

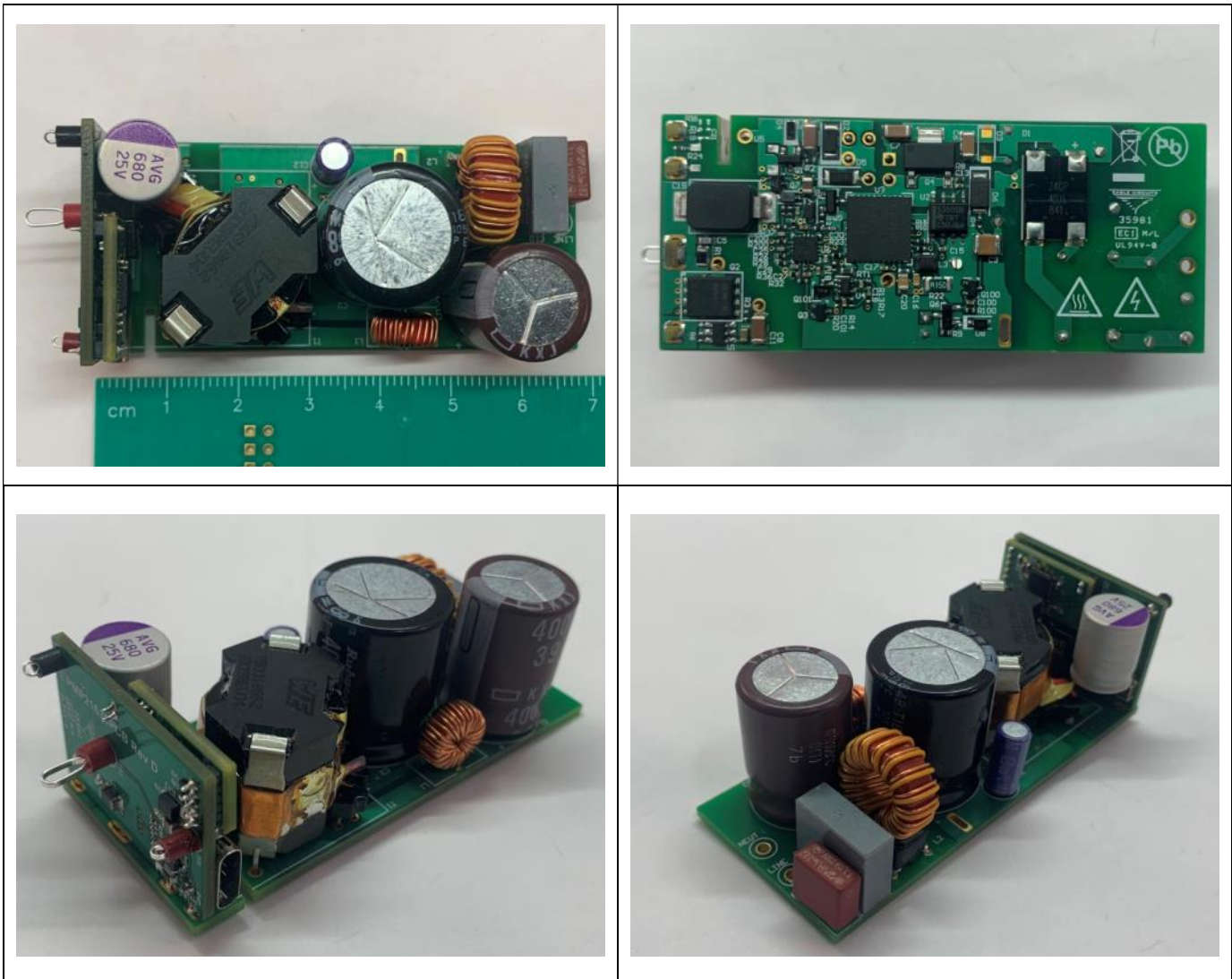
Test Report: PMP21639

65-W USB Type-C™ High Density Active Clamp Flyback With GaN Reference Design



Description

This reference design is a high density USB adapter that uses the UCC28780 active clamp flyback controller and LMG3411R150 GaN with integrated driver and protection. The maximum power rating is 65W at 20V output but is adjustable for 20V/15V/9V/5V output voltage and 3A. This design reaches a peak efficiency of 93.7%. 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 2.54" x 1.13" x 0.95" (65mm x 28mm x 25mm).



