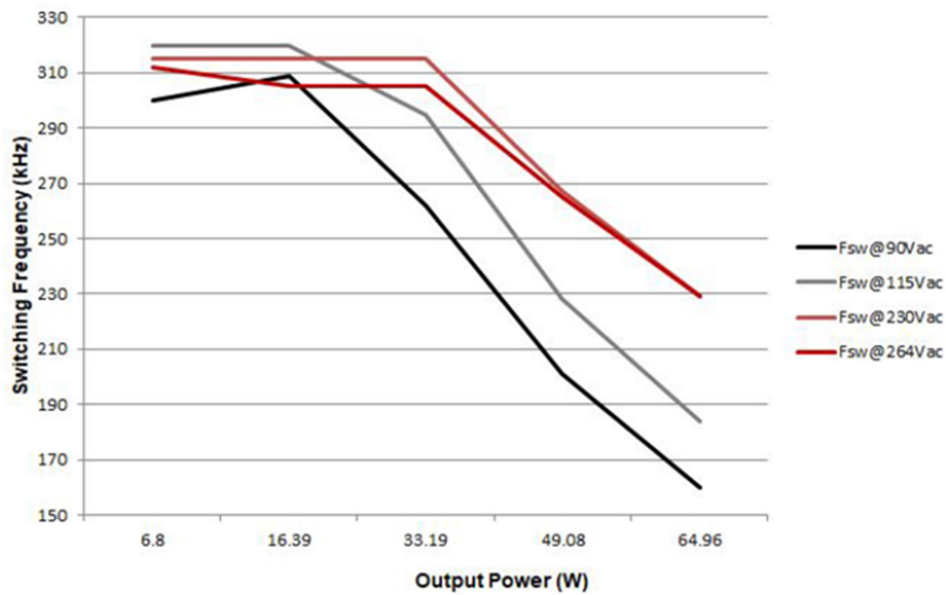


2.2.4 265VAC/50Hz Input, 20V/3.25A Output



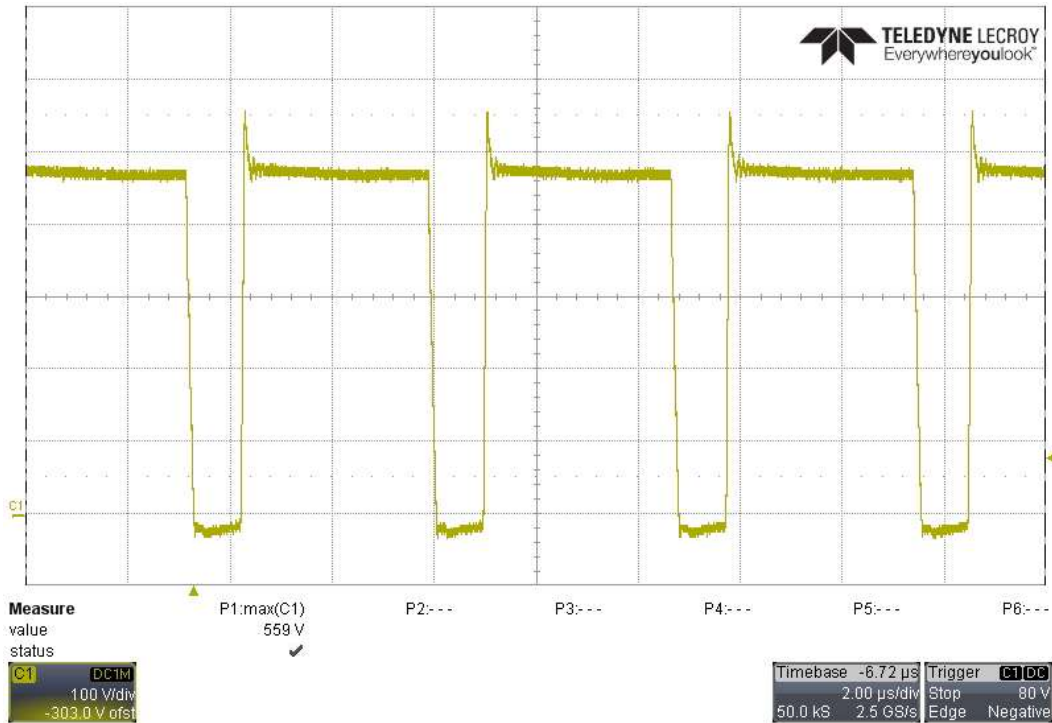


2.3 Switching Frequency with 20Vout

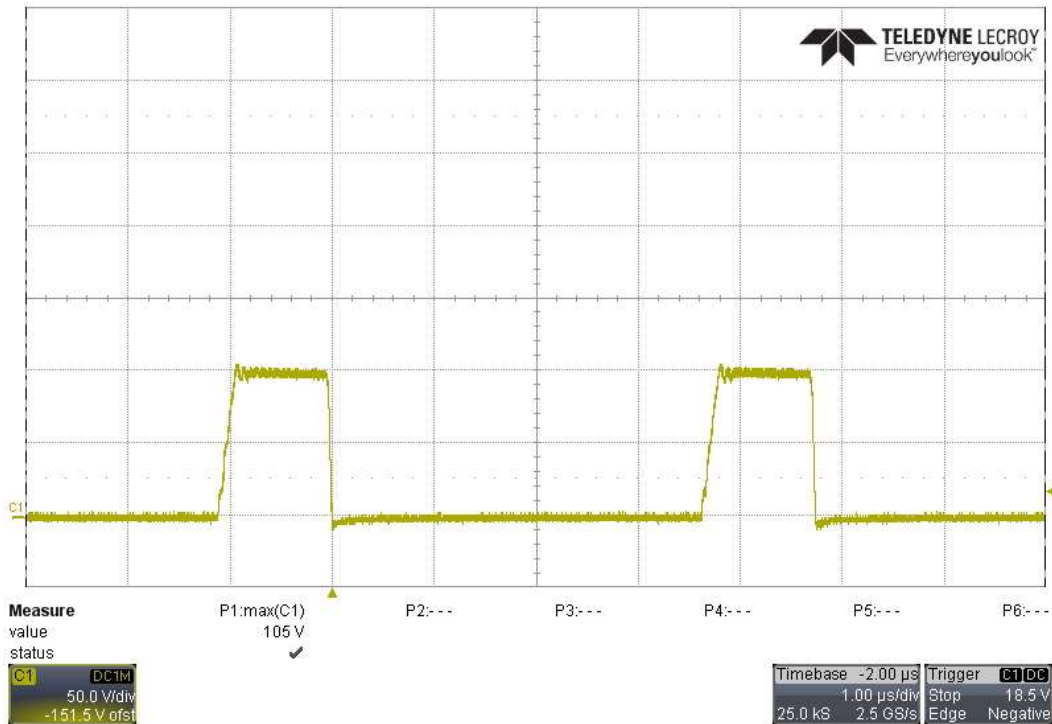


2.4 Switching Waveforms

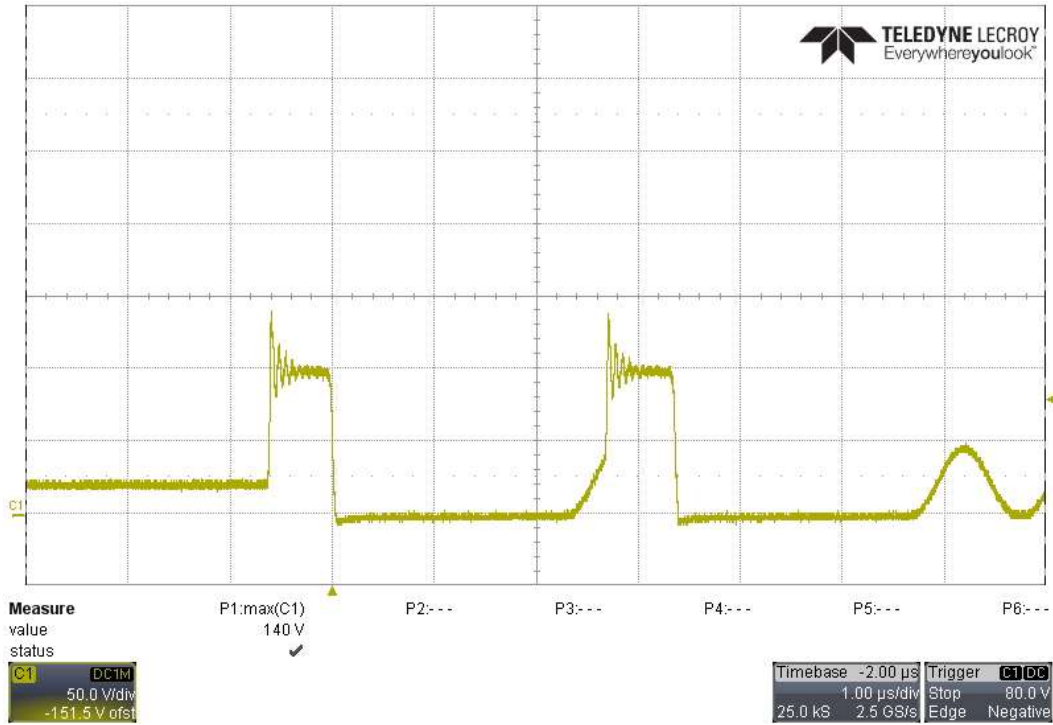
2.4.1 Drain of Primary Switch (Q2), 265VAC/50Hz Input, 20V/3.25A Output



2.4.2 Vds of SR FET (Q8), 265VAC/50Hz Input, 20V/3.25A Output

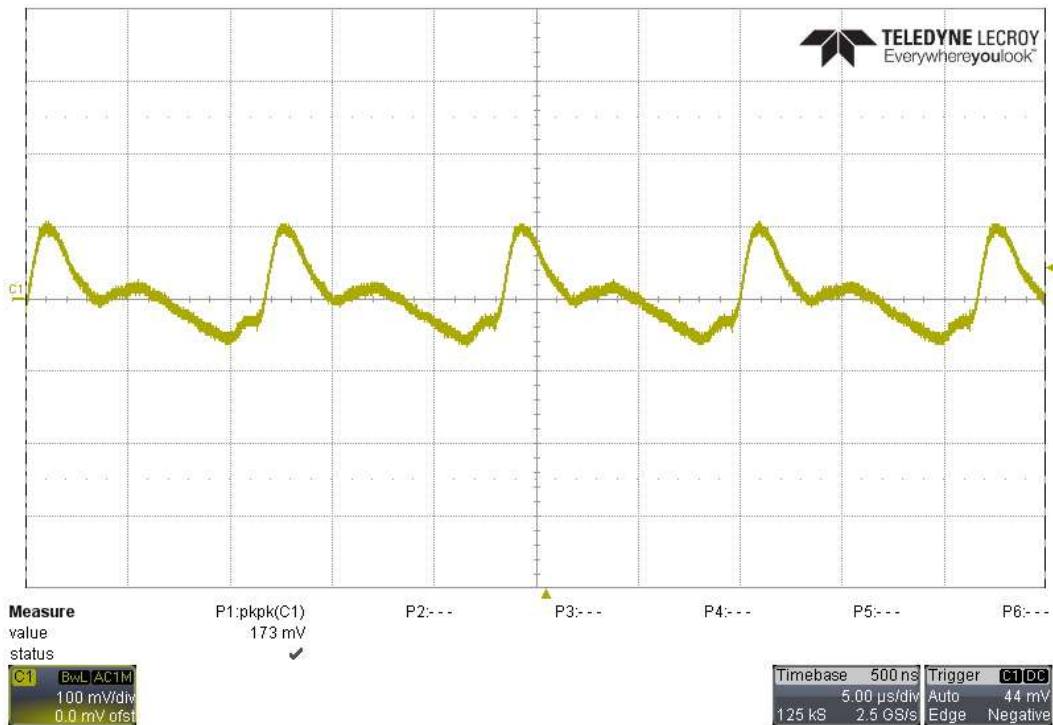


2.4.3 Vds of SR FET (Q8), 265VAC/50Hz Input, 20V/300mA Output

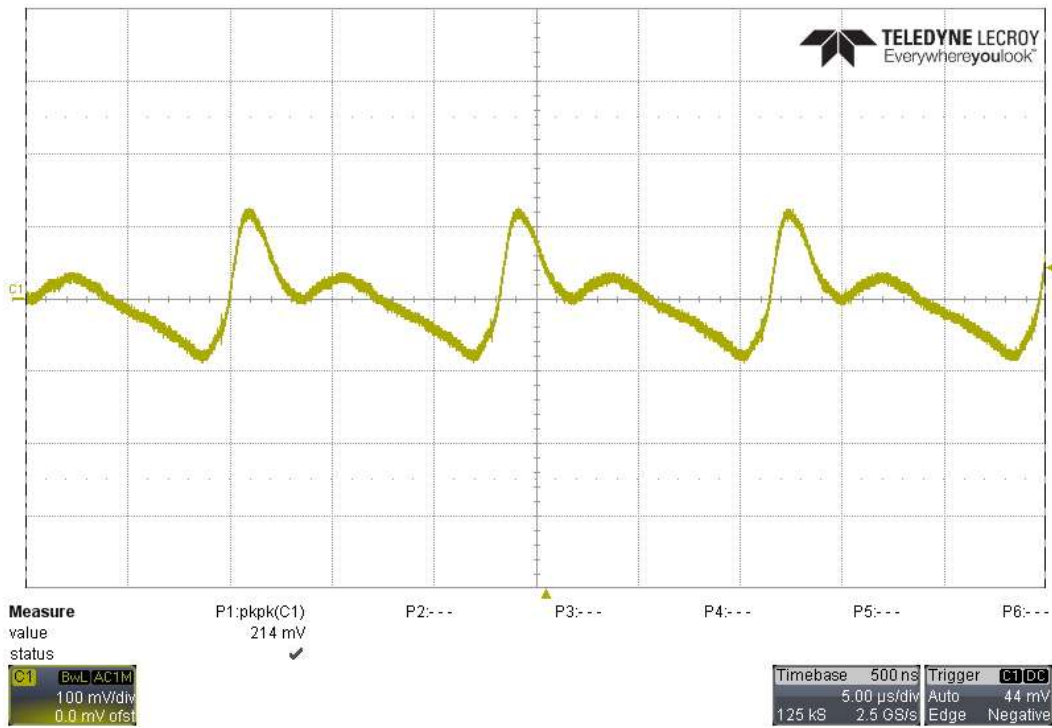


2.5 Output Voltage Ripple at Maximum Load Current

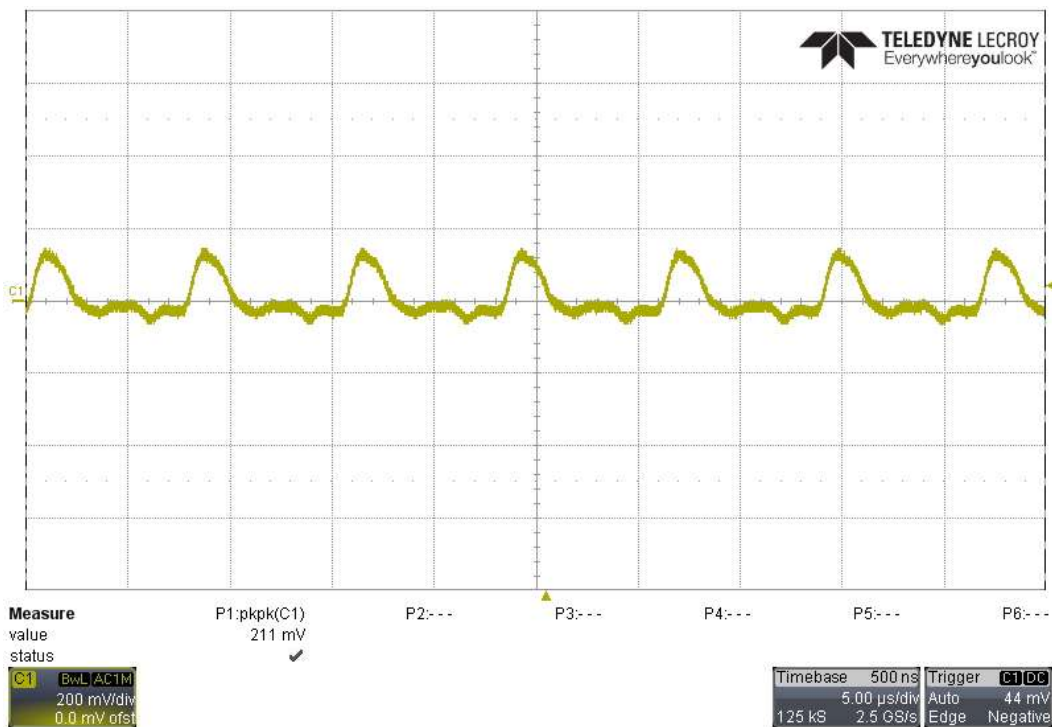
2.5.1 5V/3A Output, 115VAC/60Hz Input



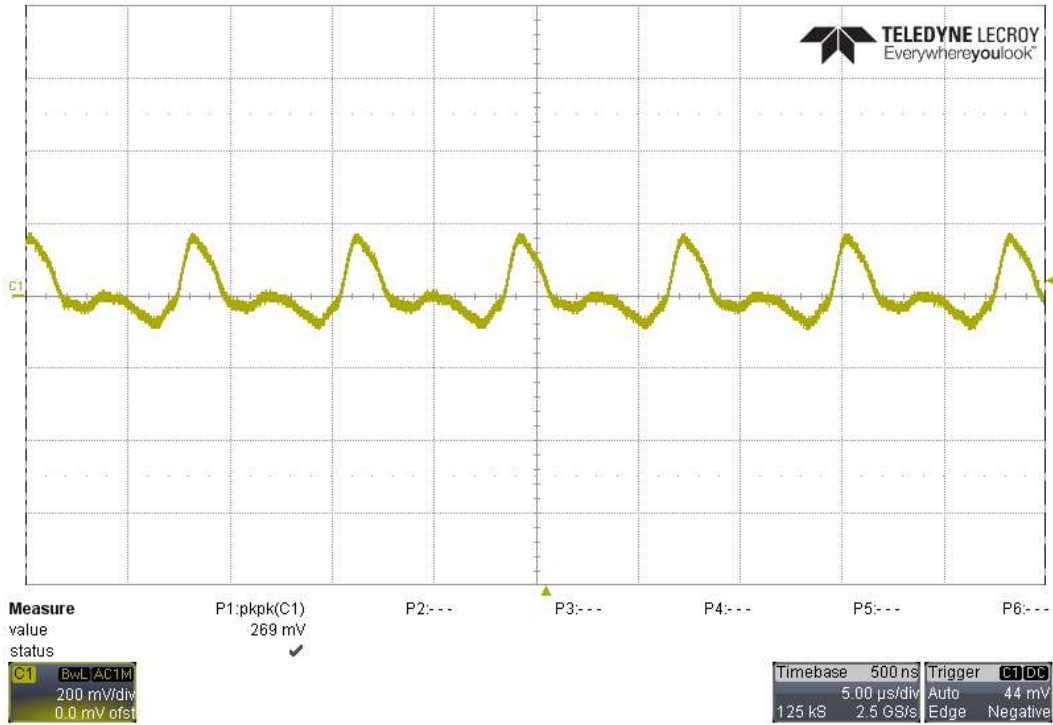
2.5.2 5V/3A Output, 230VAC/50Hz Input



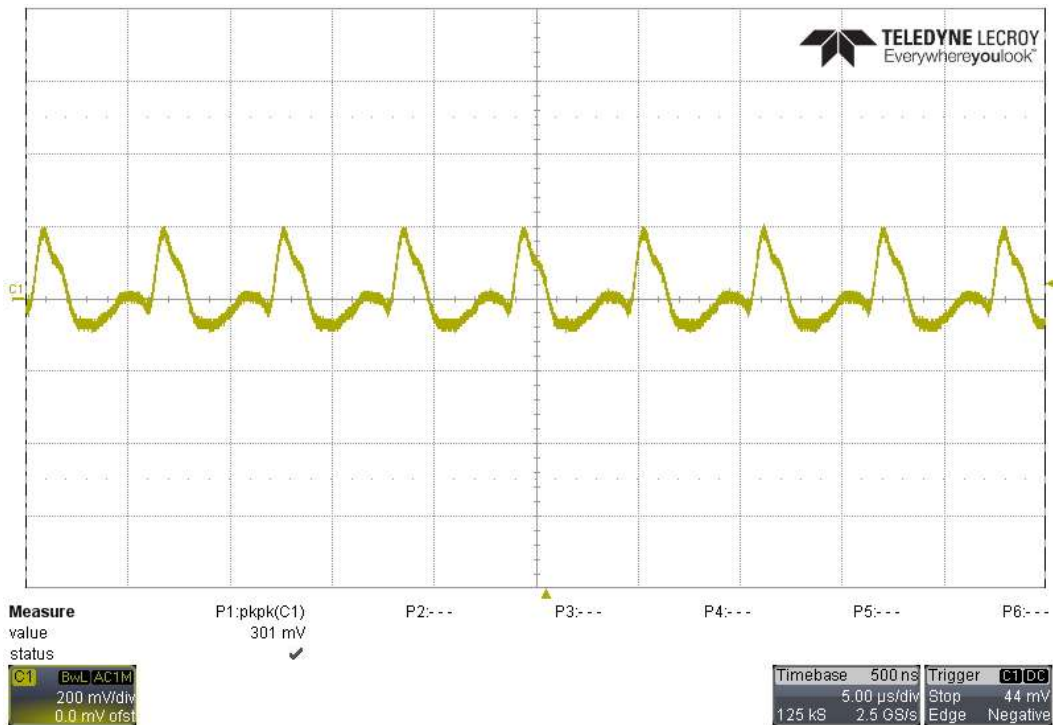
2.5.3 9V/3A Output, 115VAC/60Hz Input



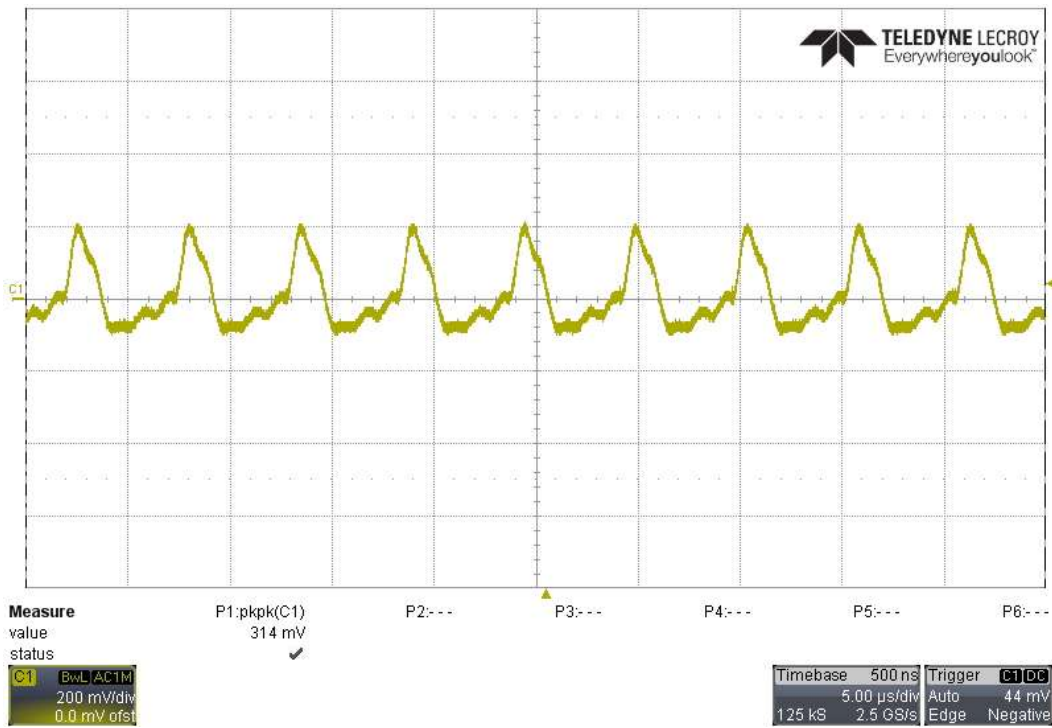
2.5.4 9V/3A Output, 230VAC/50Hz Input



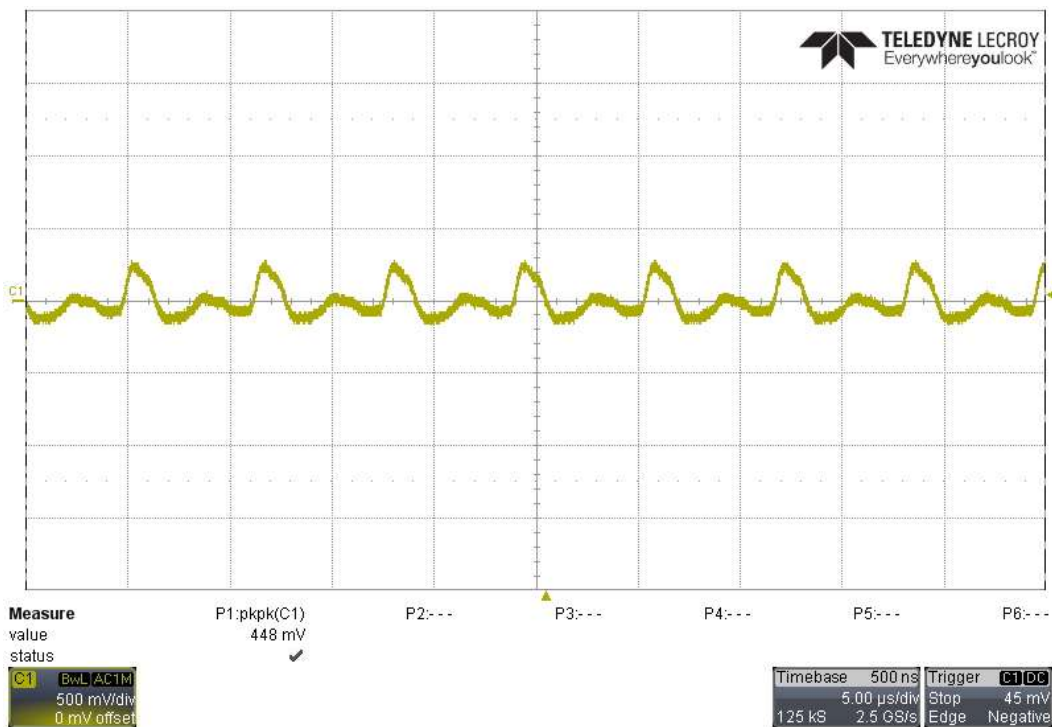
2.5.5 15V/3A Output, 115VAC/60Hz Input



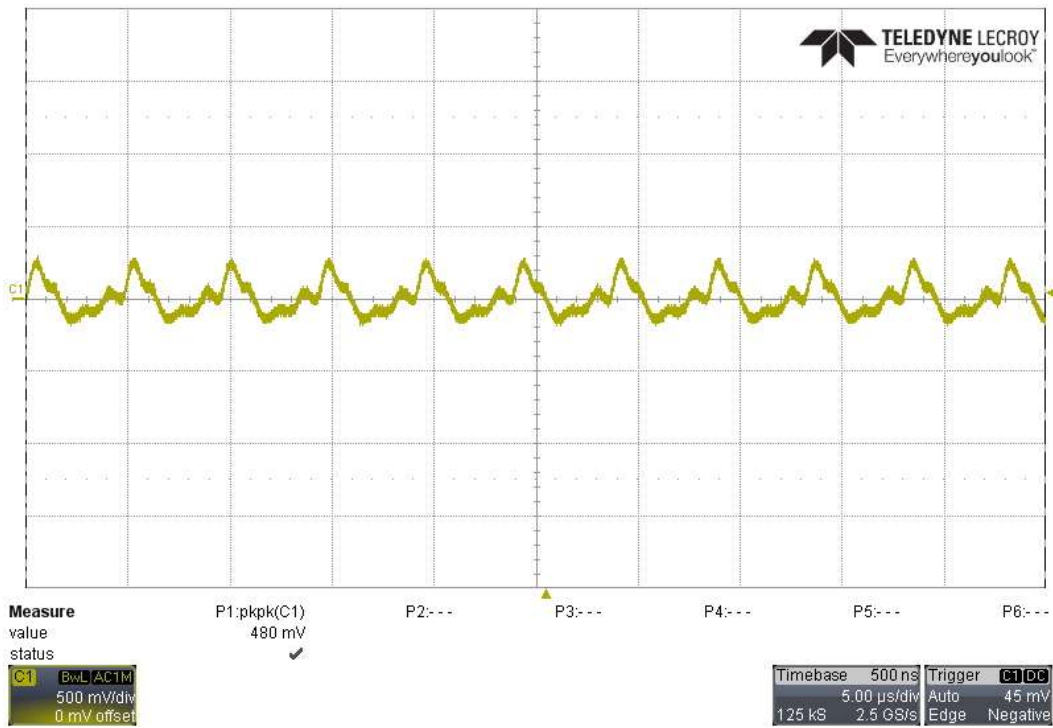
2.5.6 15V/3A Output, 230VAC/50Hz Input



2.5.7 20V/3.25A Output, 115VAC/60Hz Input

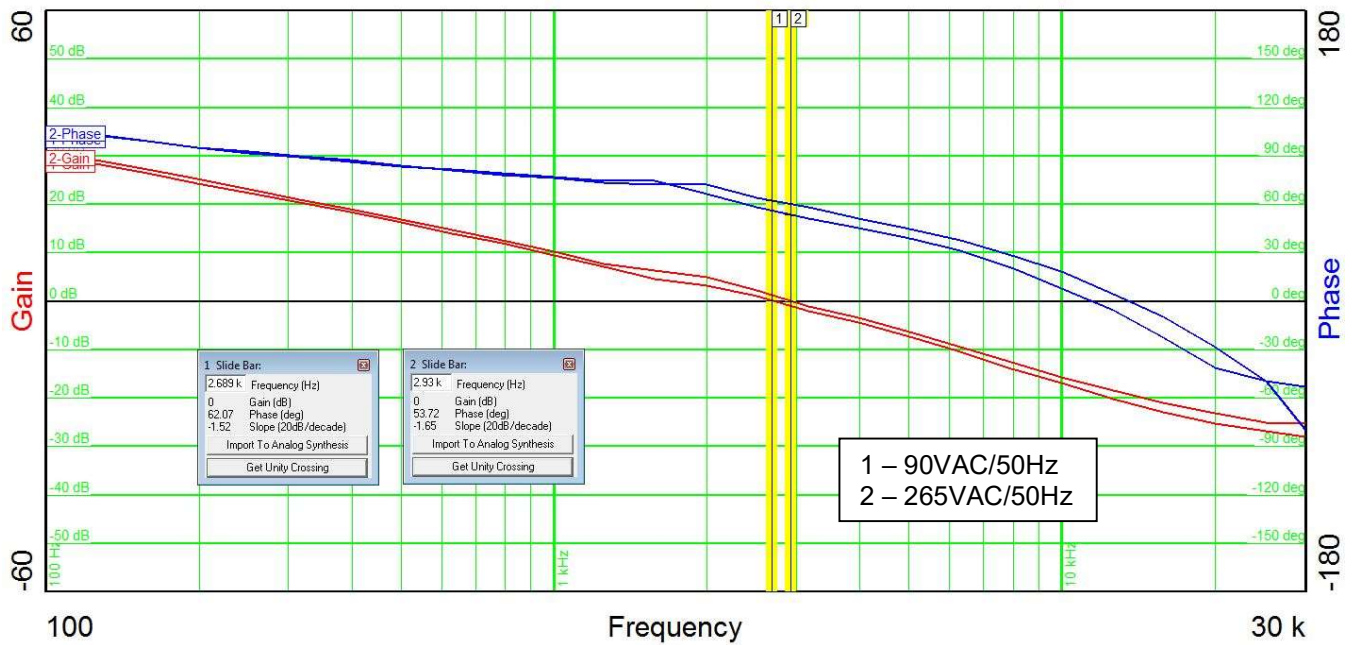


2.5.8 20V/3.25A Output, 230VAC/50Hz Input

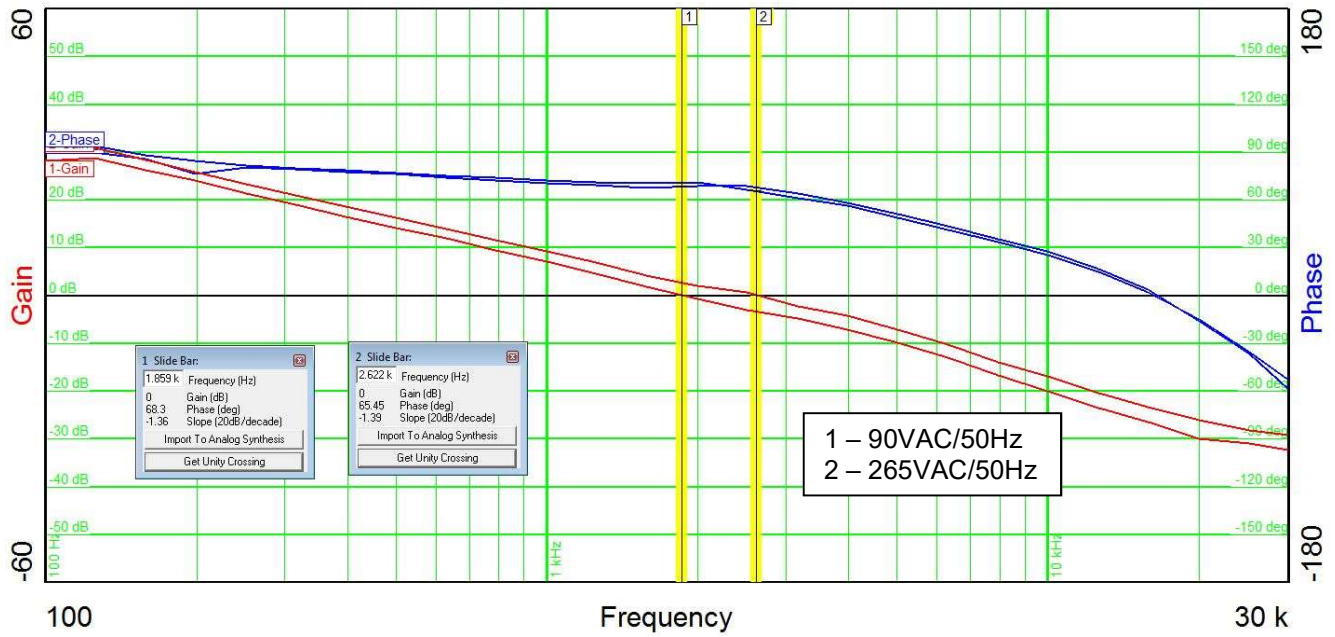


2.6 Bode Plot

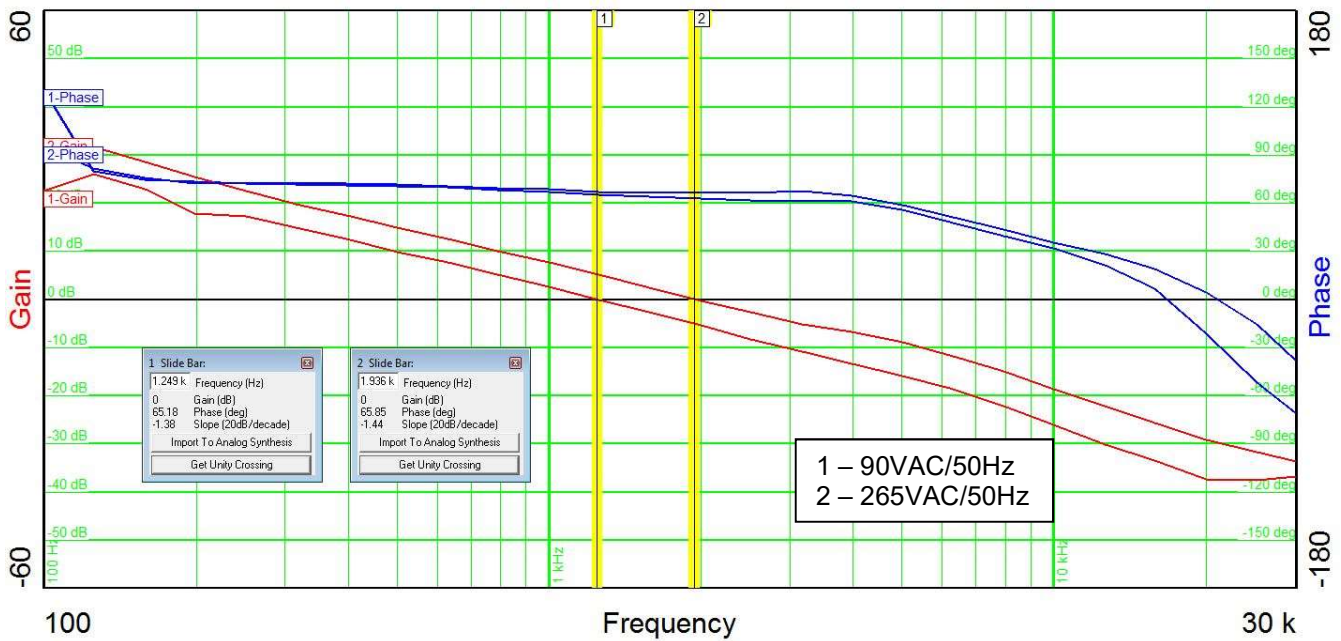
2.6.1 5V/3A Output



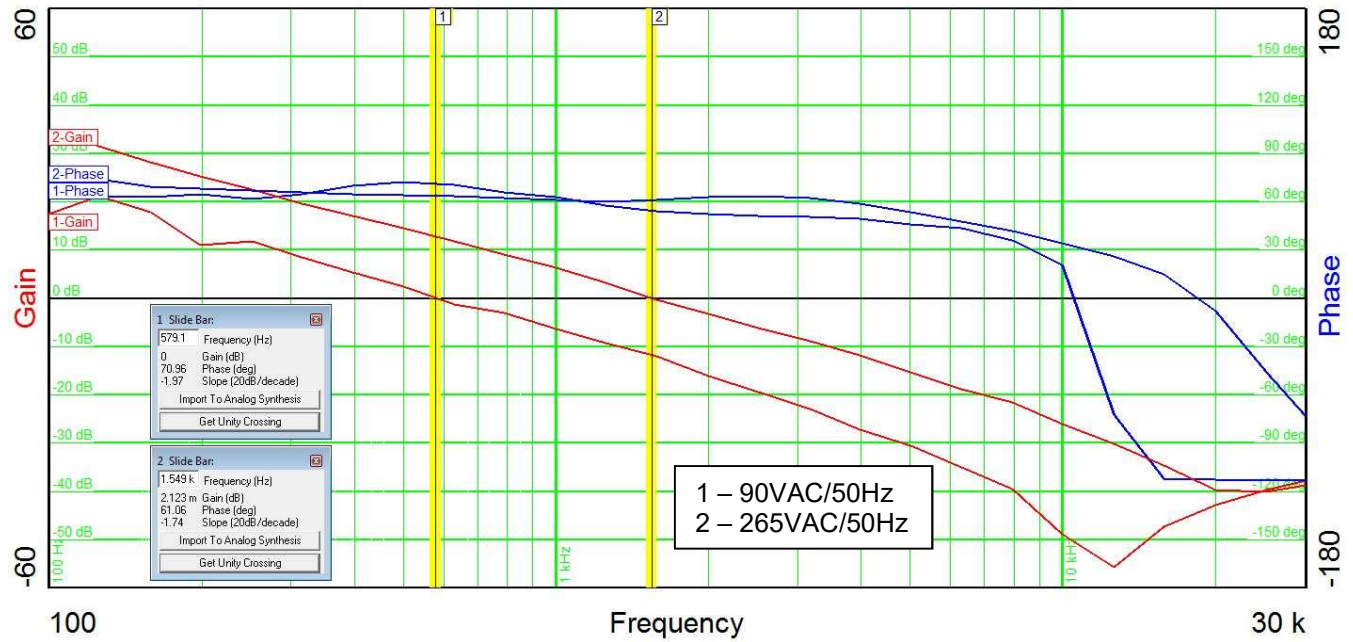
2.6.2 9V/3A Output



2.6.3 15V/3A Output

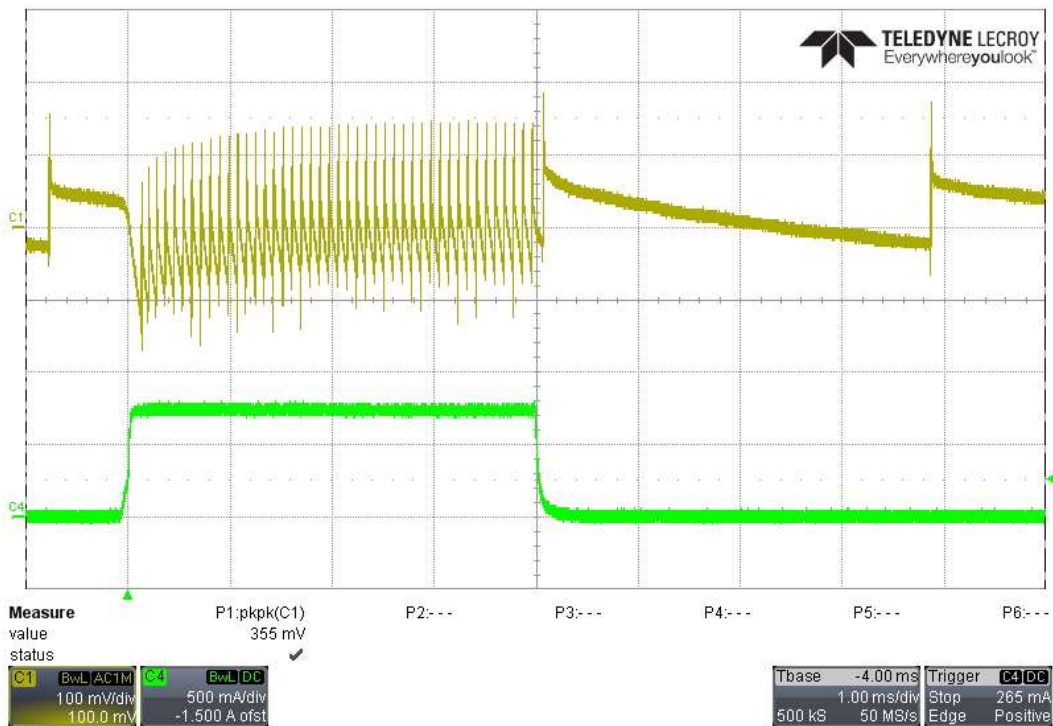


2.6.4 20V/3.25A Output

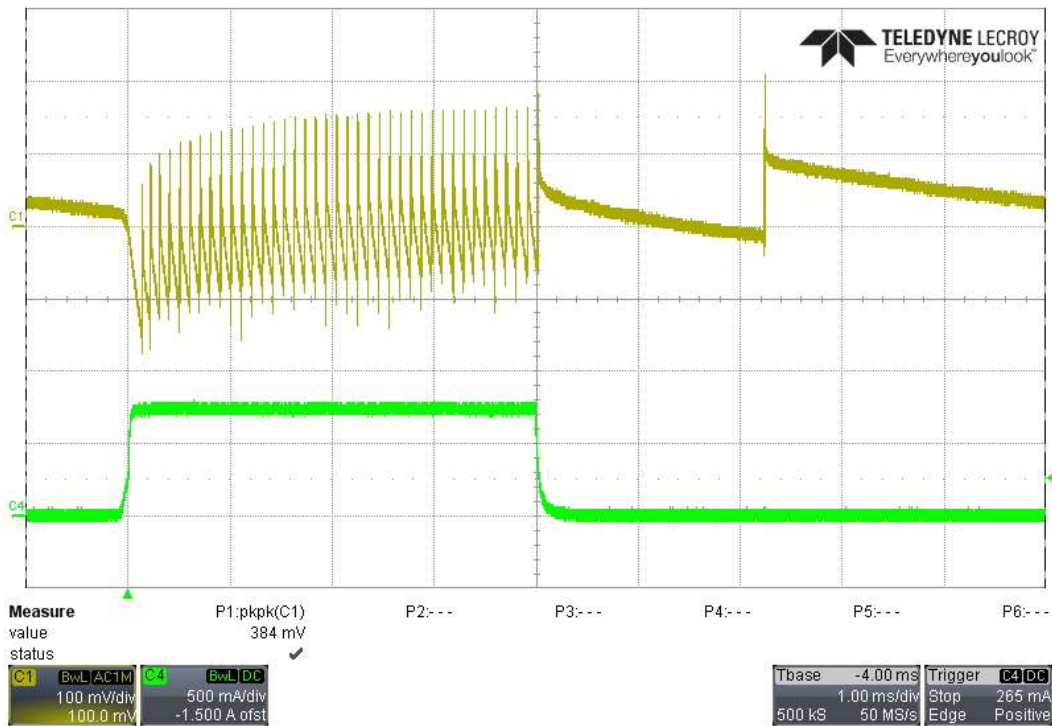


2.7 5V Output Load Transients

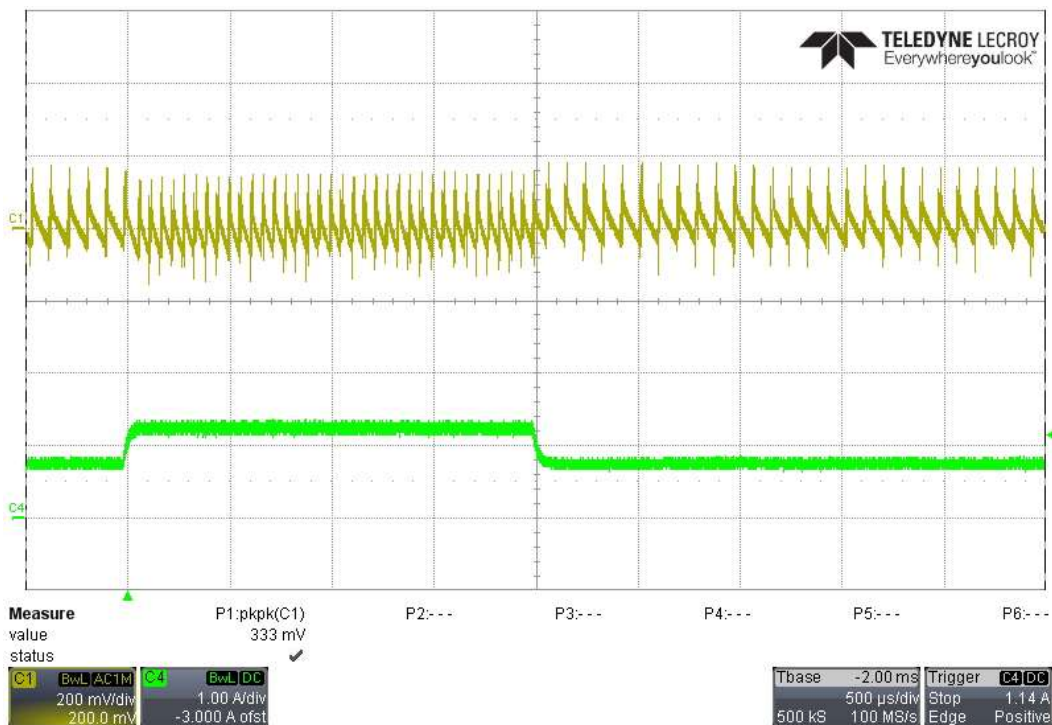
2.7.1 5V Output, 0A to 750mA Load Step, 115VAC/60Hz Input