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

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1 Test Prerequisites

1.1 Voltage and Current Requirements

Table 1. Voltage and Current Requirements

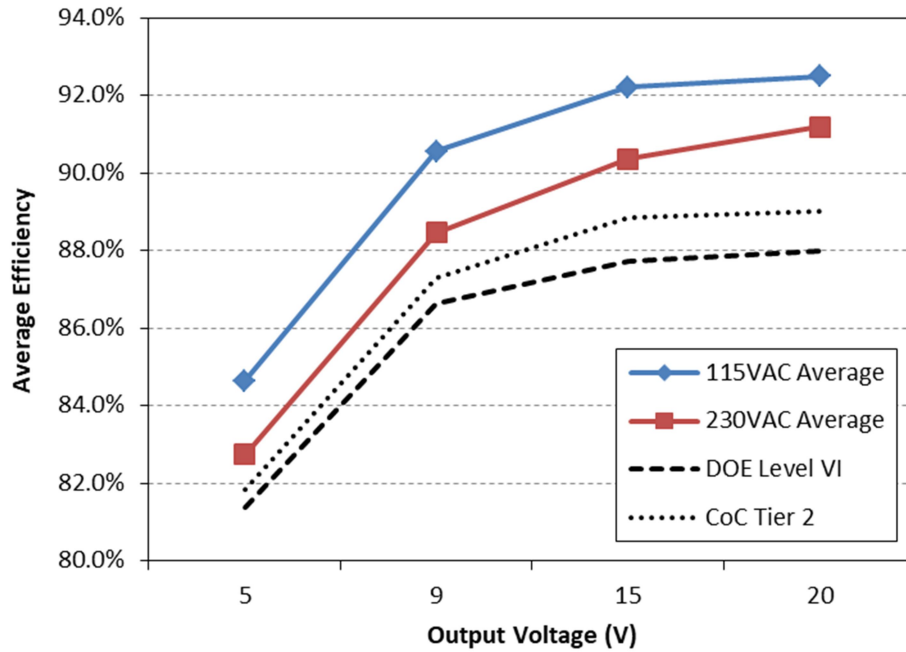
PARAMETER	SPECIFICATIONS
Line Input Voltage Range	90VACrms – 265VACrms
Line Input Frequency	50Hz/60Hz
Output Voltage/Current	5V/3A, 9V/3A, 15V/3A, 20V/3.25A

2 Testing and Results

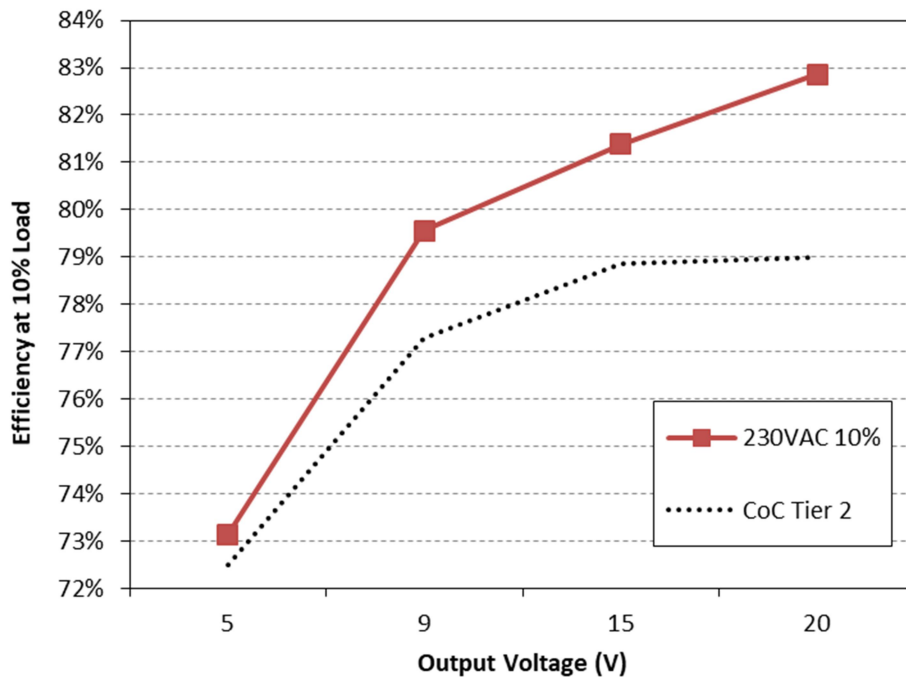
2.1 Efficiency

Data measured on Rev C2 board.