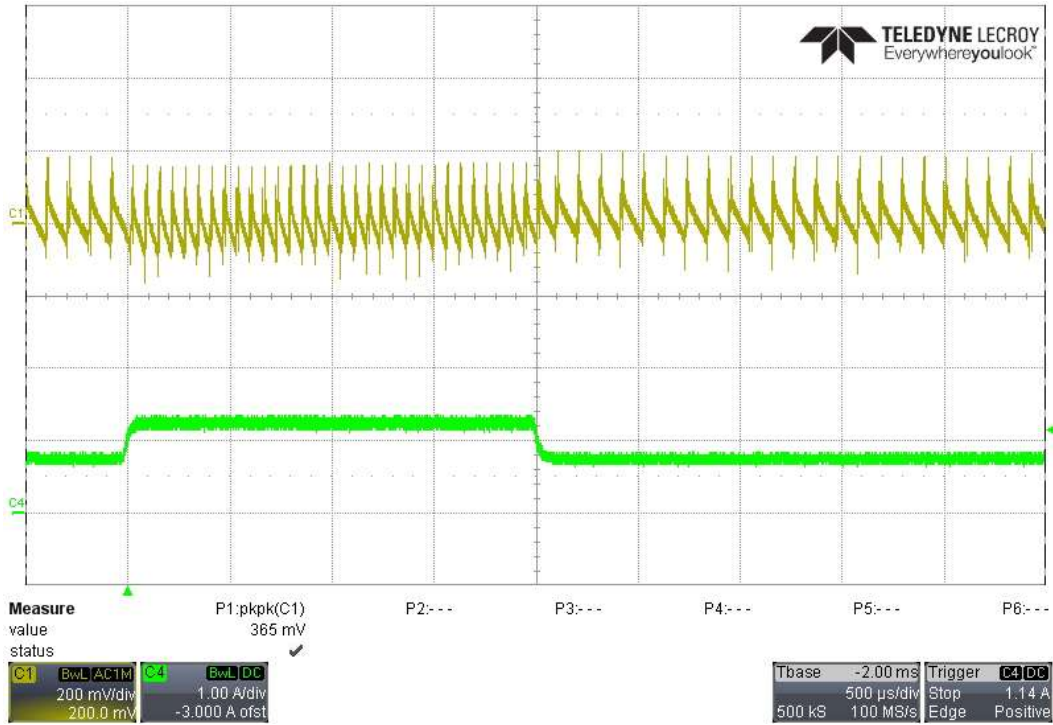
2.7.2 5V Output, 0A to 750mA Load Step, 230VAC/50Hz Input



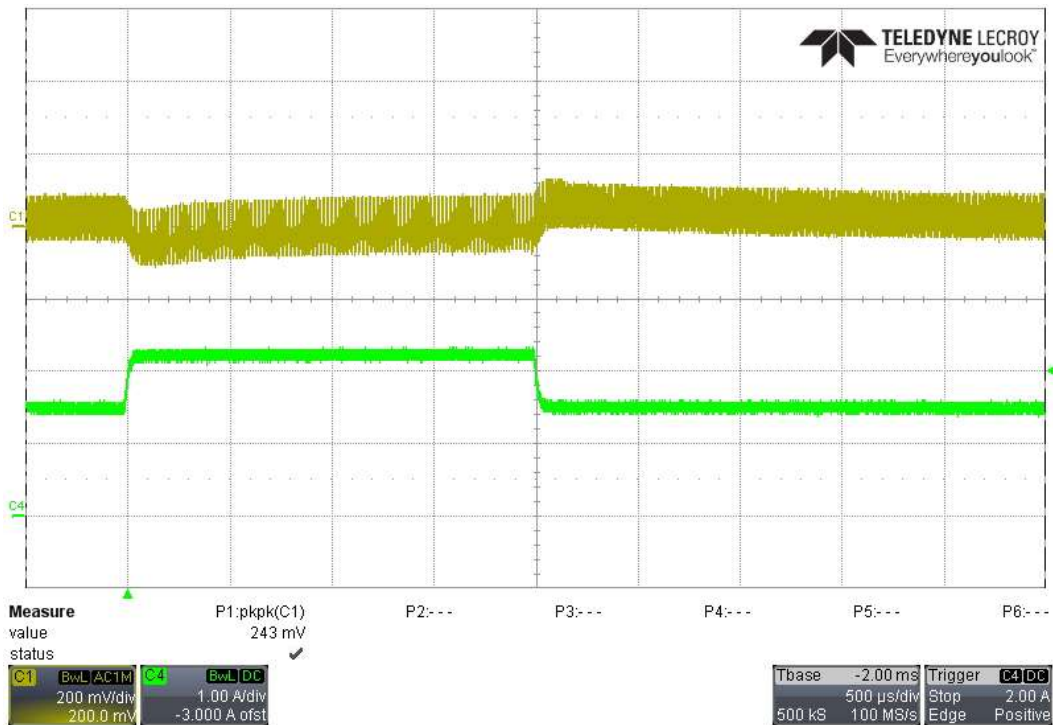
2.7.3 5V Output, 750mA to 1.5A Load Step, 115VAC/60Hz Input



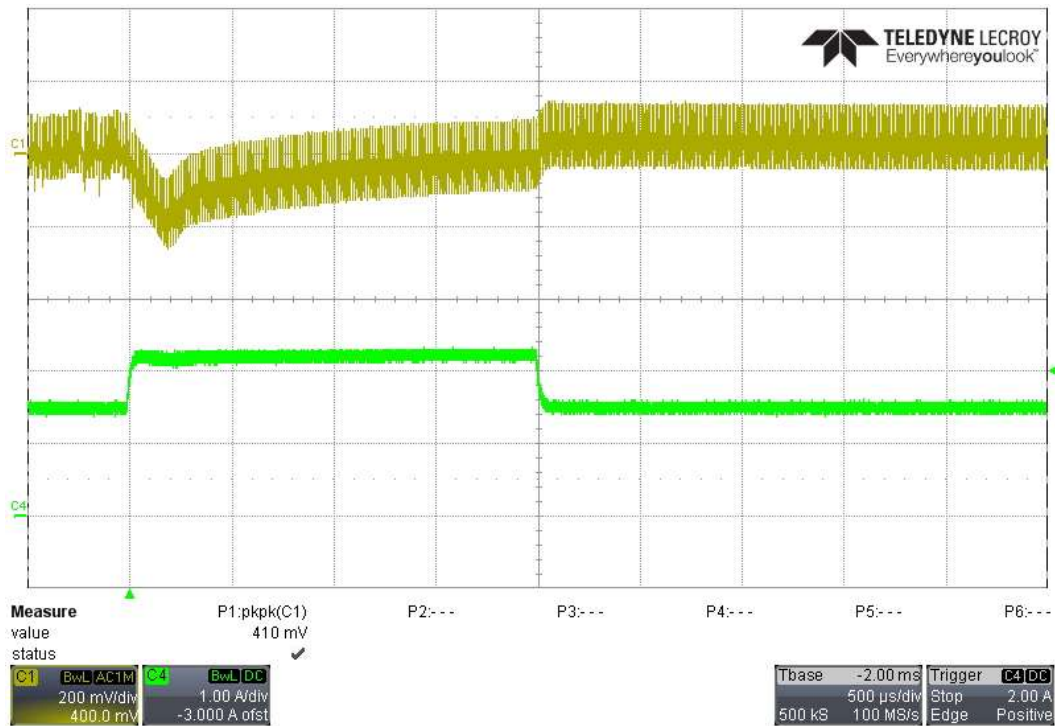
2.7.4 5V Output, 750mA to 1.5A Load Step, 230VAC/50Hz Input



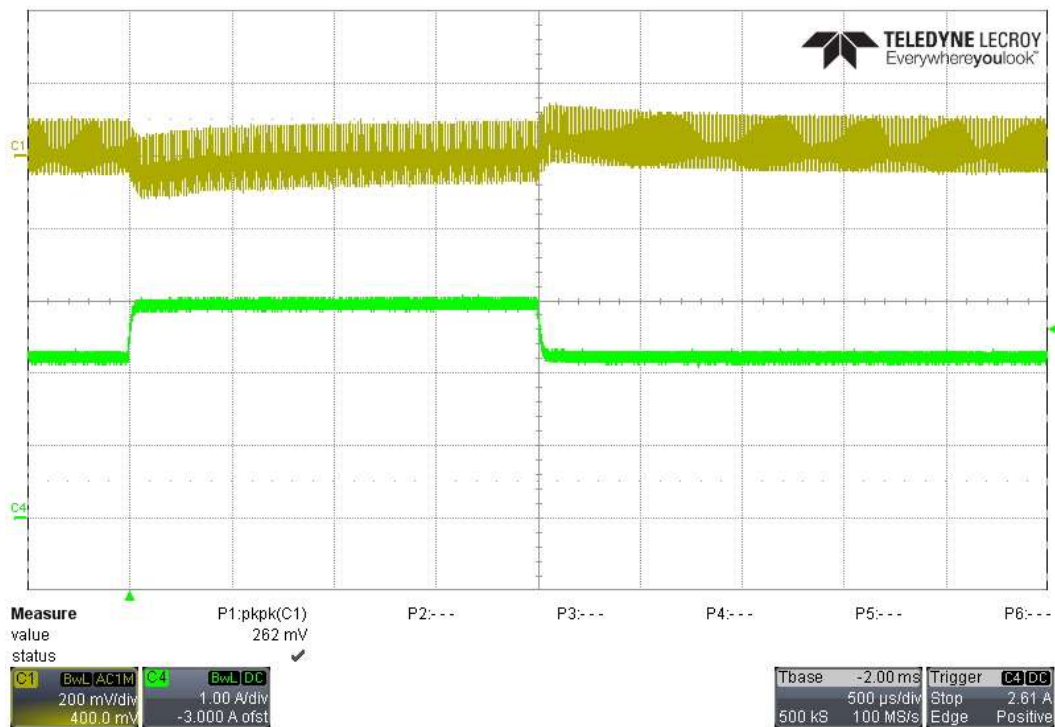
2.7.5 5V Output, 1.5A to 2.25A Load Step, 115VAC/60Hz Input



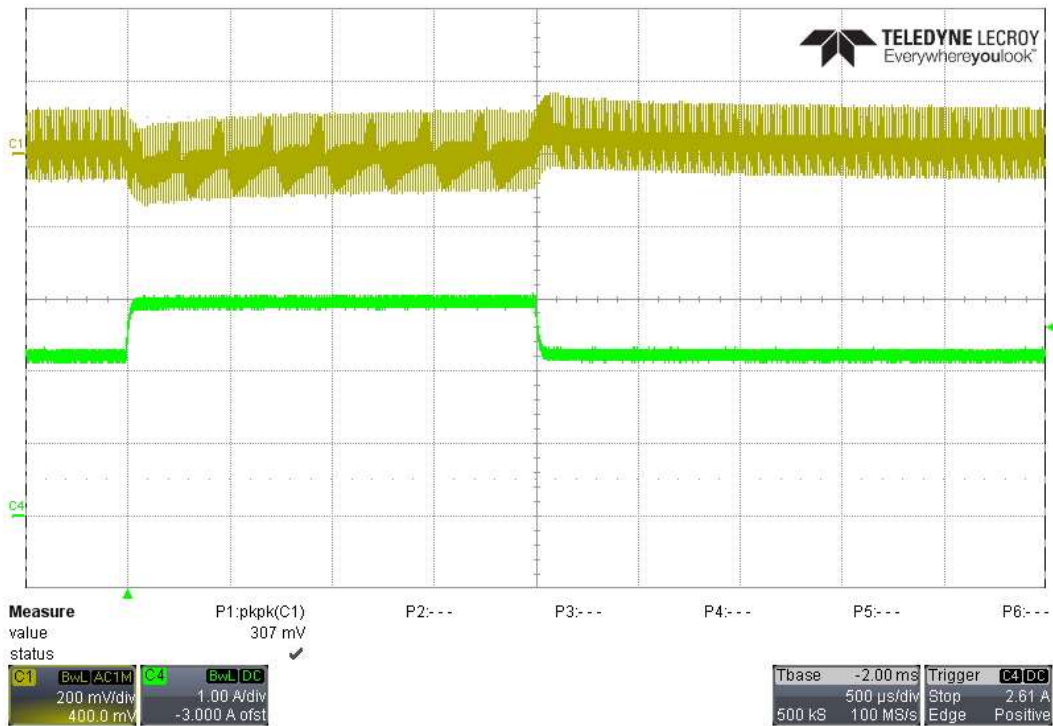
2.7.6 5V Output, 1.5A to 2.25A Load Step, 230VAC/50Hz Input



2.7.7 5V Output, 2.25A to 3.0A Load Step, 115VAC/60Hz Input

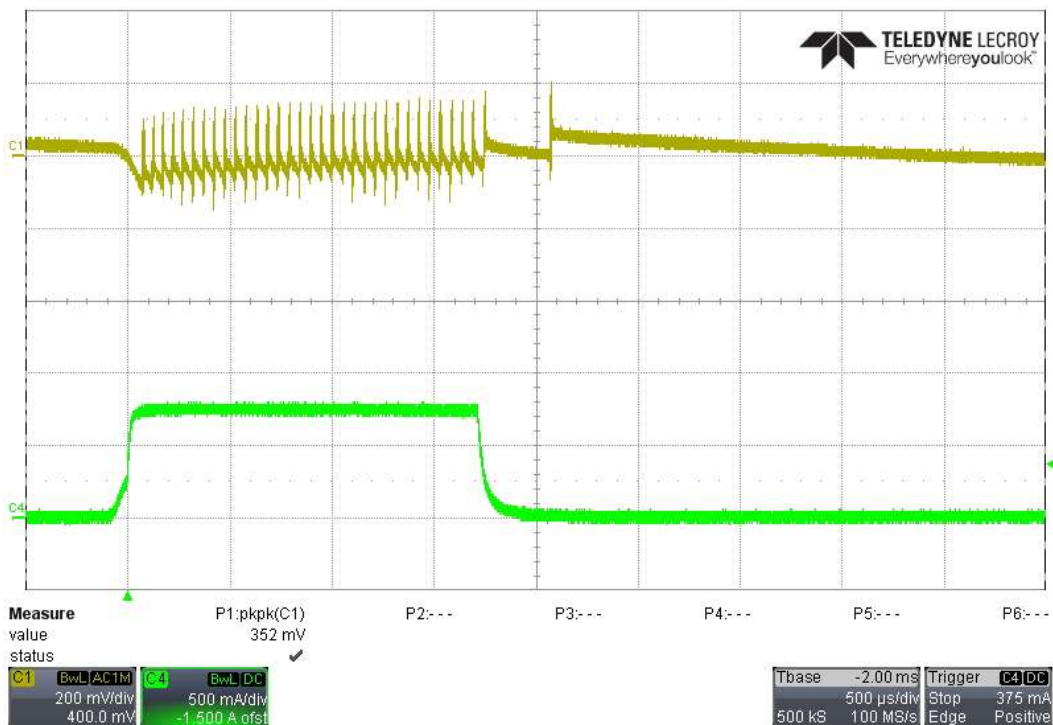


2.7.8 5V Output, 2.25A to 3.0A Load Step, 230VAC/50Hz Input

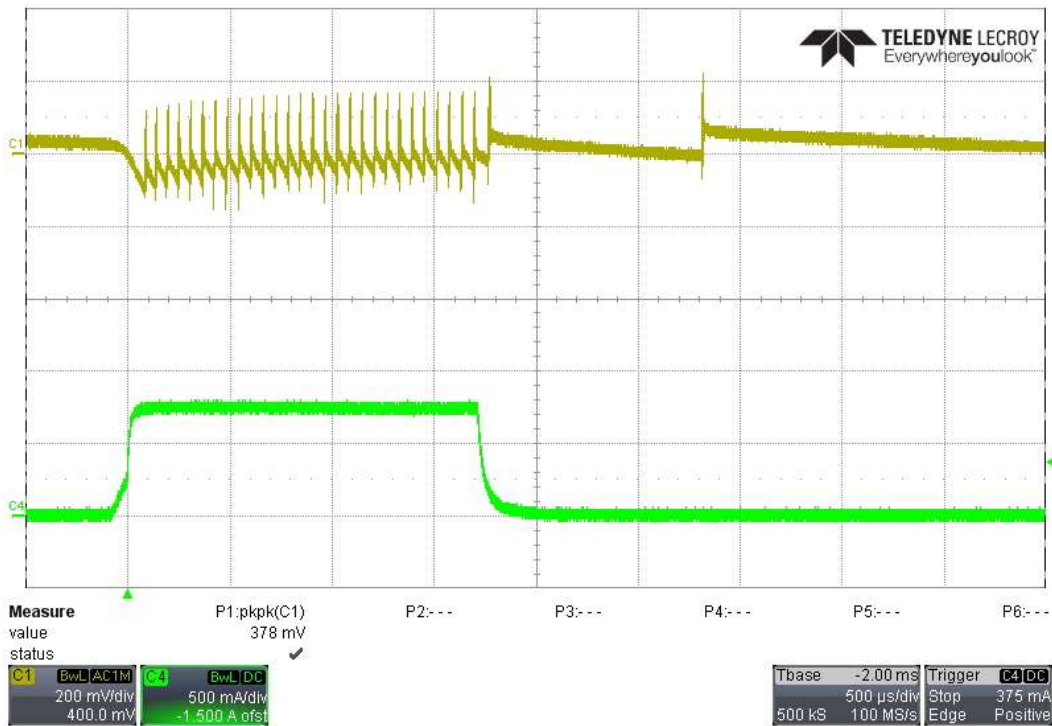


2.8 9V Output Load Transients

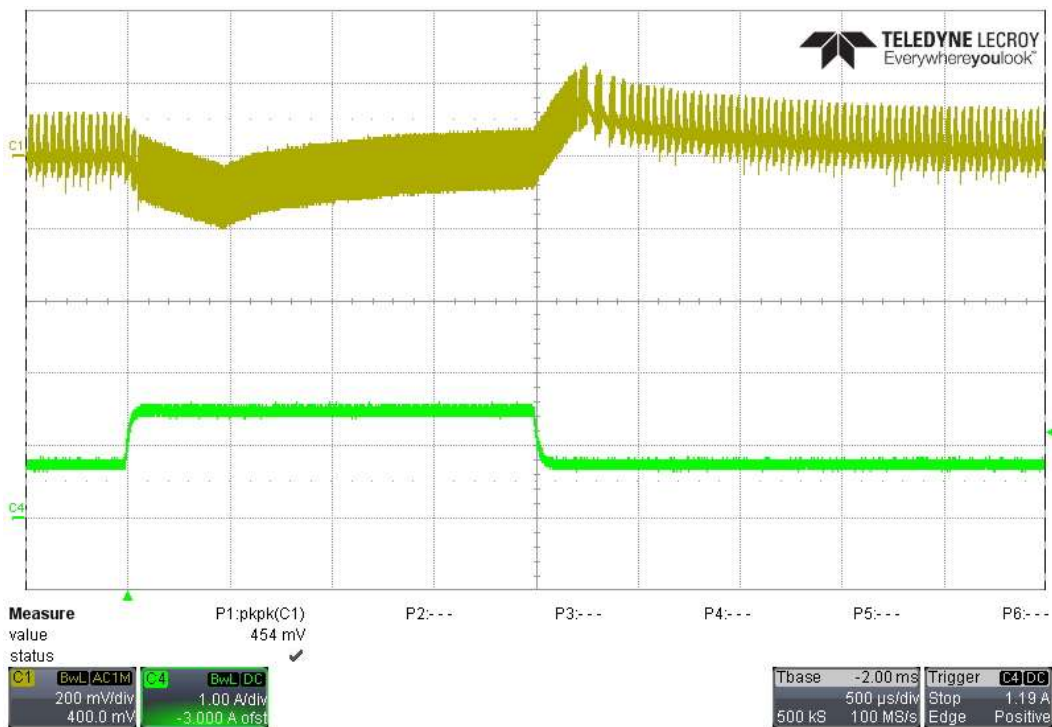
2.8.1 9V Output, 0A to 750mA Load Step, 115VAC/60Hz Input



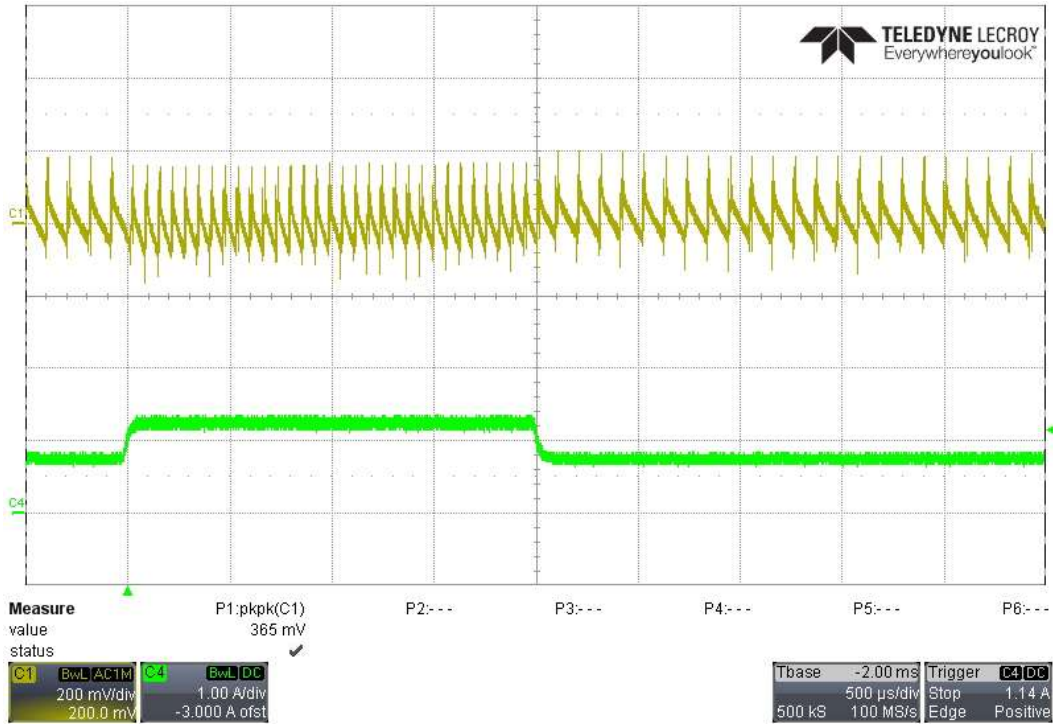
2.8.2 9V Output, 0A to 750mA Load Step, 230VAC/50Hz Input



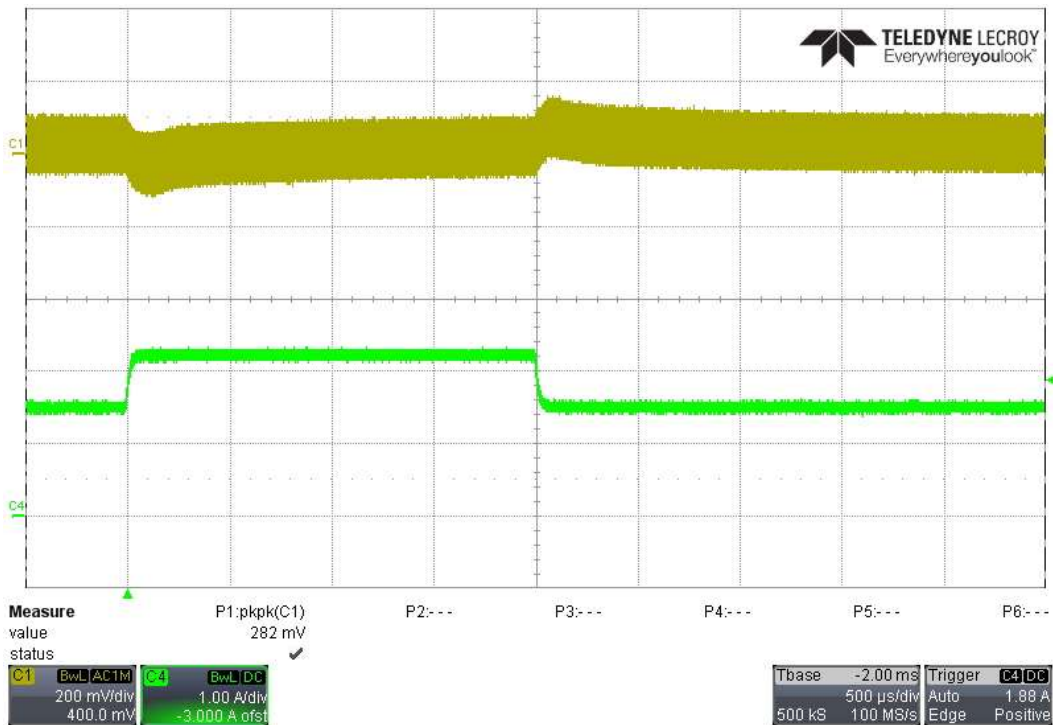
2.8.3 9V Output, 750mA to 1.5A Load Step, 115VAC/60Hz Input