2.1.1 Average Efficiency



2.1.2 Efficiency at 10% Load



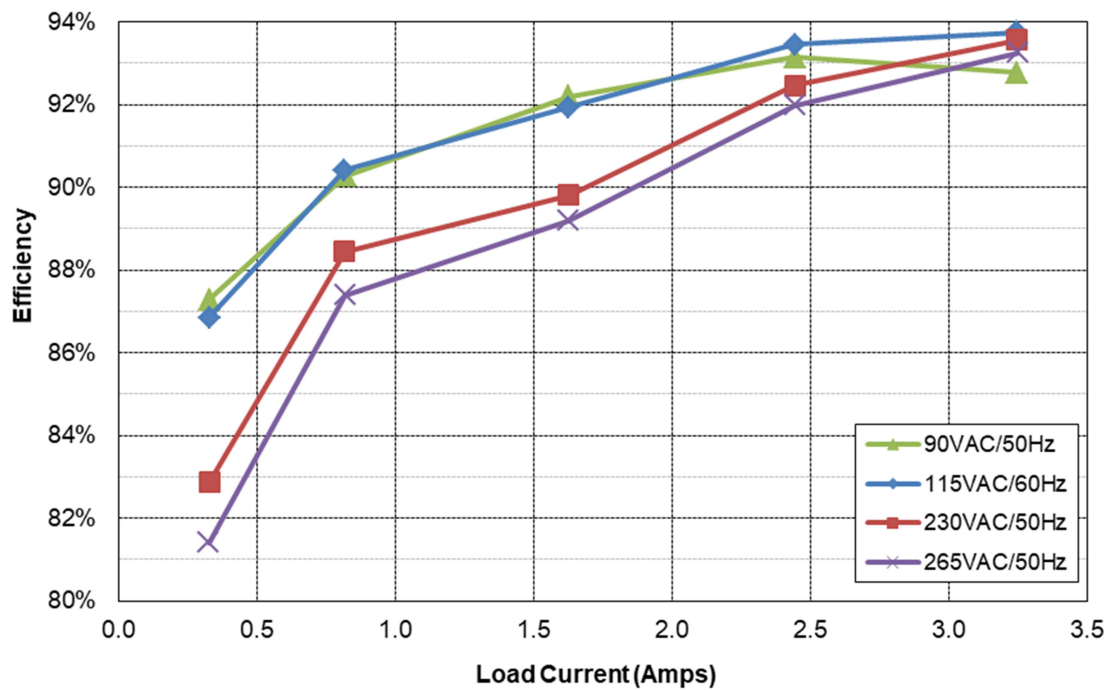
2.1.3 Standby (Output Cable Unplugged)

Vin RMS	Line Frequency	Pin (mW)
115V	60	36.2
230V	50	41.4

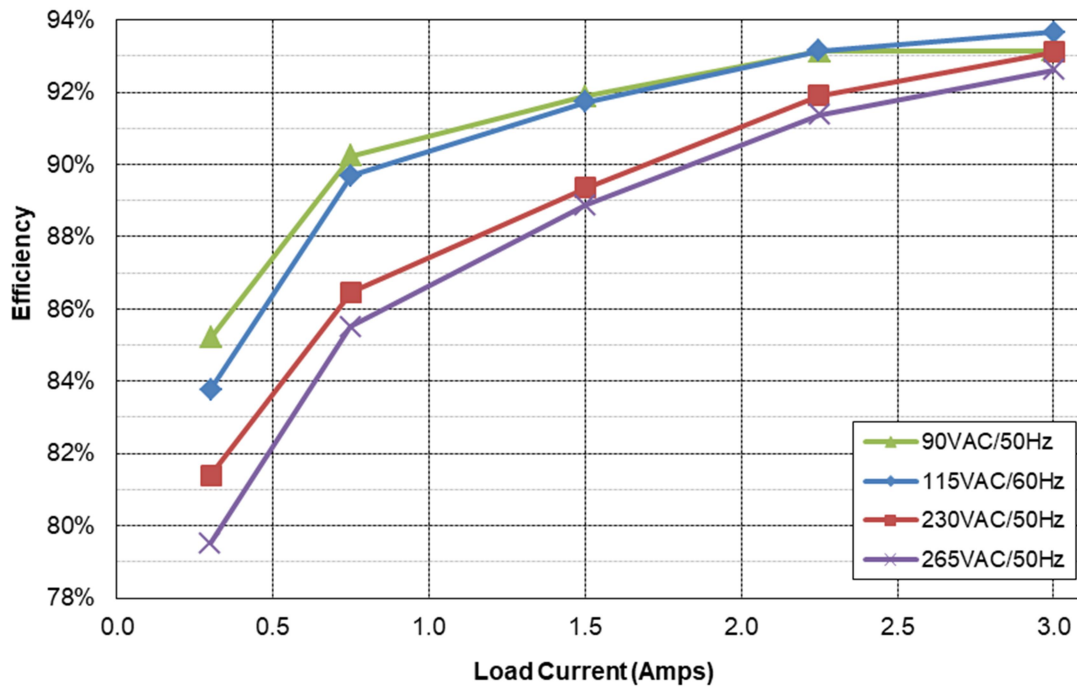
2.1.4 Tiny Load (20V Output at 250mw Load)

Vin RMS	Line Frequency	Efficiency
115V	60	56.8%
230V	50	59.4%

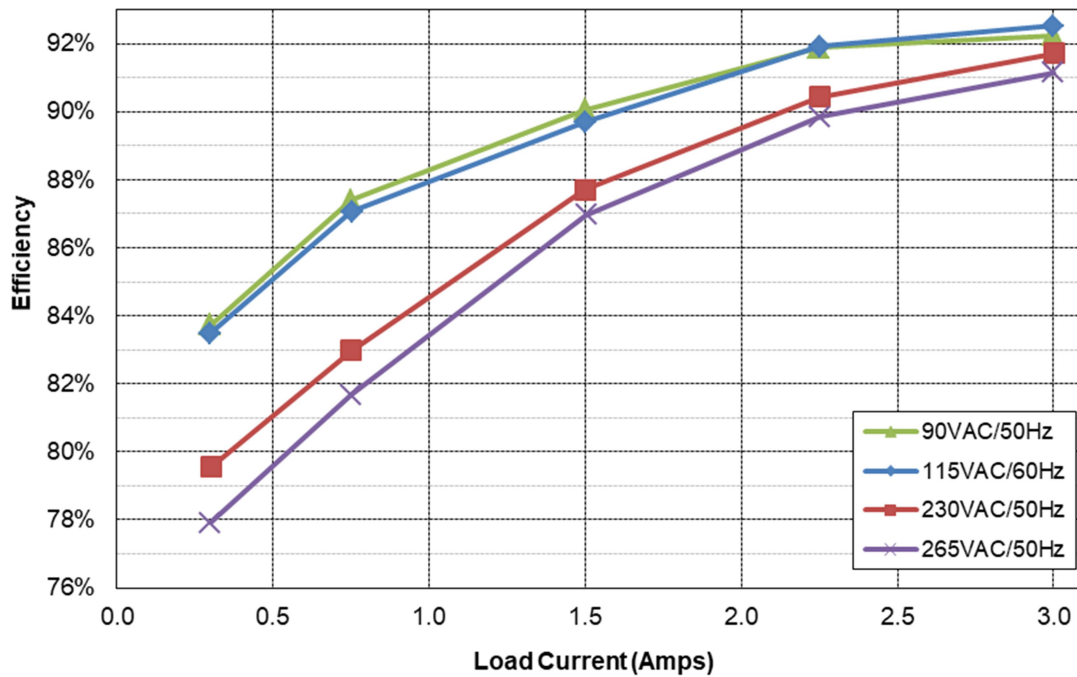
2.1.5 20V Output



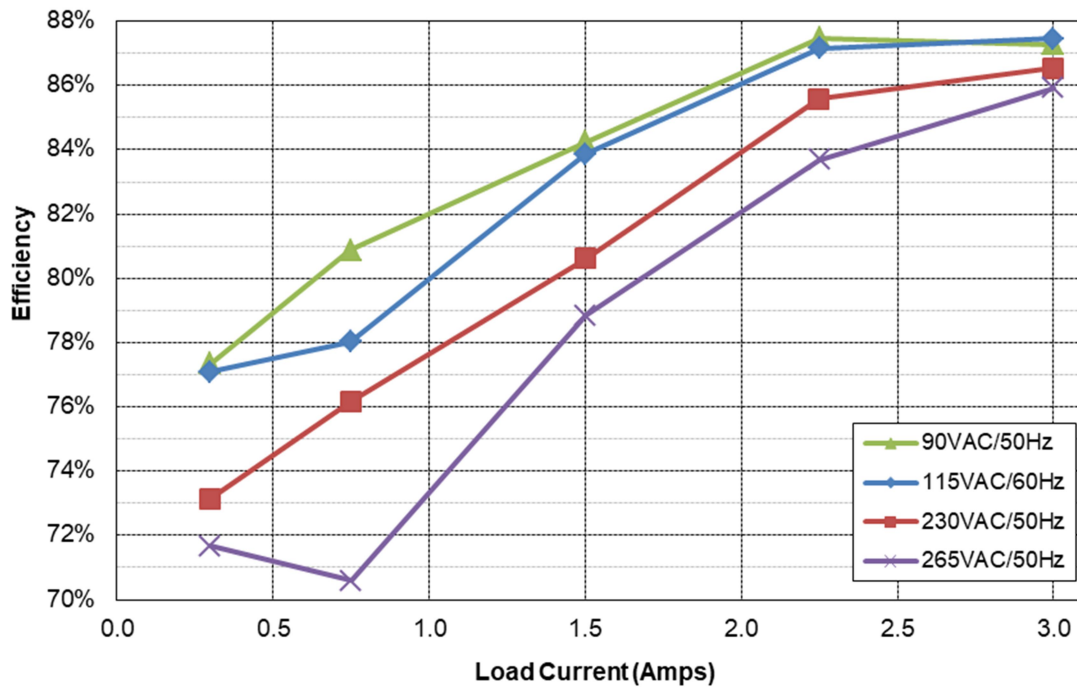
2.1.6 15V Output