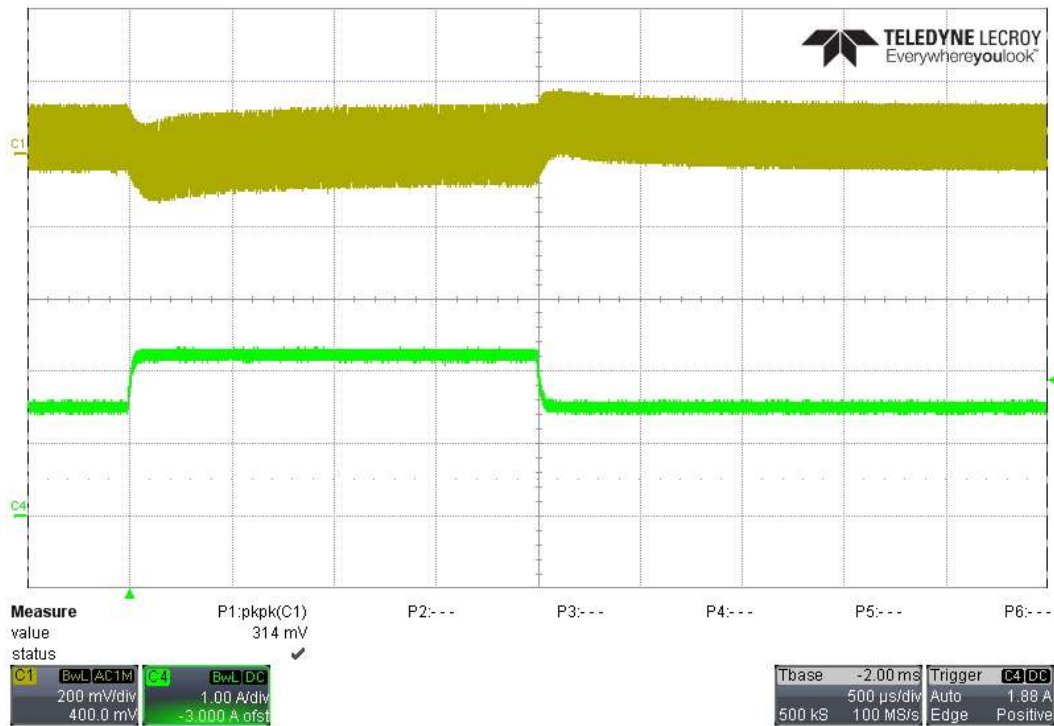
2.8.4 9V Output, 750mA to 1.5A Load Step, 230VAC/50Hz Input



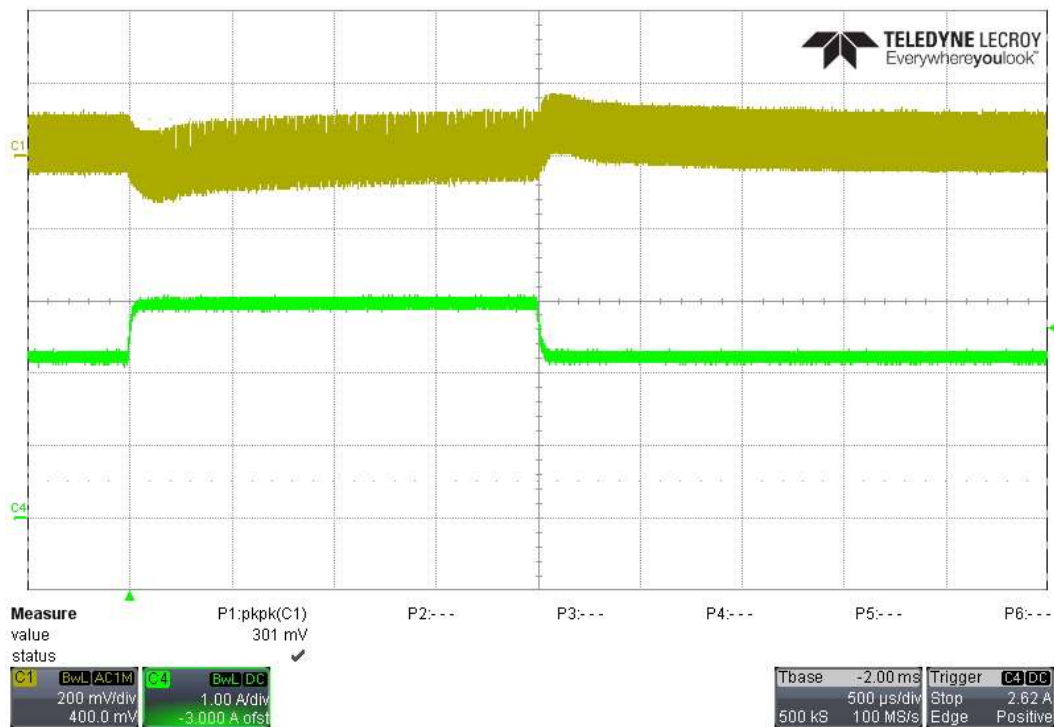
2.8.5 9V Output, 1.5A to 2.25A Load Step, 115VAC/60Hz Input



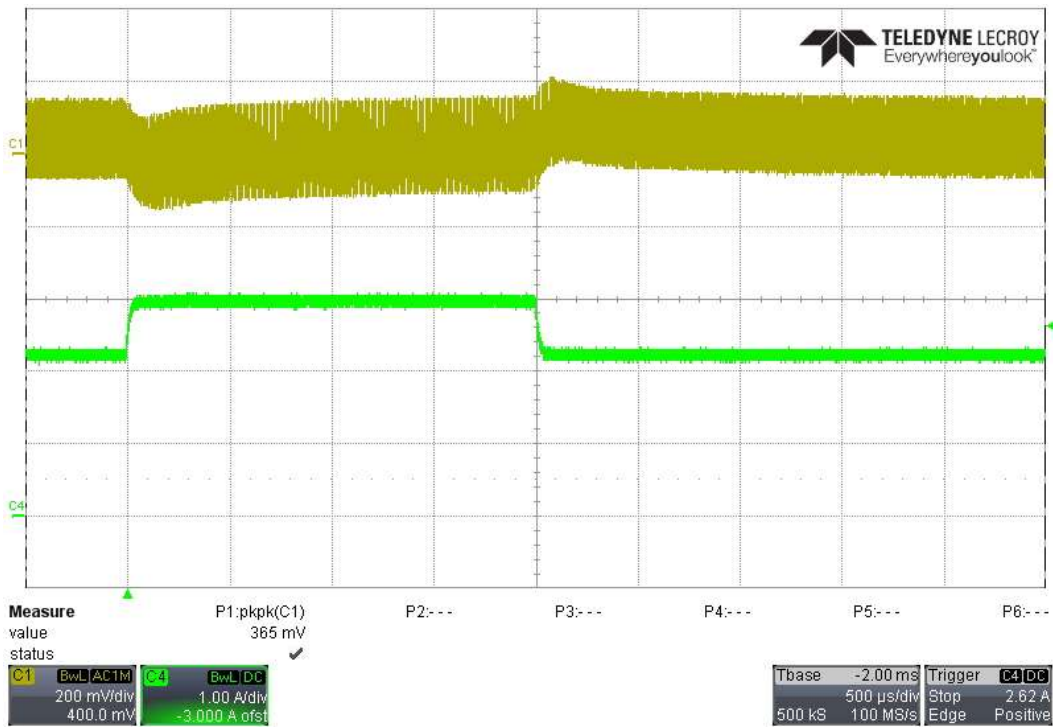
2.8.6 9V Output, 1.5A to 2.25A Load Step, 230VAC/50Hz Input



2.8.7 9V Output, 2.25A to 3.0A Load Step, 115VAC/60Hz Input

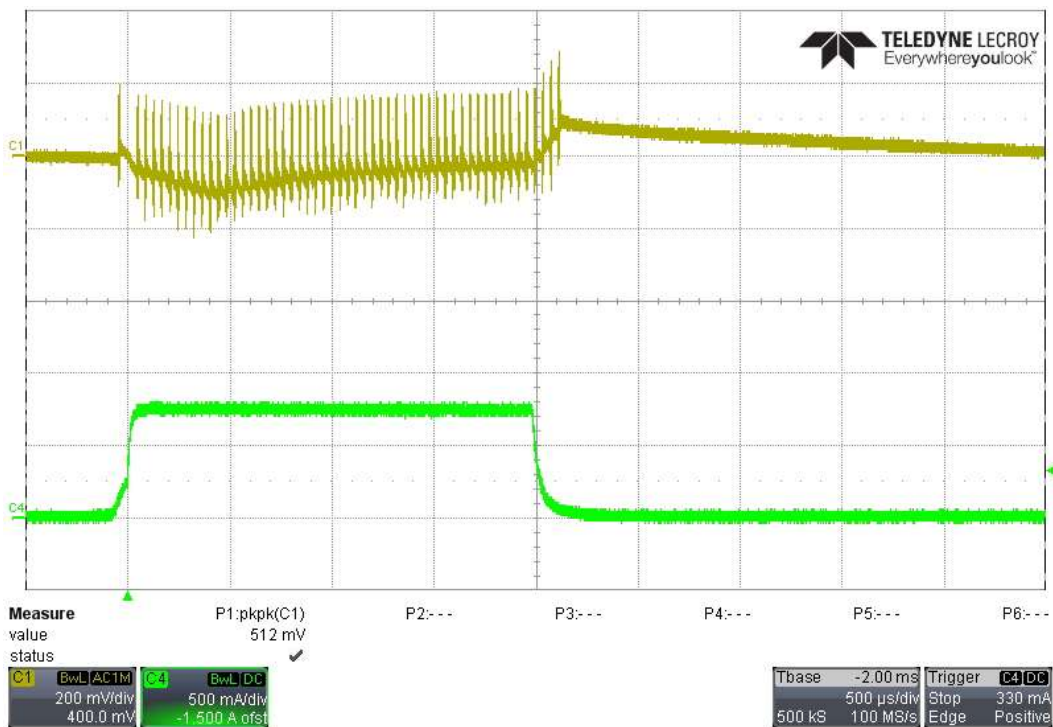


2.8.8 9V Output, 2.25A to 3.0A Load Step, 230VAC/50Hz Input

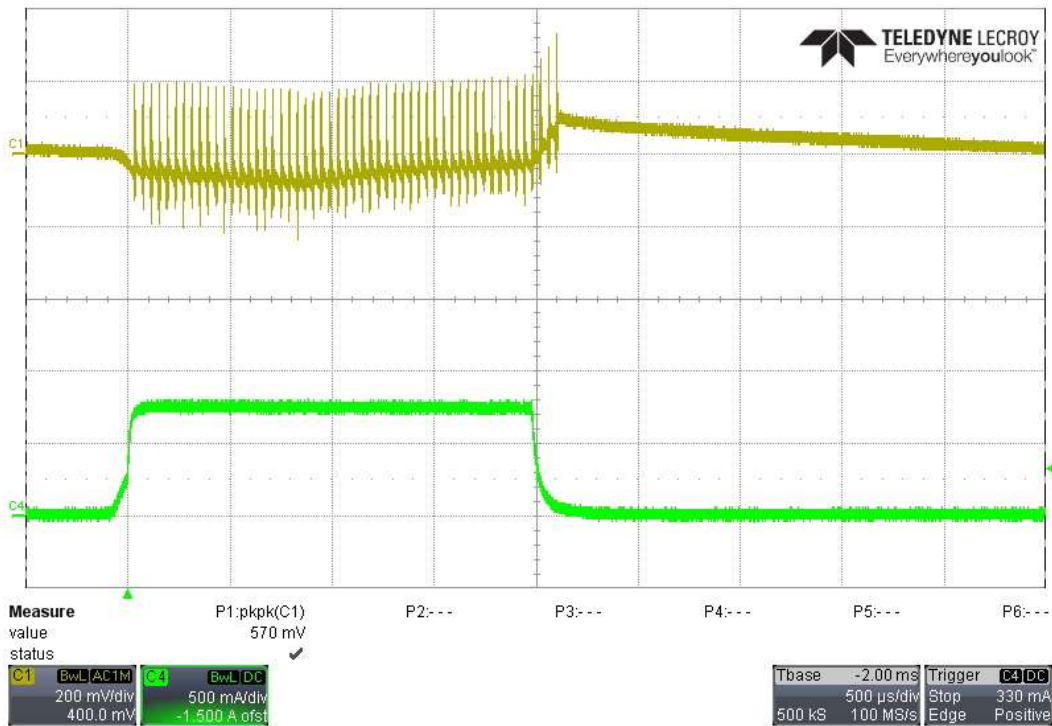


2.9 15V Output Load Transients

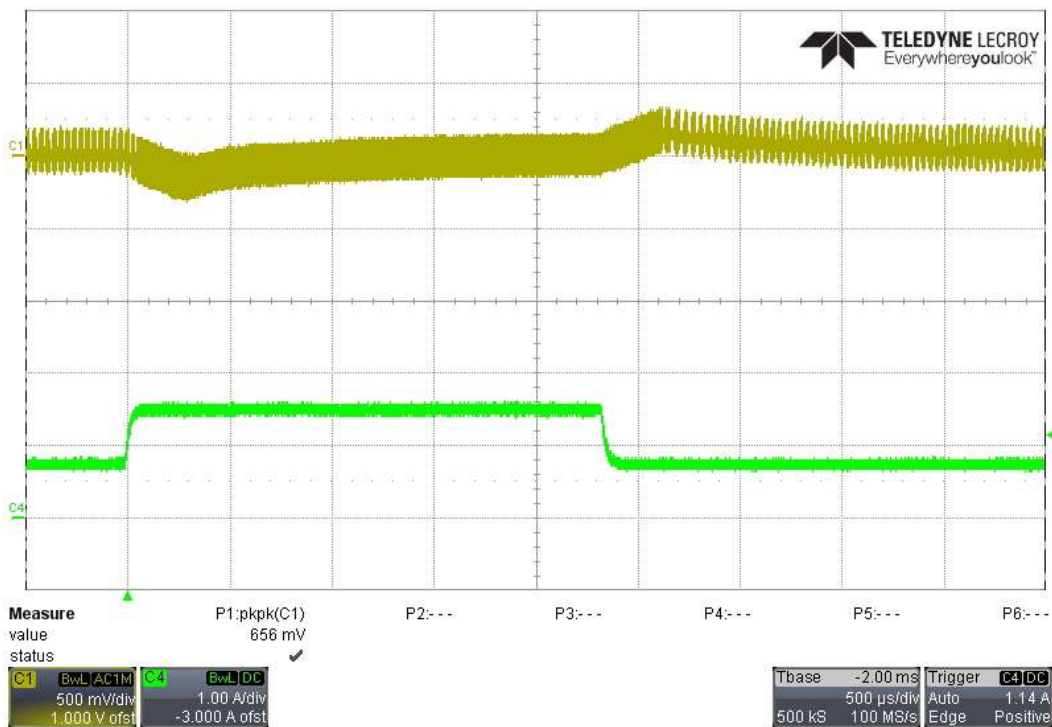
2.9.1 15V Output, 0A to 750mA Load Step, 115VAC/60Hz Input



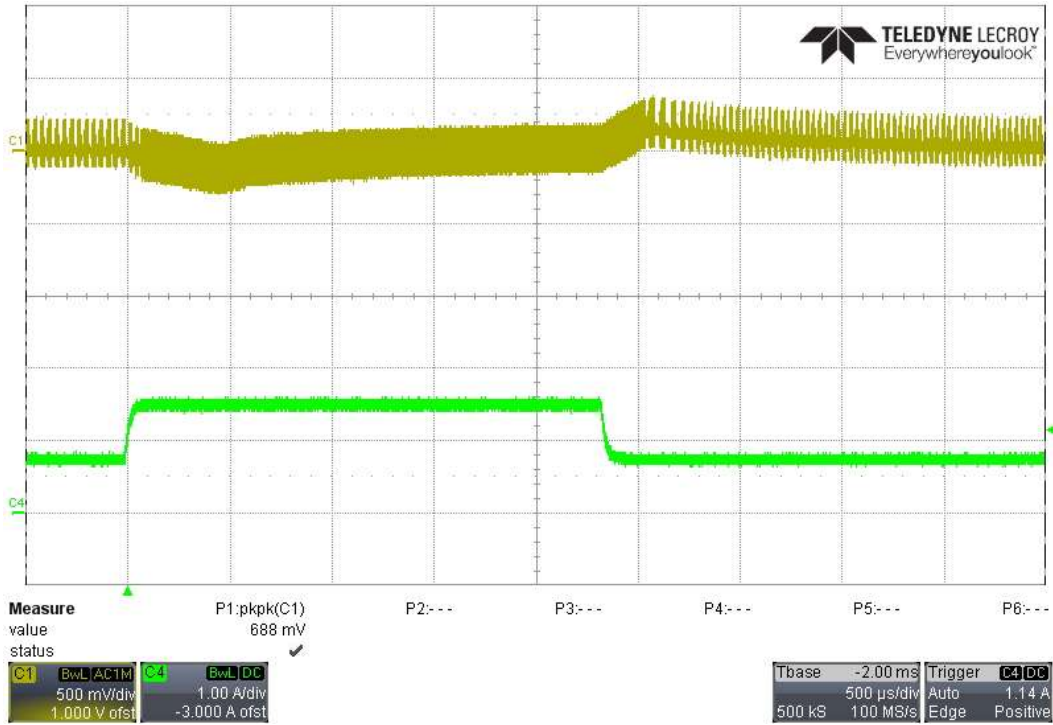
2.9.2 15V Output, 0A to 750mA Load Step, 230VAC/50Hz Input



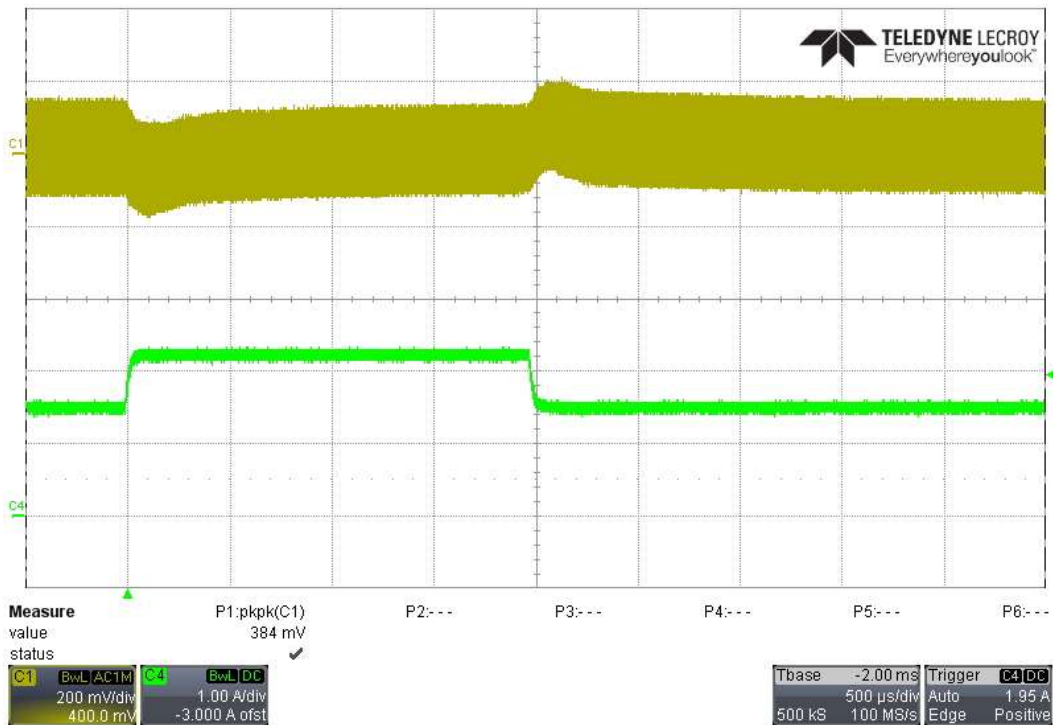
2.9.3 15V Output, 750mA to 1.5A Load Step, 115VAC/60Hz Input



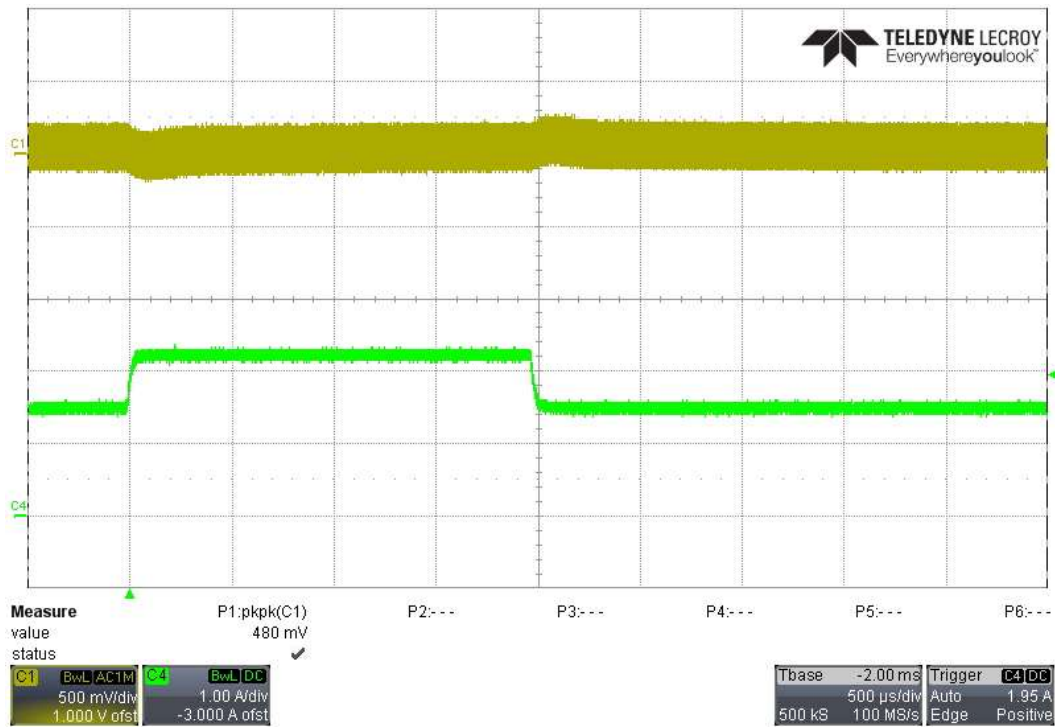
2.9.4 15V Output, 750mA to 1.5A Load Step, 230VAC/50Hz Input



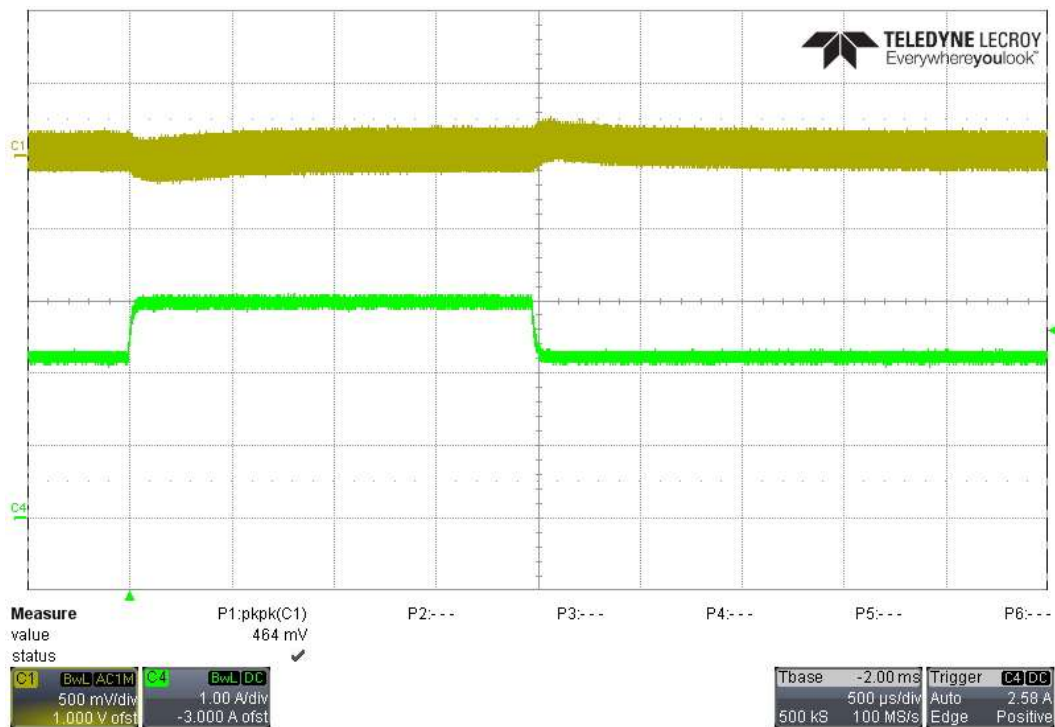
2.9.5 15V Output, 1.5A to 2.25A Load Step, 115VAC/60Hz Input



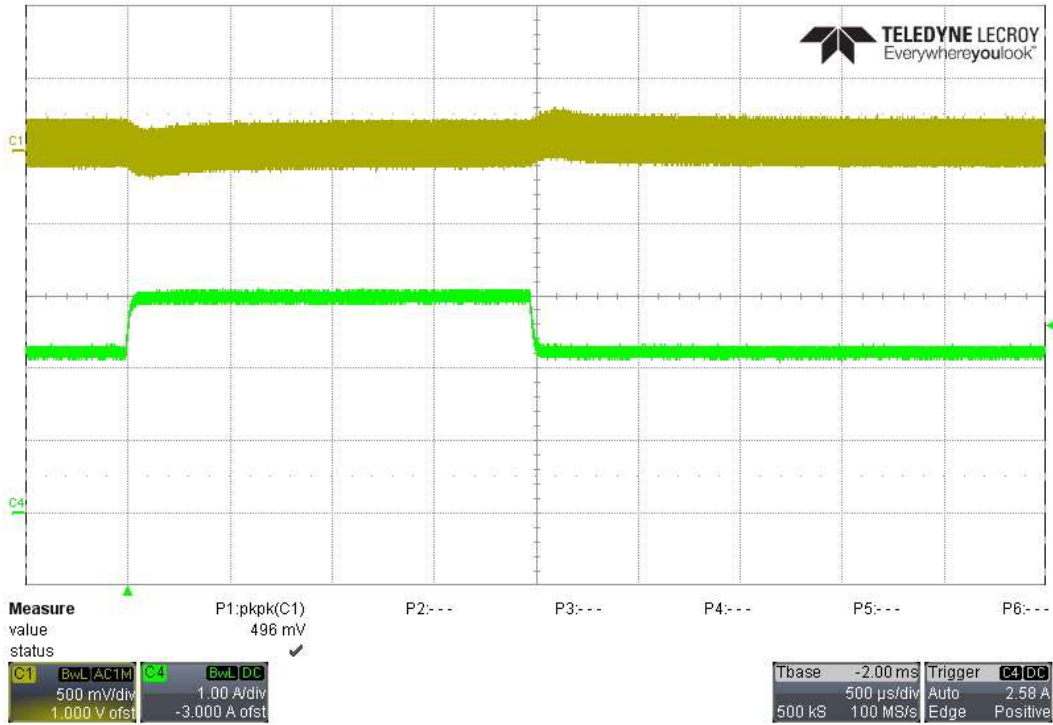
2.9.6 15V Output, 1.5A to 2.25A Load Step, 230VAC/50Hz Input



2.9.7 15V Output, 2.25A to 3.0A Load Step, 115VAC/60Hz Input

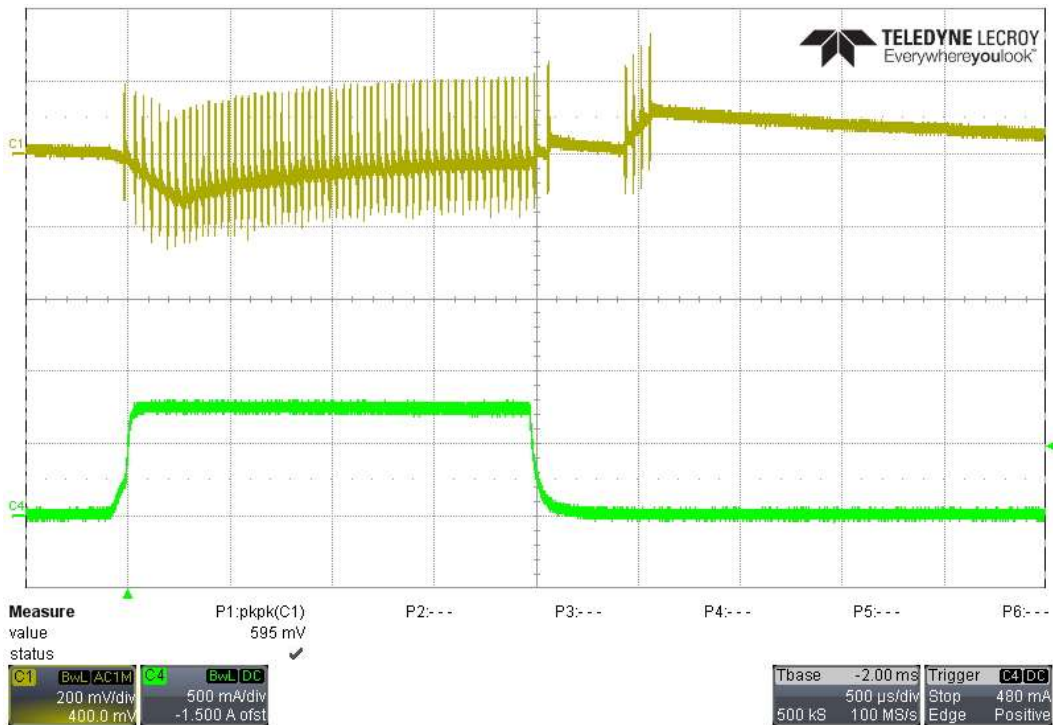


2.9.8 15V Output, 2.25A to 3.0A Load Step, 230VAC/50Hz Input

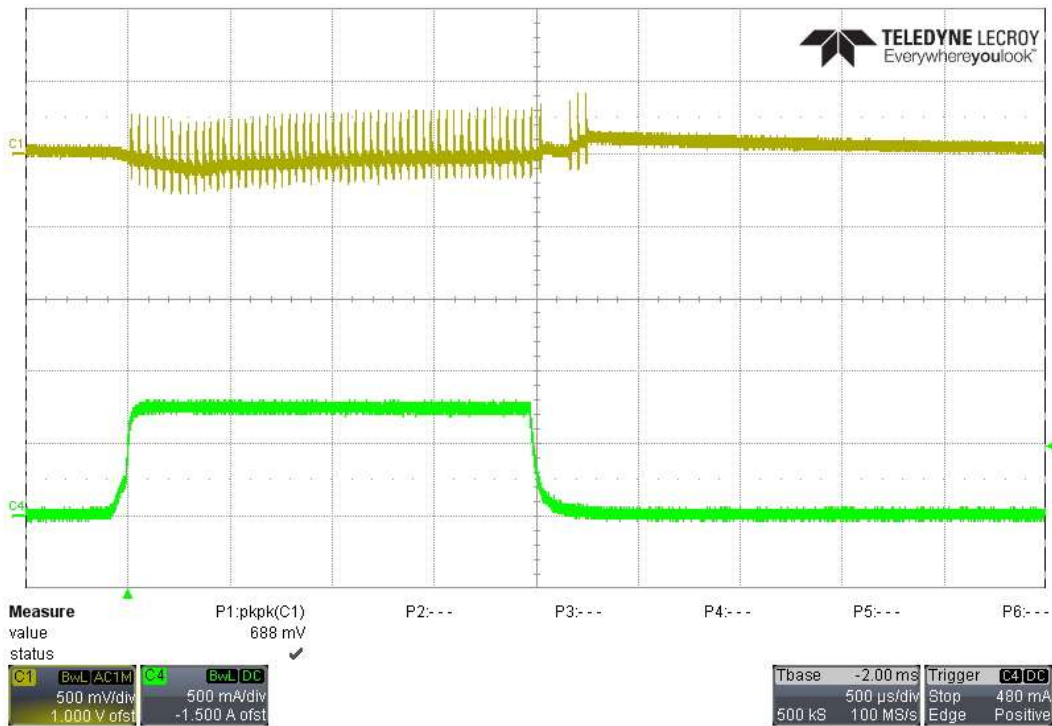


2.10 20V Output Load Transients

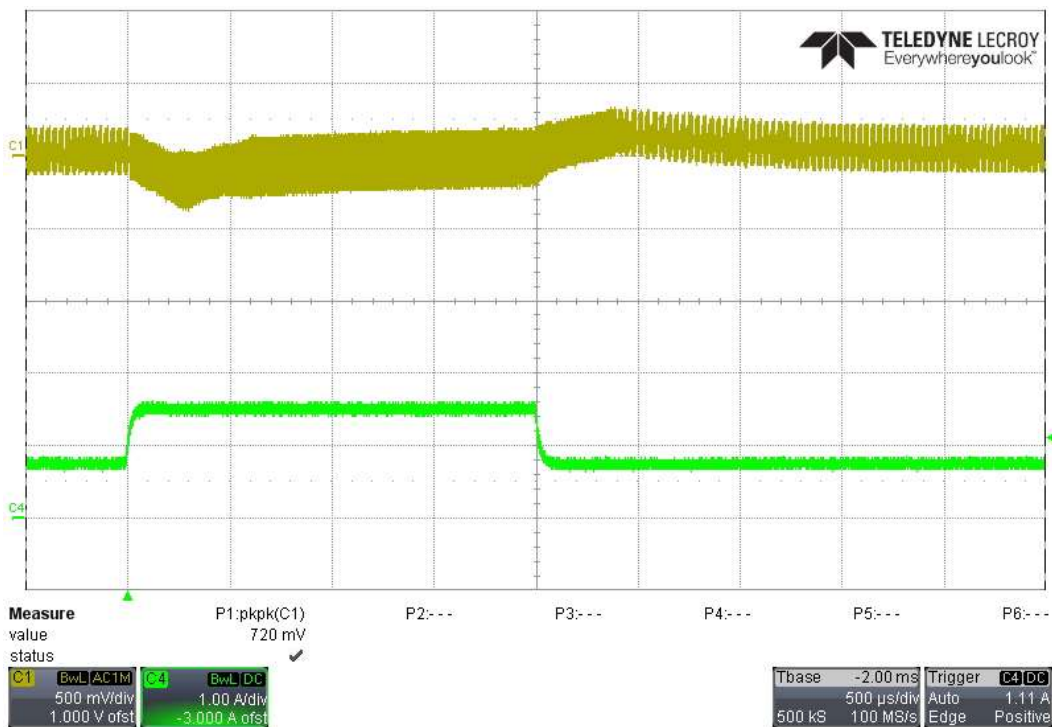
2.10.1 20V Output, 0A to 750mA Load Step, 115VAC/60Hz Input



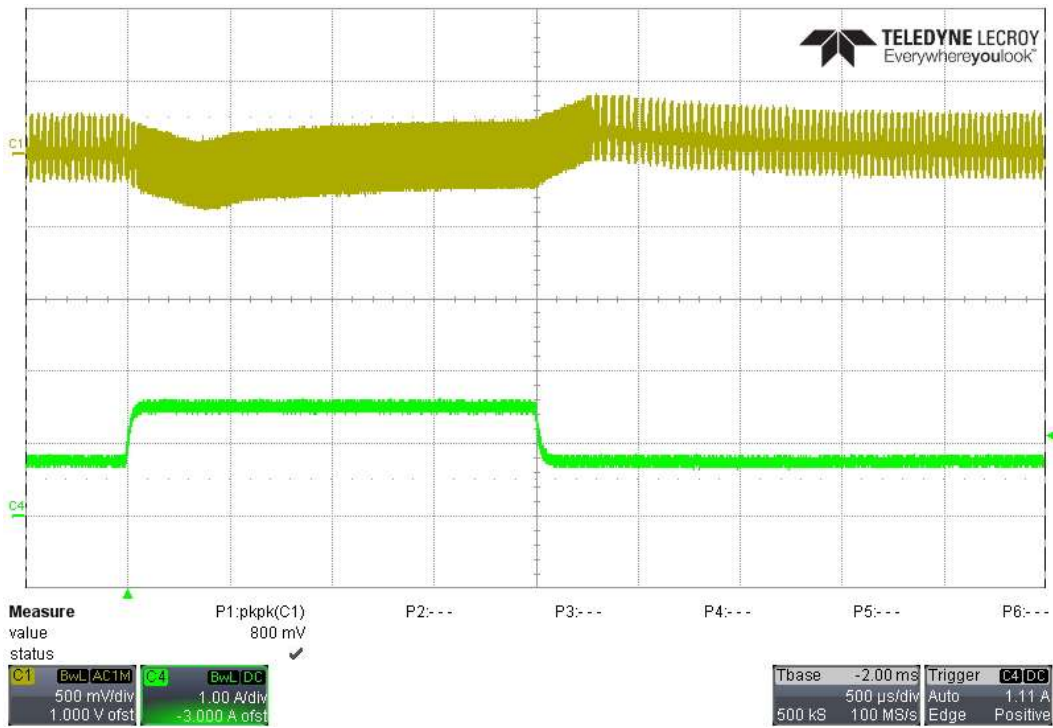
2.10.2 20V Output, 0A to 750mA Load Step, 230VAC/50Hz Input



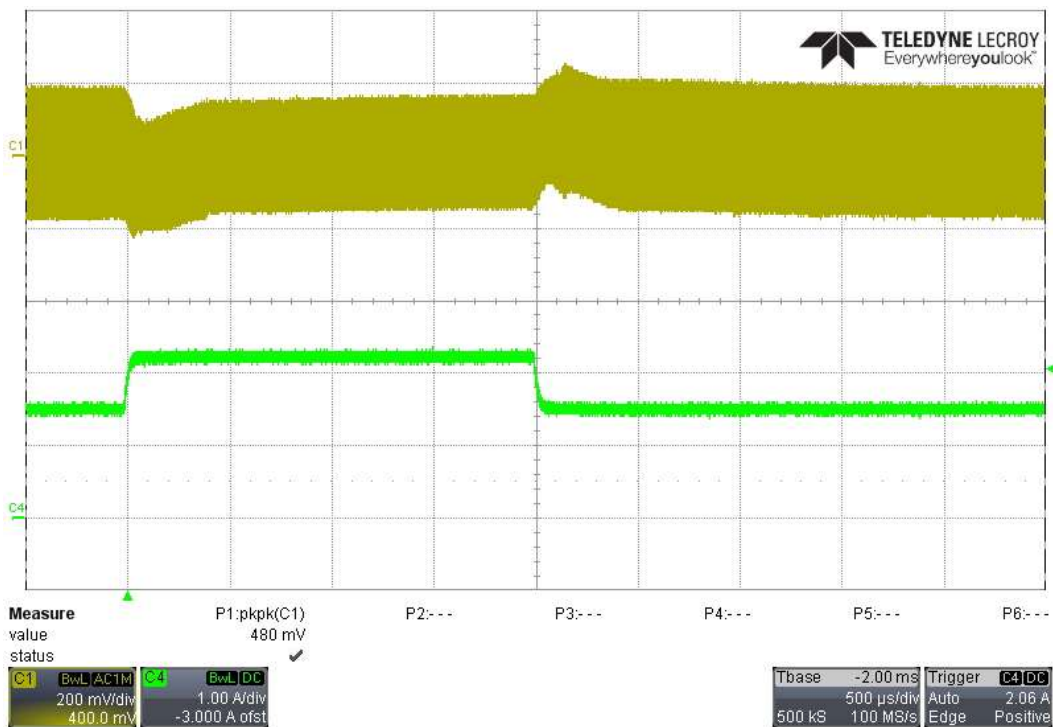
2.10.3 20V Output, 750mA to 1.5A Load Step, 115VAC/60Hz Input



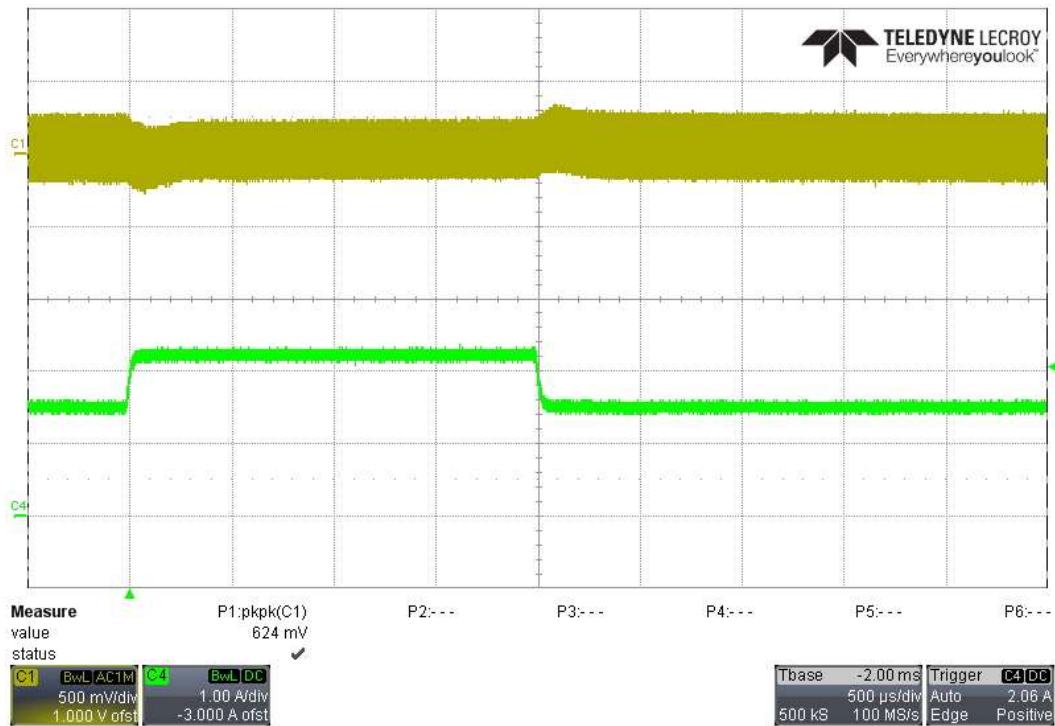
2.10.4 20V Output, 750mA to 1.5A Load Step, 230VAC/50Hz Input



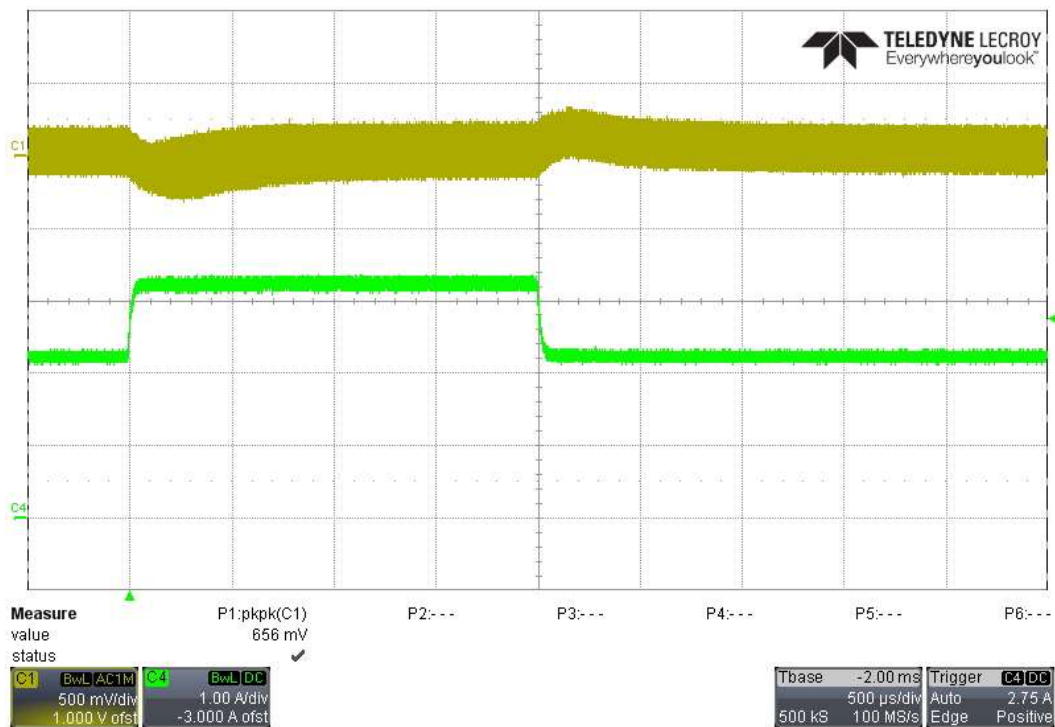
2.10.5 20V Output, 1.5A to 2.25A Load Step, 115VAC/60Hz Input



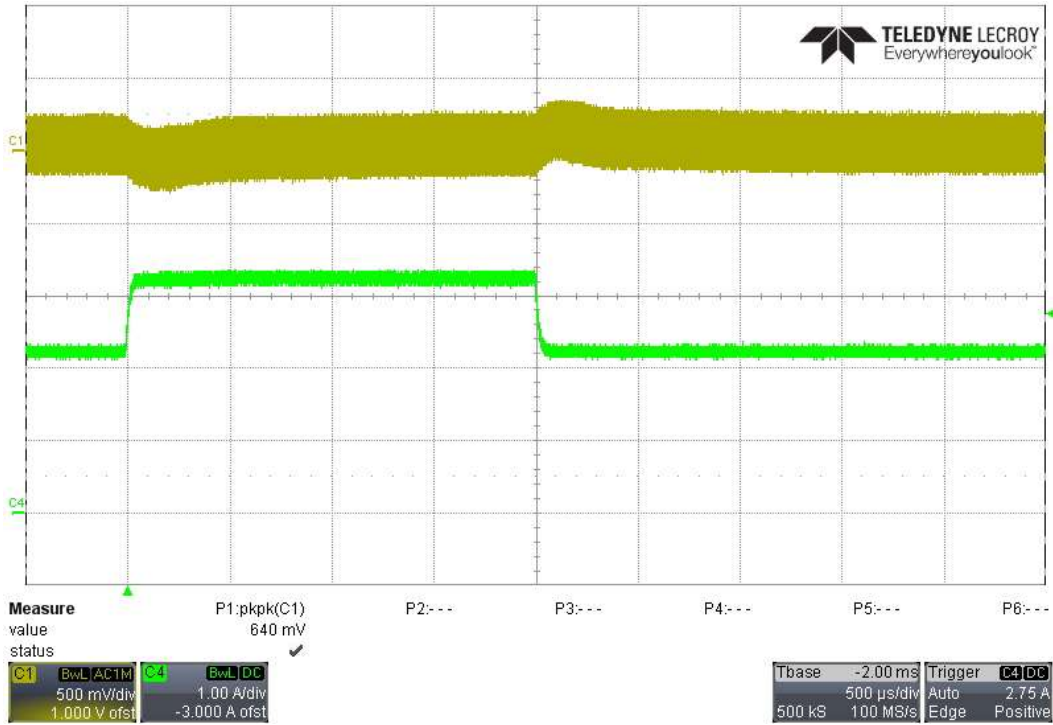
2.10.6 20V Output, 1.5A to 2.25A Load Step, 230VAC/50Hz Input