2.1.7 9V Output



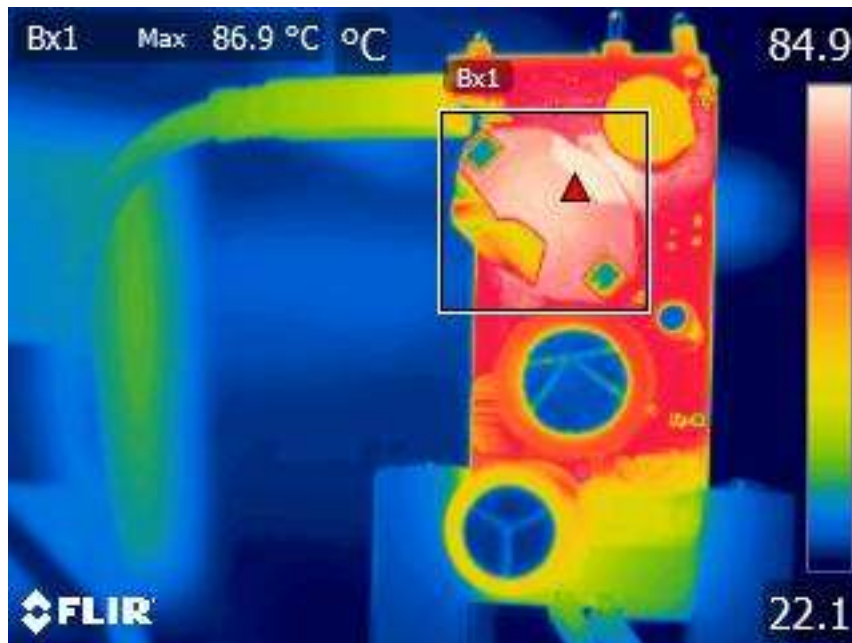
2.1.8 5V Output

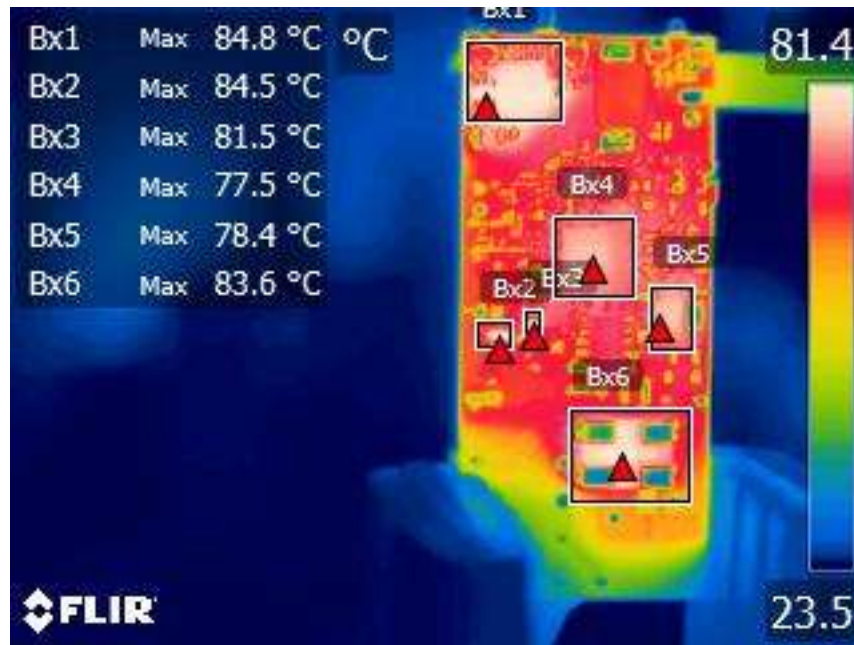


2.2 Thermal Images

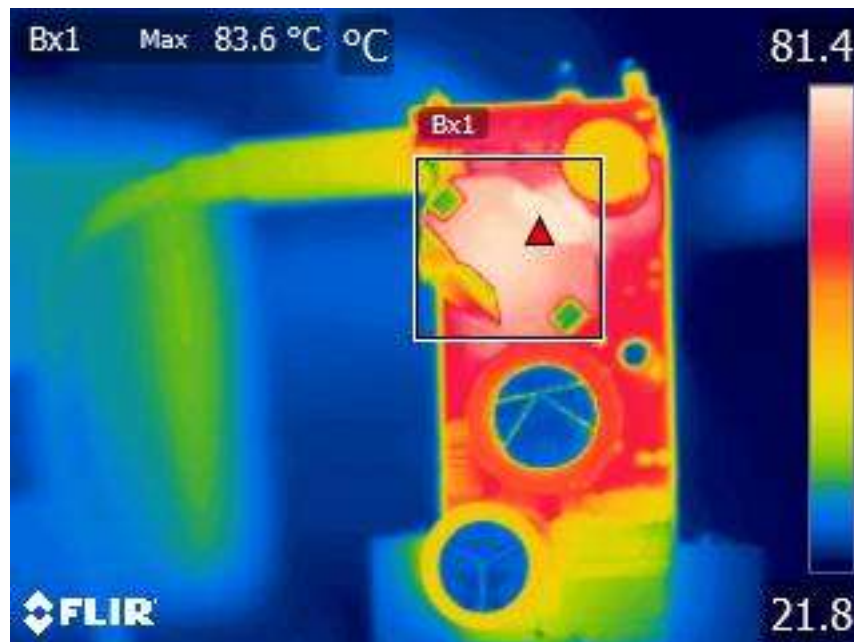