2.10.7 20V Output, 2.25A to 3.25A Load Step, 115VAC/60Hz Input

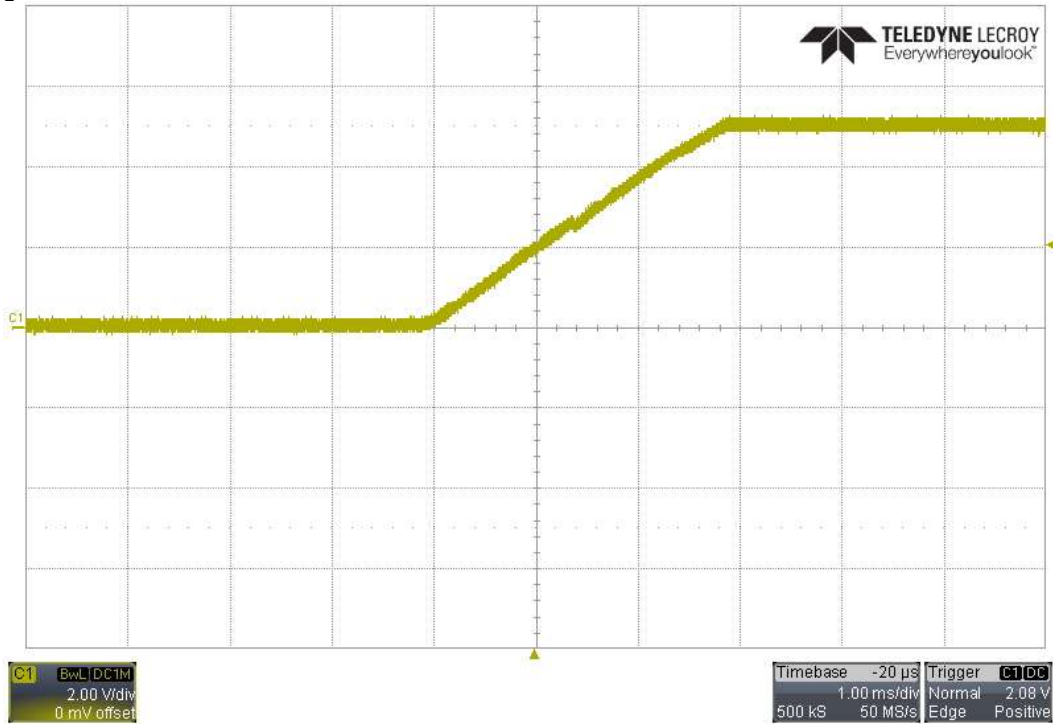


2.10.8 20V Output, 2.25A to 3.25A Load Step, 230VAC/50Hz Input



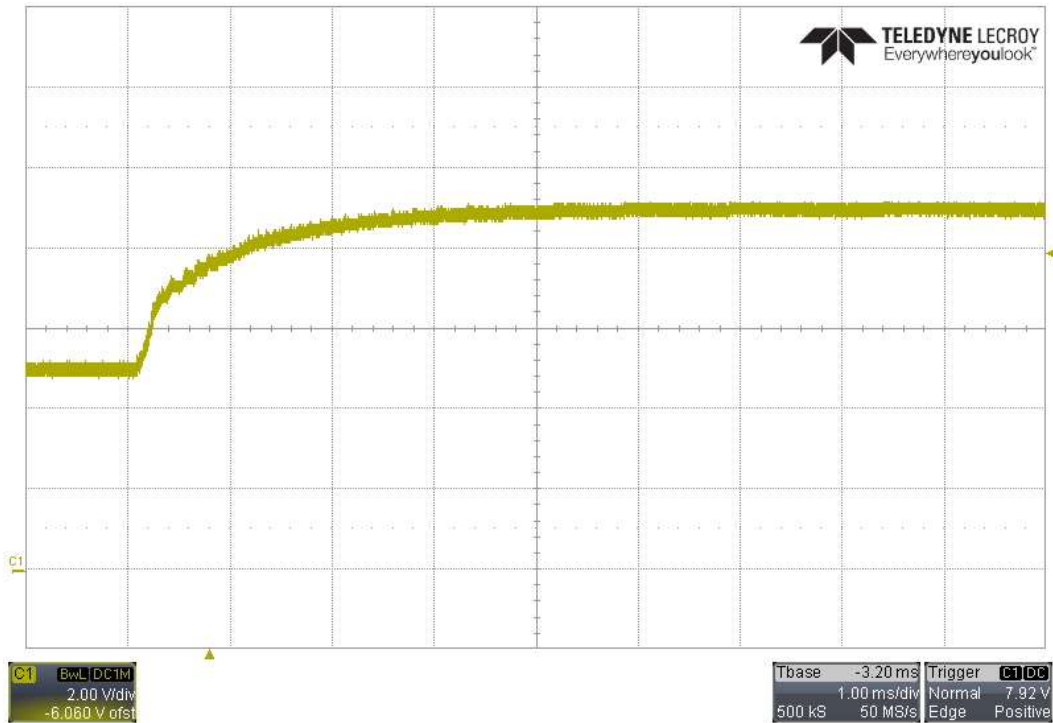
2.11 Startup

Output voltage measured at connector when USB-C cable inserted with no load.

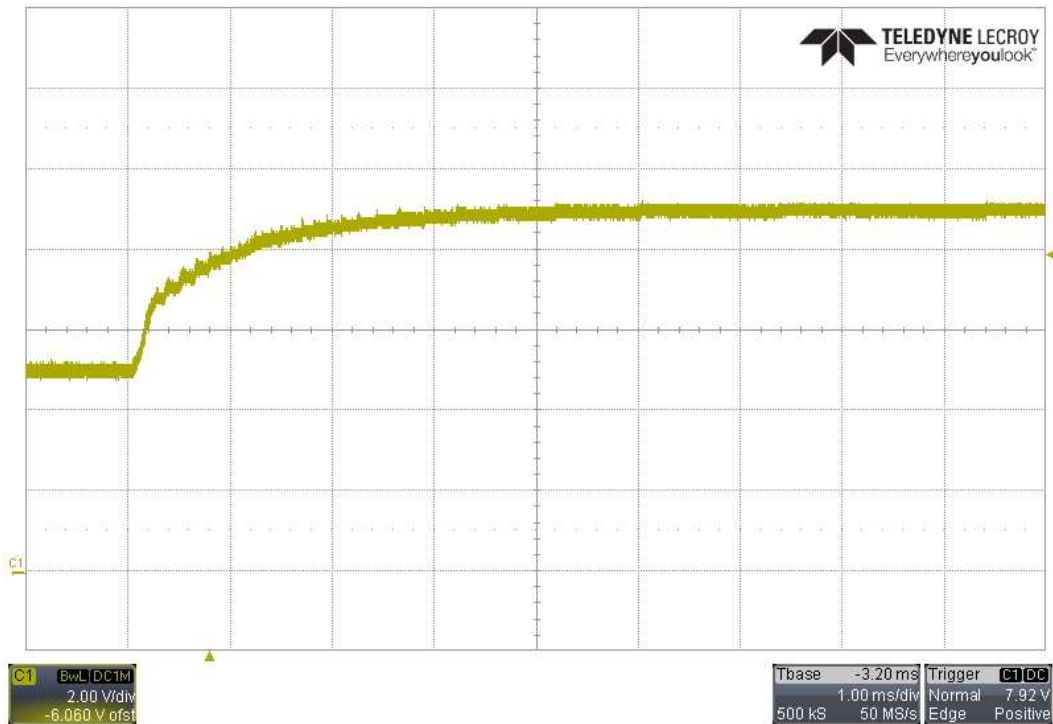


2.12 Voltage Transitions

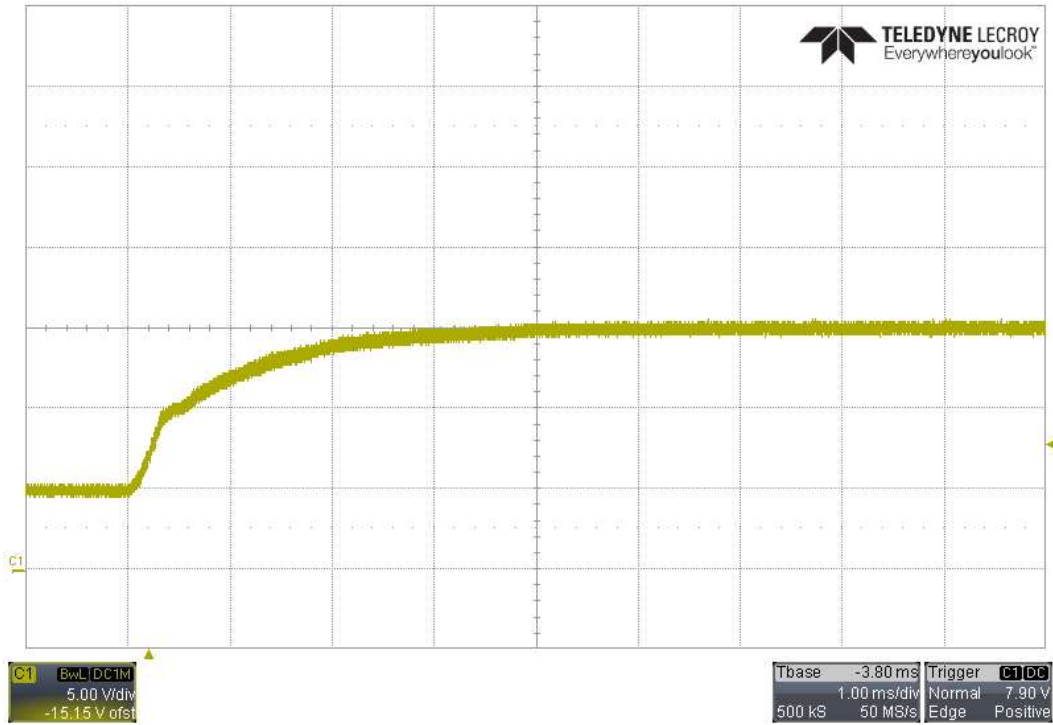
2.12.1 5V to 9V, 115VAC/60Hz Input, No Load



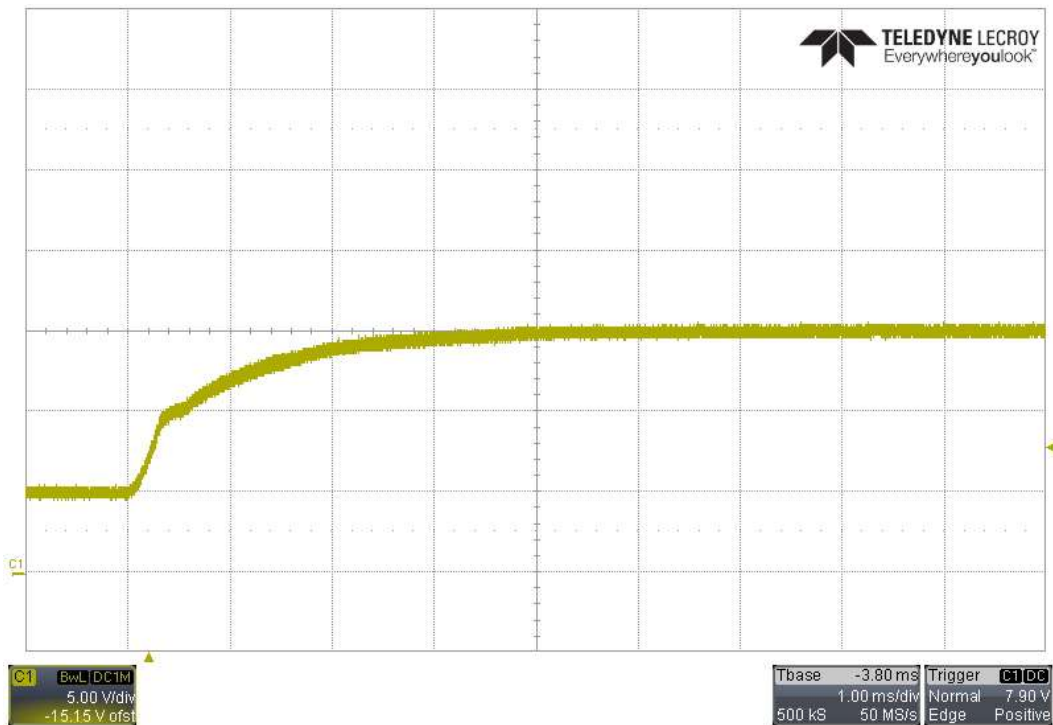
2.12.2 5V to 9V, 230VAC/50Hz Input, No Load



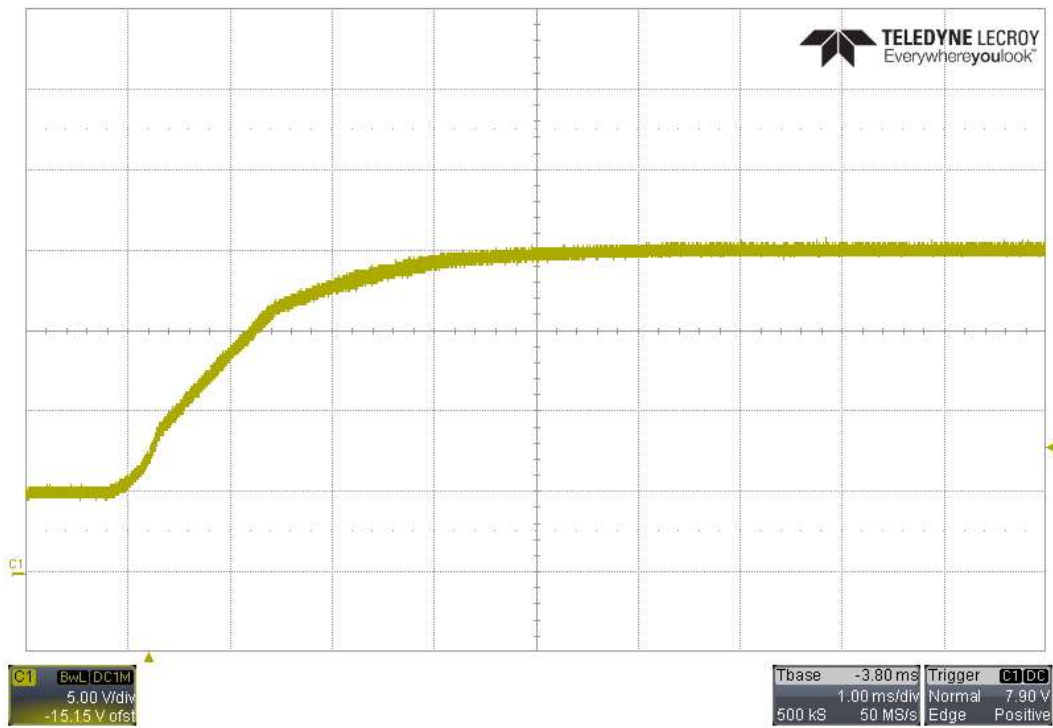
2.12.3 5V to 15V, 115VAC/60Hz Input, No Load



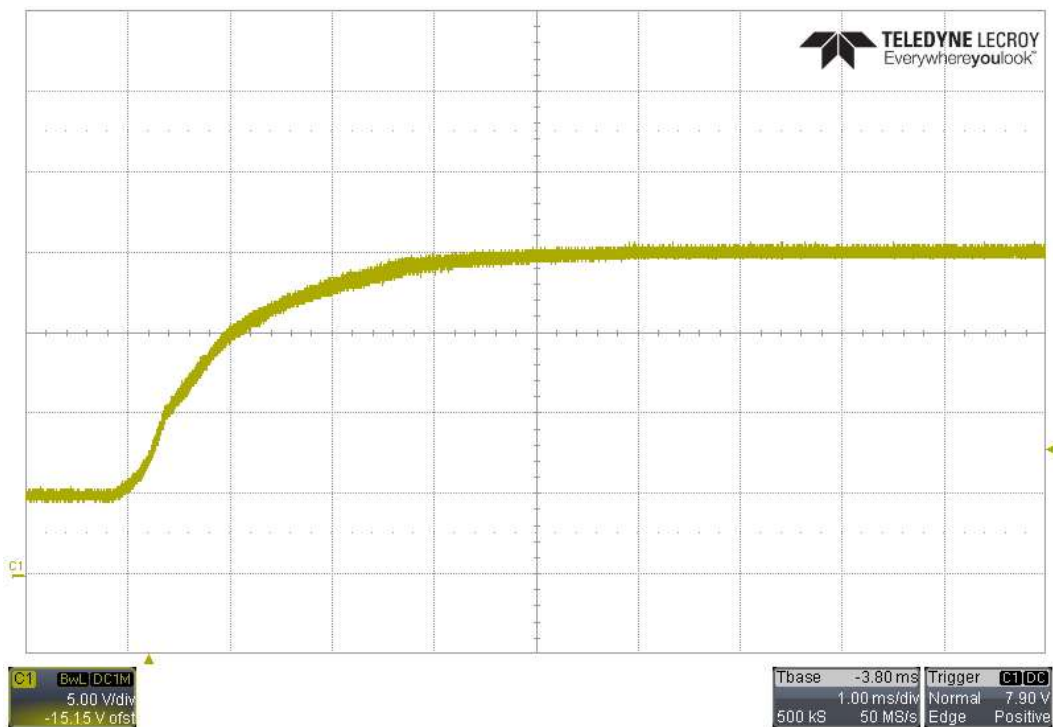
2.12.4 5V to 15V, 230VAC/50Hz Input, No Load



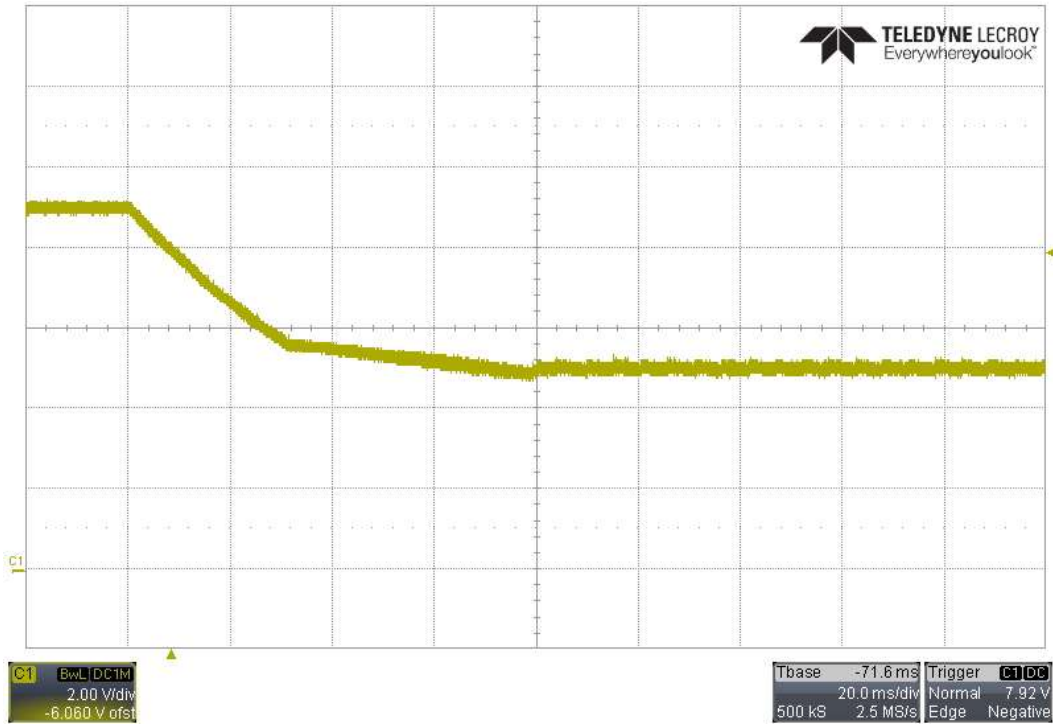
2.12.5 5V to 20V, 115VAC/60Hz Input, No Load



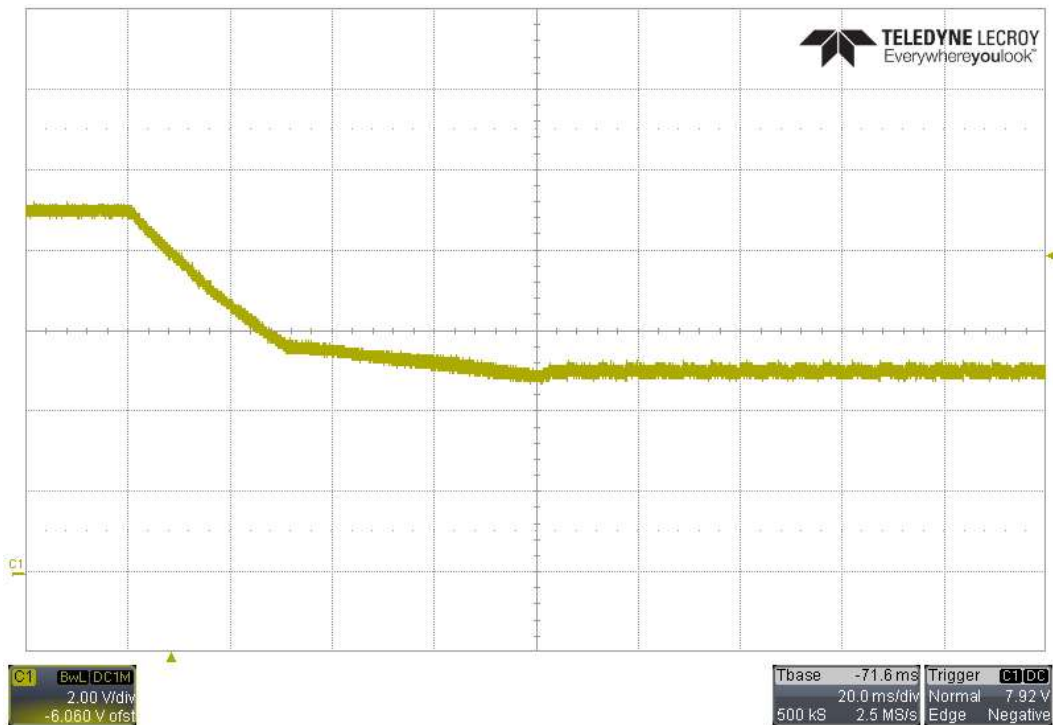
2.12.6 5V to 20V, 230VAC/50Hz Input, No Load



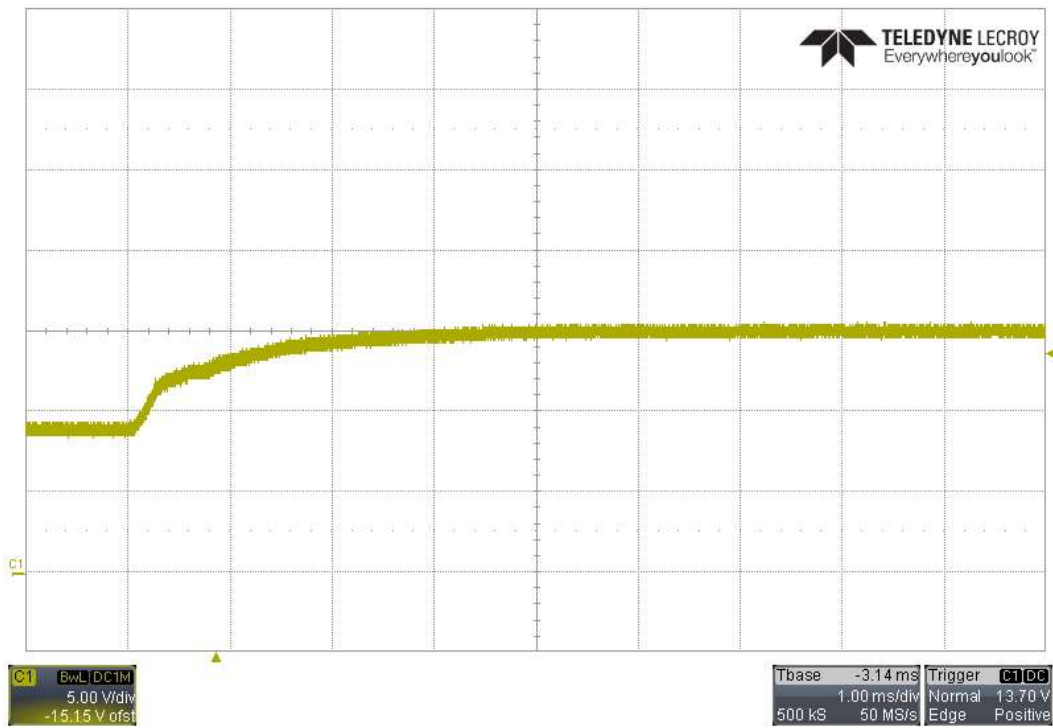
2.12.7 9V to 5V, 115VAC/60Hz Input, No Load



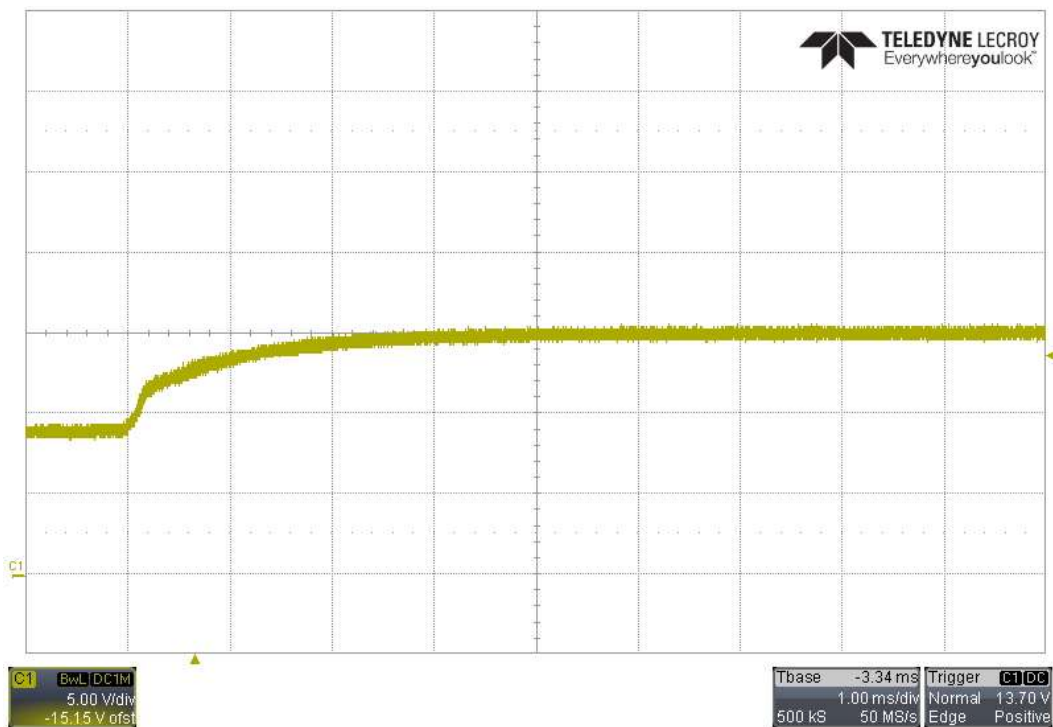
2.12.8 9V to 5V, 230VAC/50Hz Input, No Load



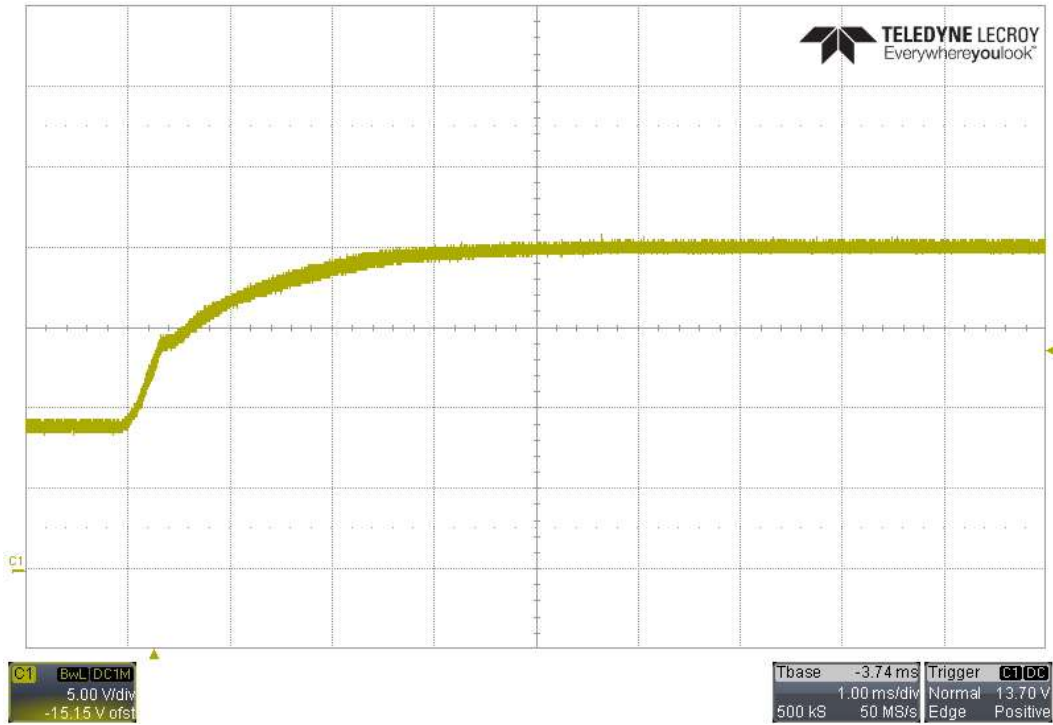
2.12.9 9V to 15V, 115VAC/60Hz Input, No Load



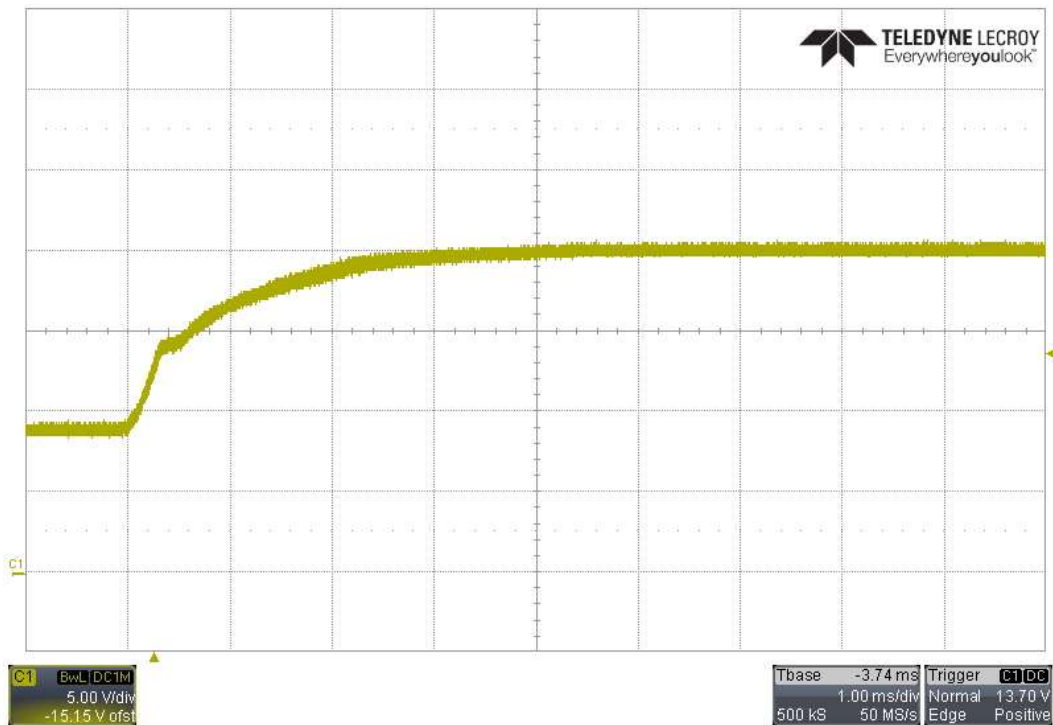
2.12.10 9V to 15V, 230VAC/50Hz Input, No Load



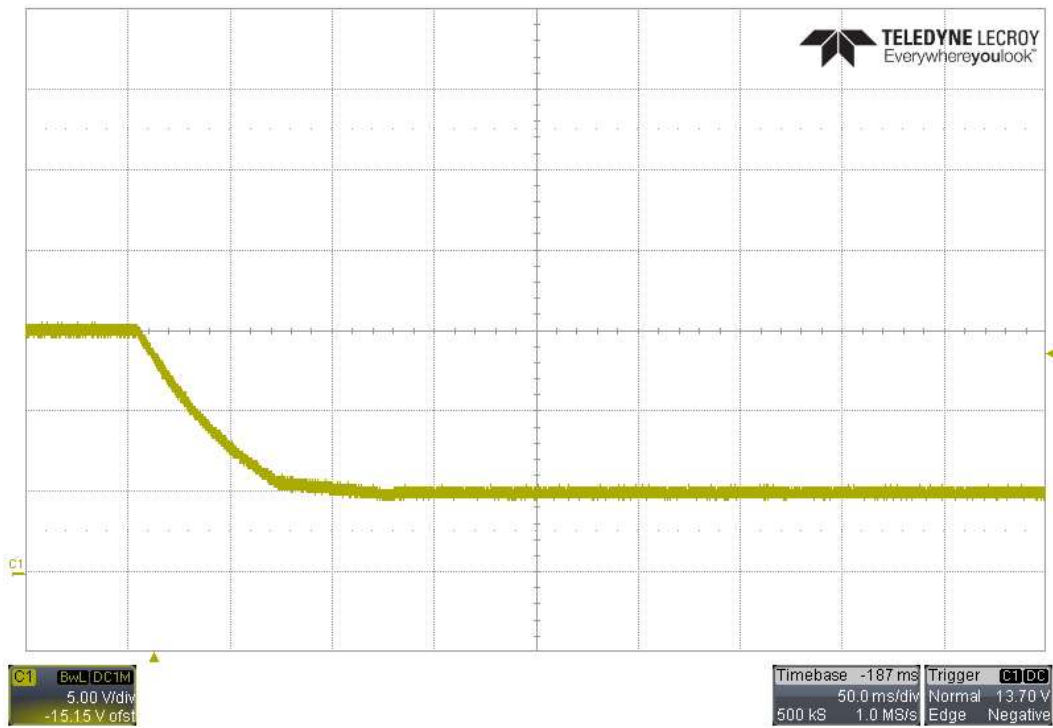
2.12.11 9V to 20V, 115VAC/60Hz Input, No Load



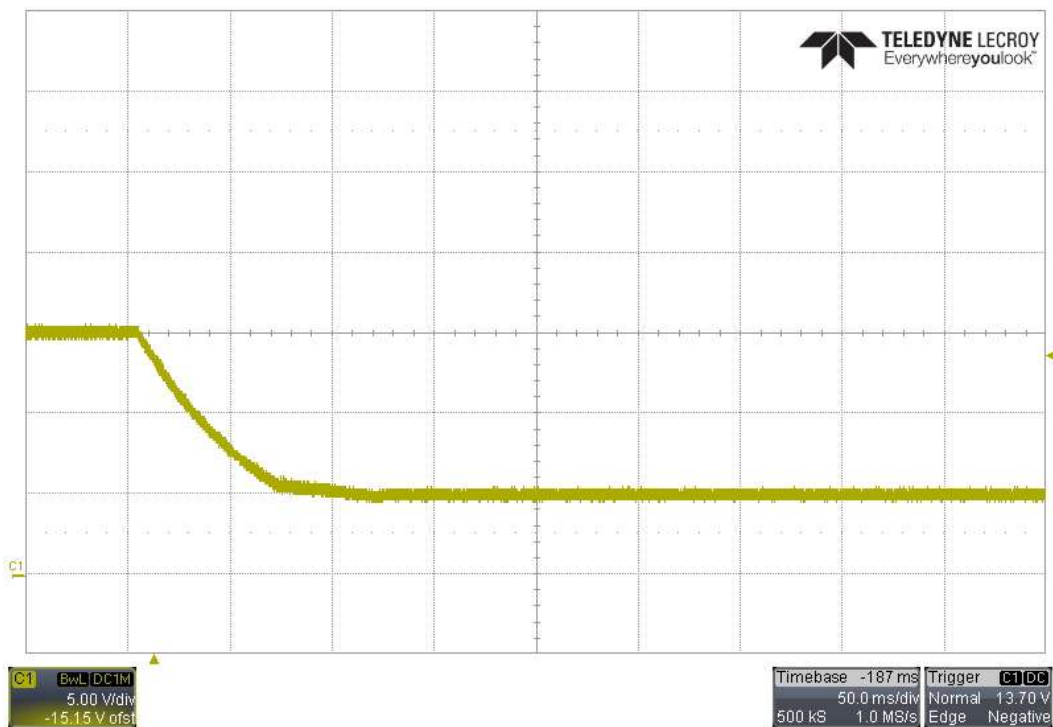
2.12.12 9V to 20V, 230VAC/50Hz Input, No Load



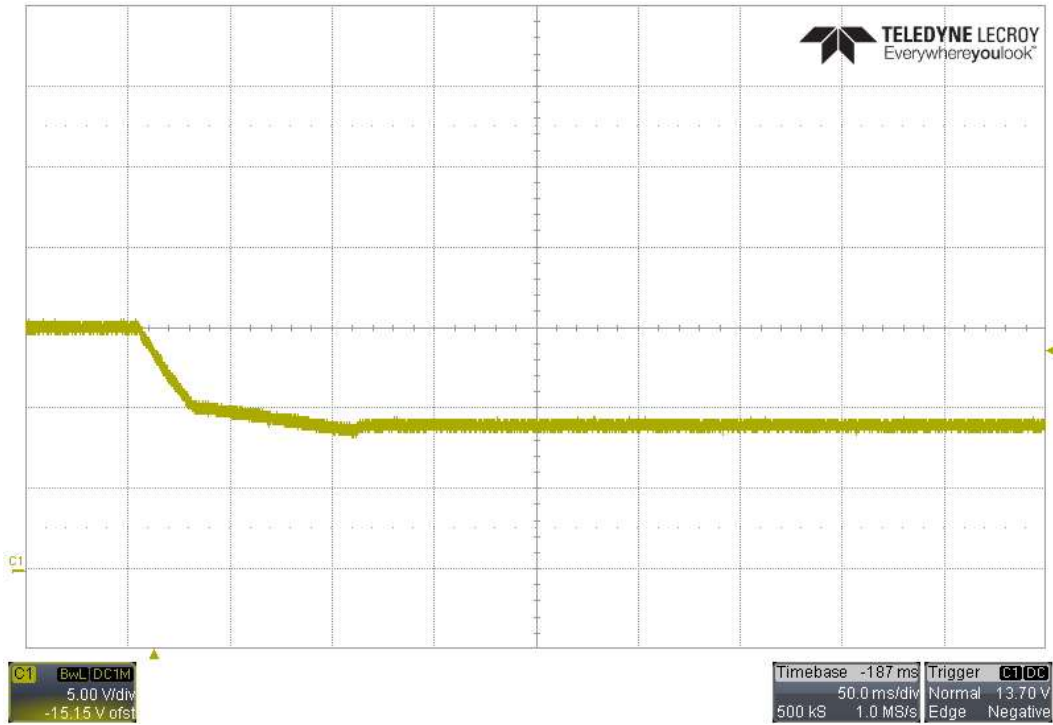
2.12.13 15V to 5V, 115VAC/60Hz Input, No Load



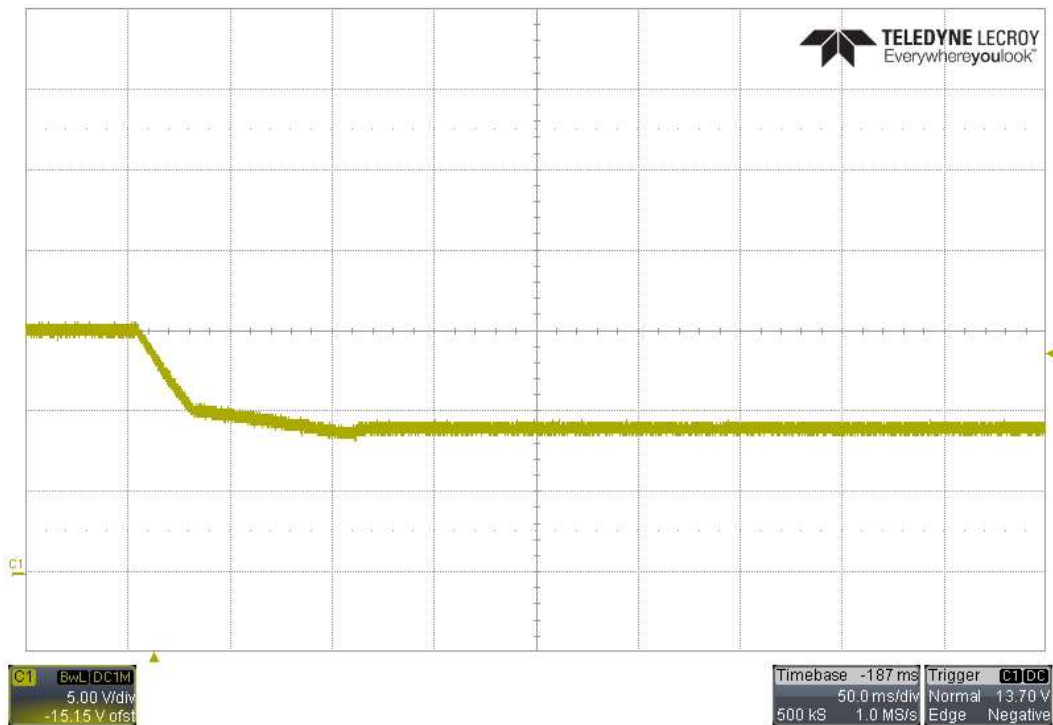
2.12.14 15V to 5V, 230VAC/50Hz Input, No Load



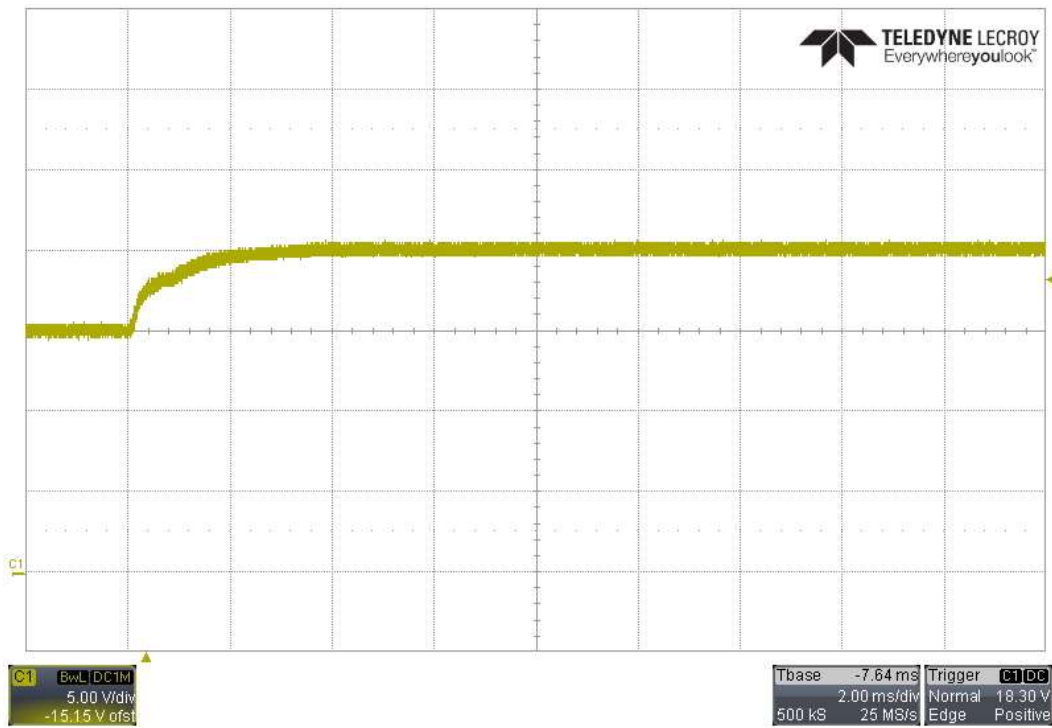
2.12.15 15V to 9V, 115VAC/60Hz Input, No Load



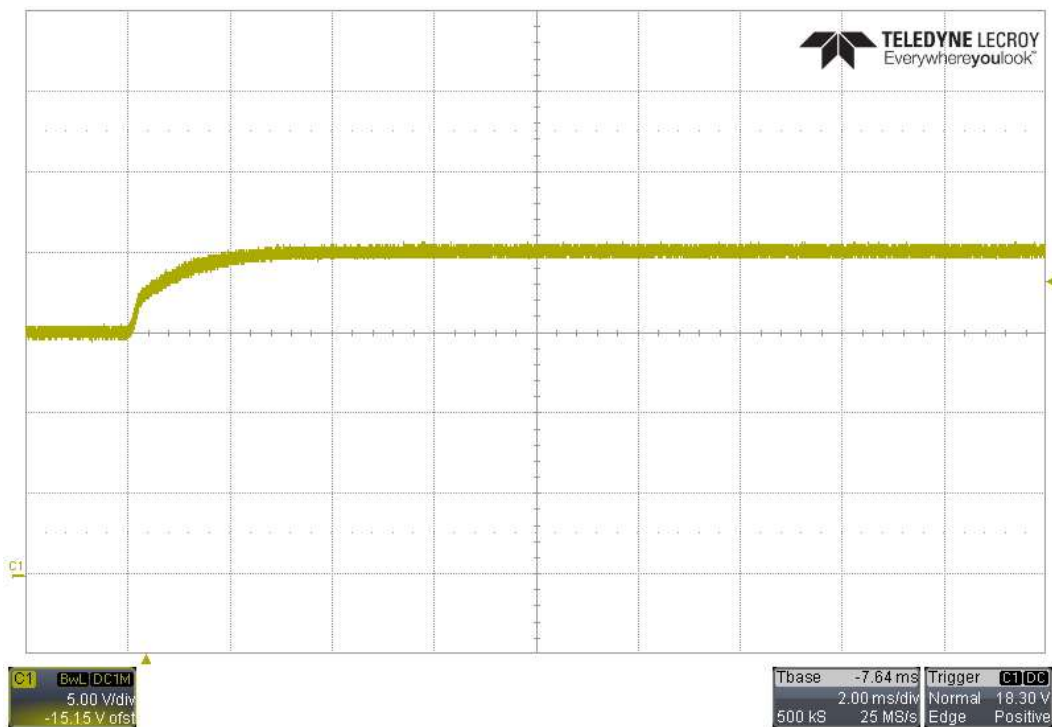
2.12.16 15V to 9V, 230VAC/50Hz Input, No Load