All images captured open frame, 25°C ambient, after a 30-minute warm up period. Data taken on Rev C2 board.

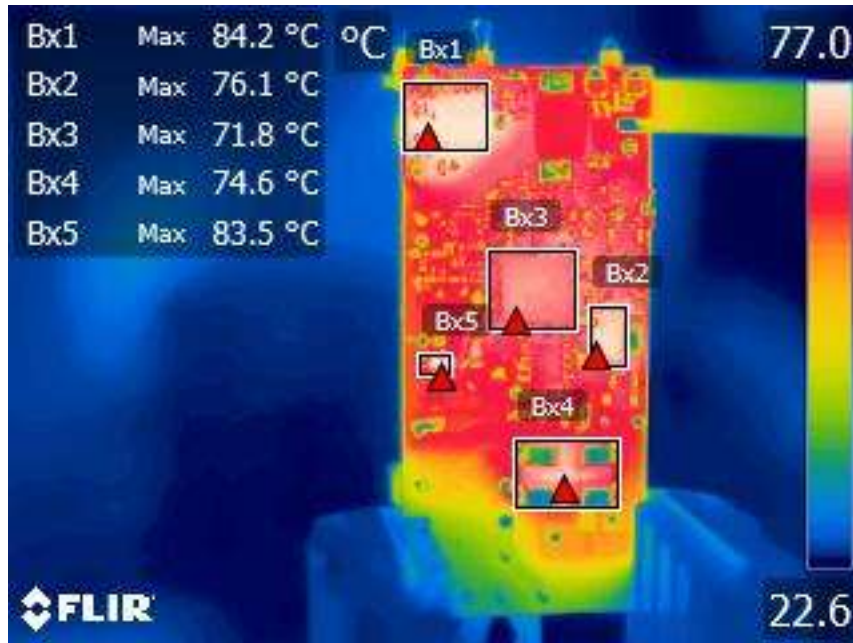
2.2.1 90VAC/50Hz Input, 20V/3.25A Output