2.12.17 15V to 20V, 115VAC/60Hz Input, No Load



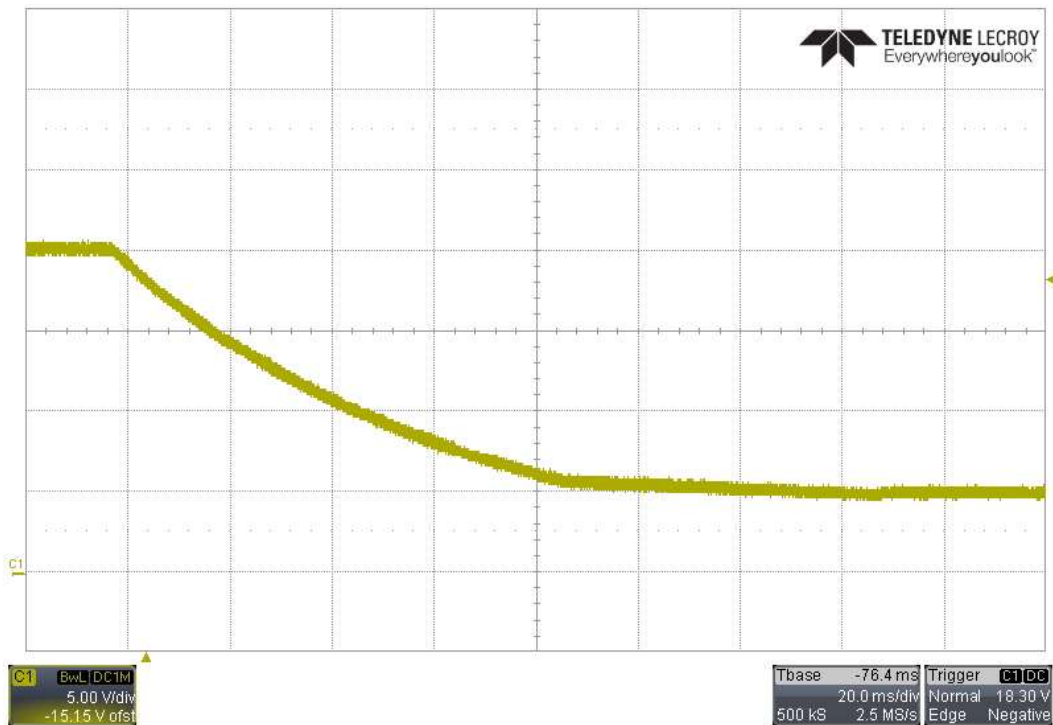
2.12.18 15V to 20V, 230VAC/50Hz Input, No Load



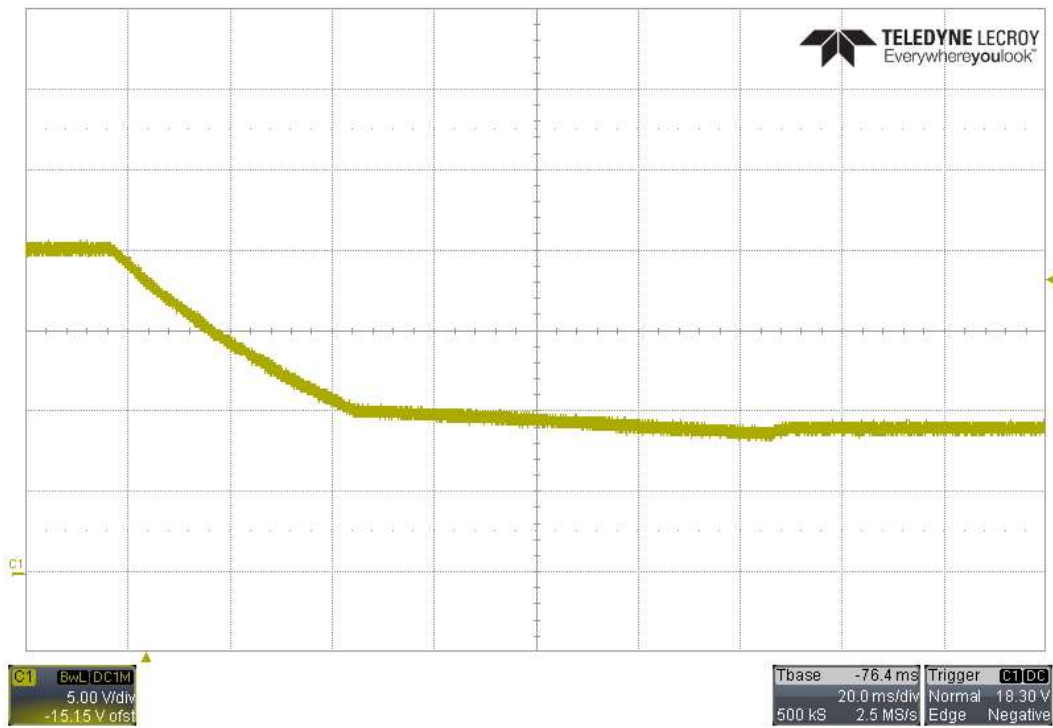
2.12.19 20V to 5V, 115VAC/60Hz Input, No Load



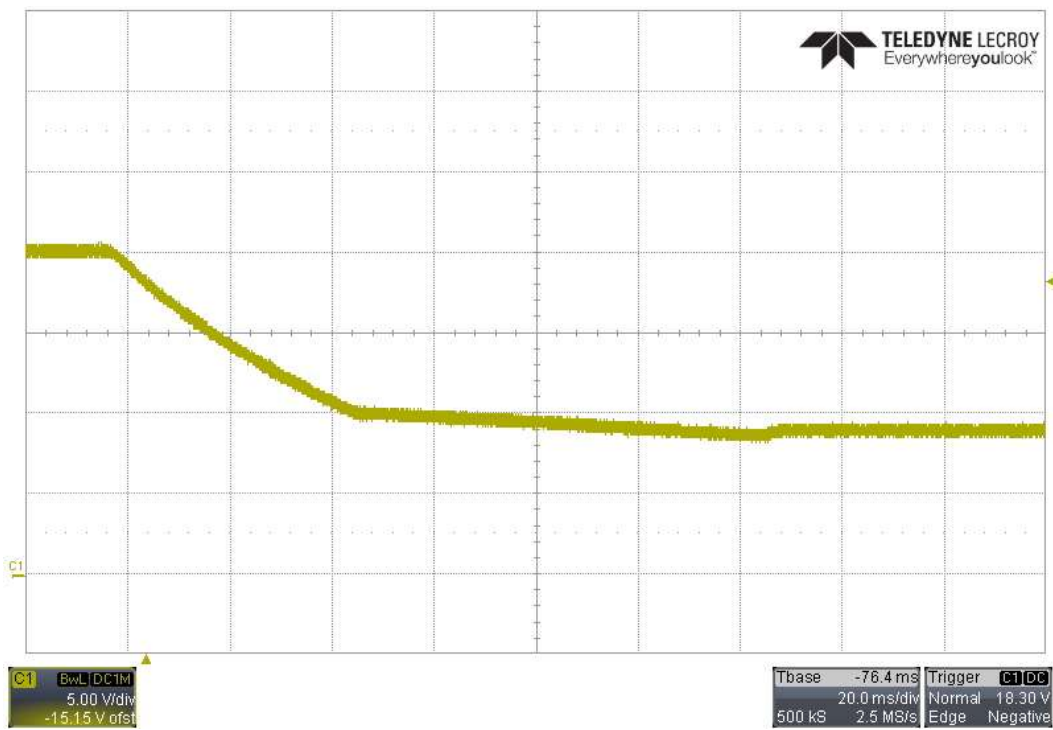
2.12.20 20V to 5V, 230VAC/50Hz Input, No Load



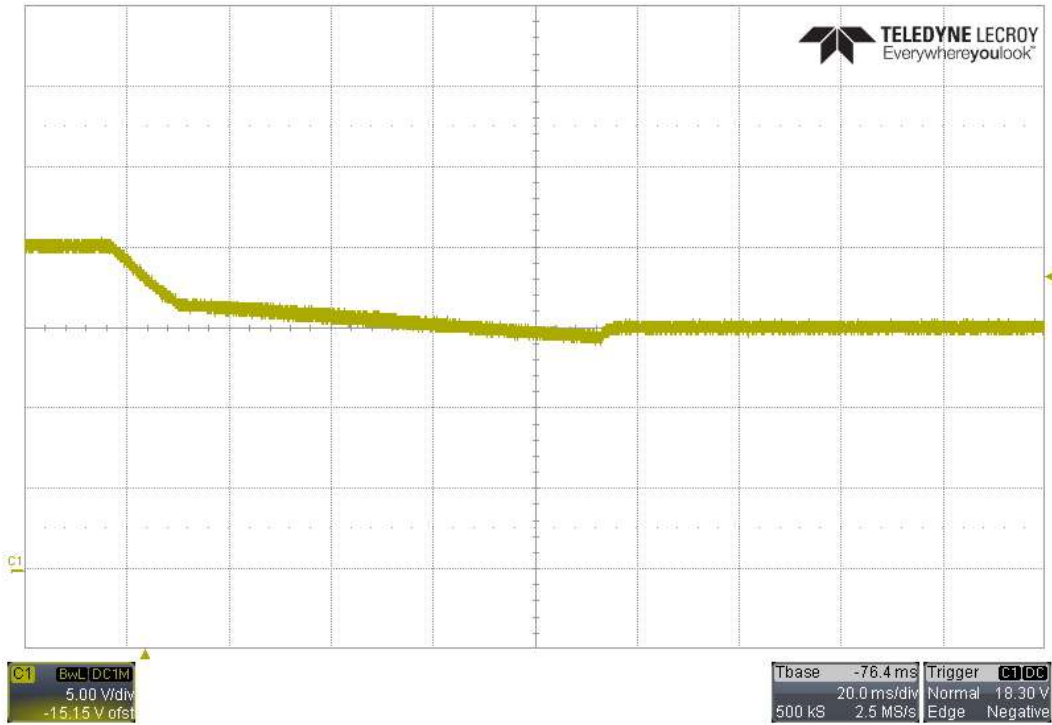
2.12.21 20V to 9V, 115VAC/60Hz Input, No Load



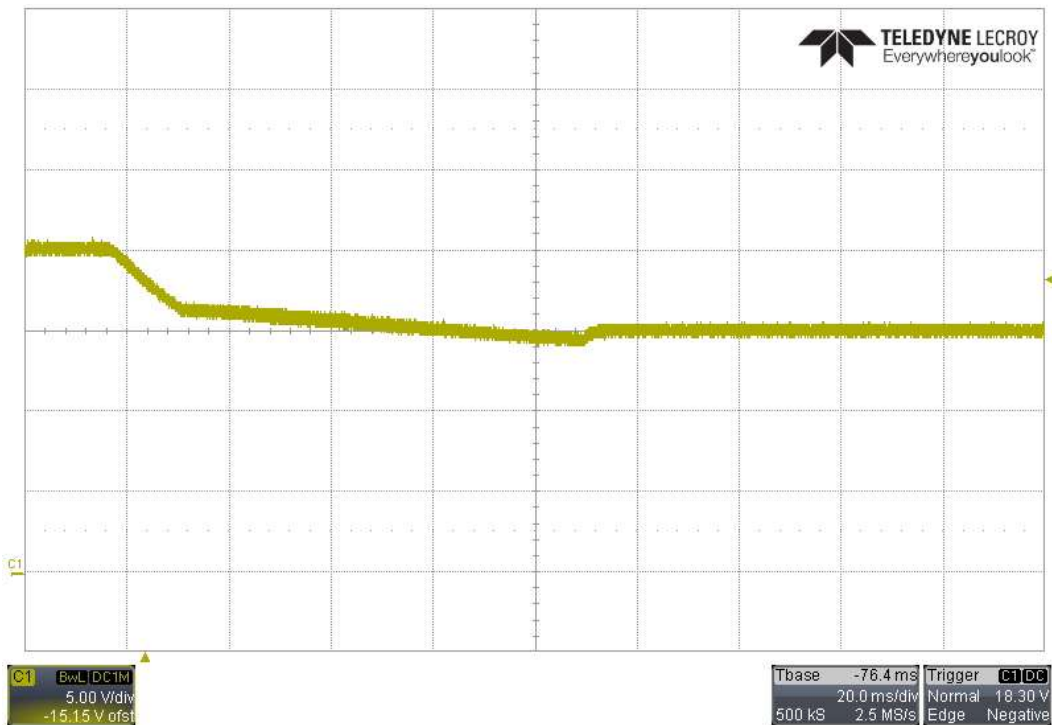
2.12.22 20V to 9V, 230VAC/50Hz Input, No Load



2.12.23 20V to 15V, 115VAC/60Hz Input, No Load

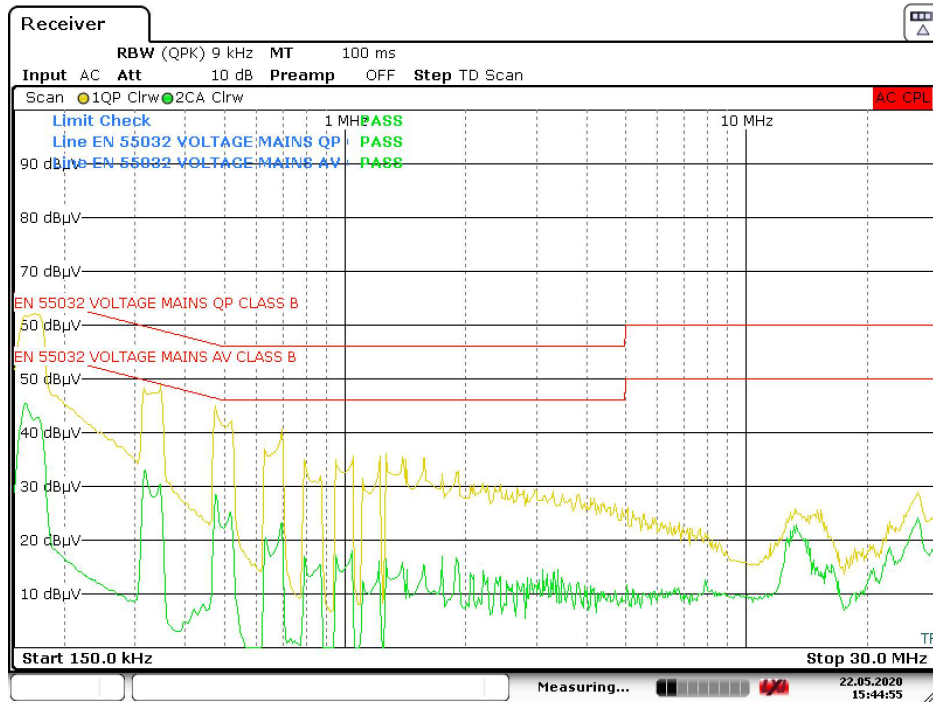


2.12.24 20V to 15V, 230VAC/50Hz Input, No Load

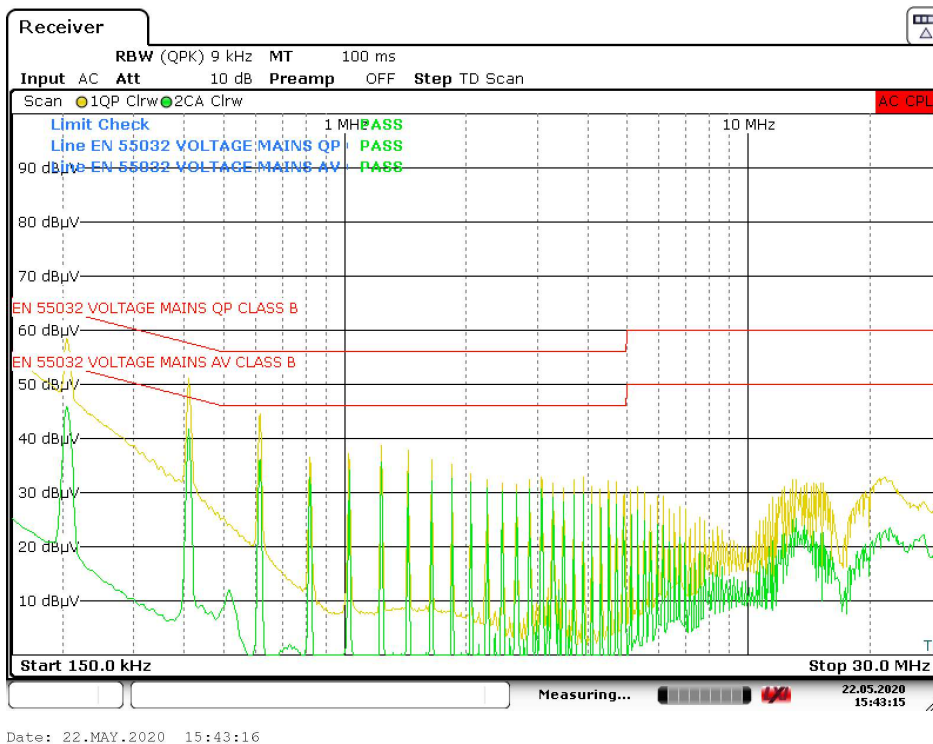


2.13 Conducted EMI

2.13.1 115VAC/60Hz Input, 20V/3.25A Output Tied to Earth Ground



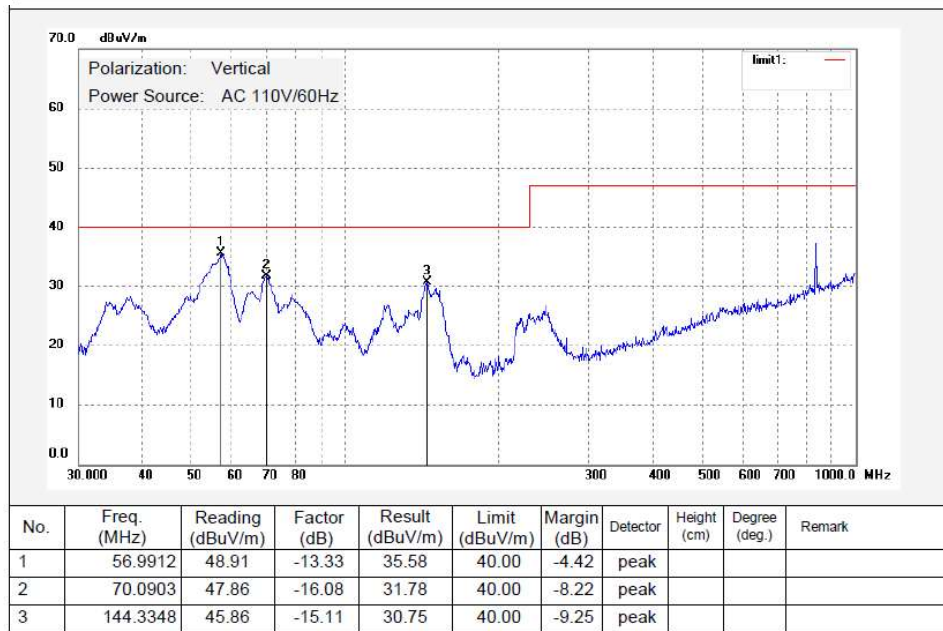
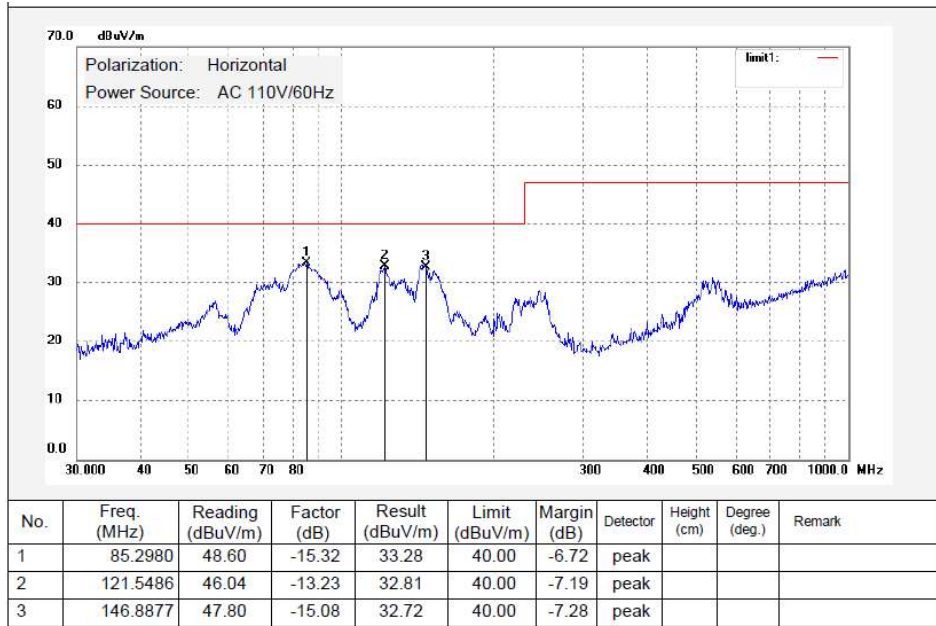
2.13.2 230VAC/50Hz Input, 20V/3.25A Output Tied to Earth Ground



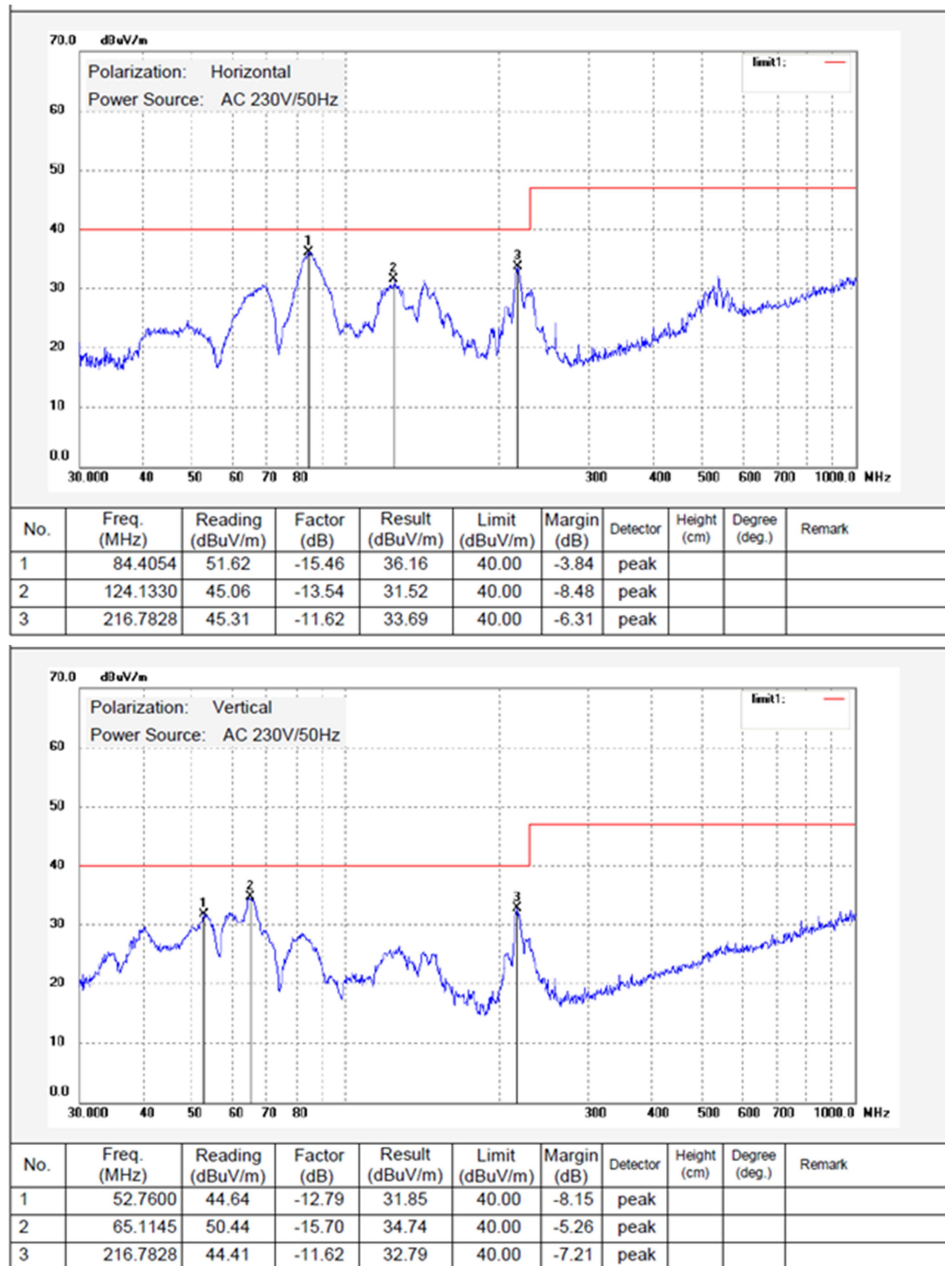
2.14 Radiated EMI

Data measured of Rev B board.

2.14.1 110VAC/60Hz Input, 20V/3.25A Floating Load



2.14.2 230VAC/60Hz Input, 20V/3.25A Floating Load



IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATASHEETS), 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, 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 (<https://www.ti.com/legal/termsofsale.html>) or other applicable terms available either on [ti.com](https://www.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.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2021, Texas Instruments Incorporated