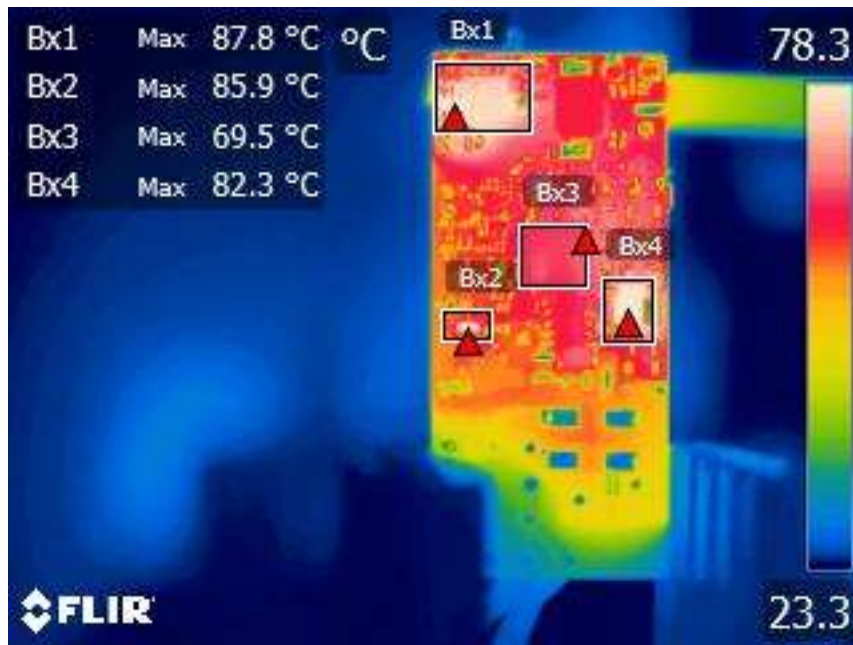
2.2.2 115VAC/60Hz Input, 20V/3.25A Output



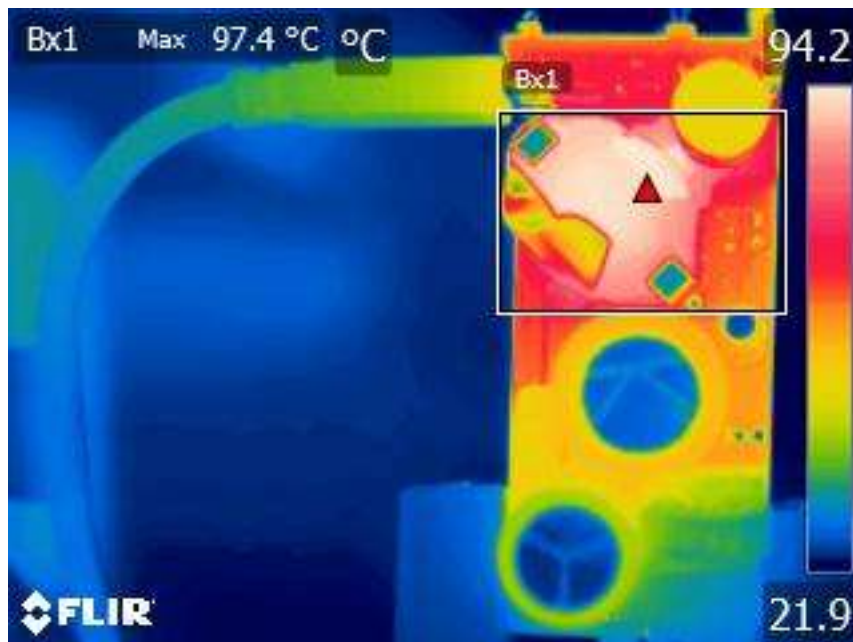


2.2.3 230VAC/50Hz Input, 20V/3.25A Output





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

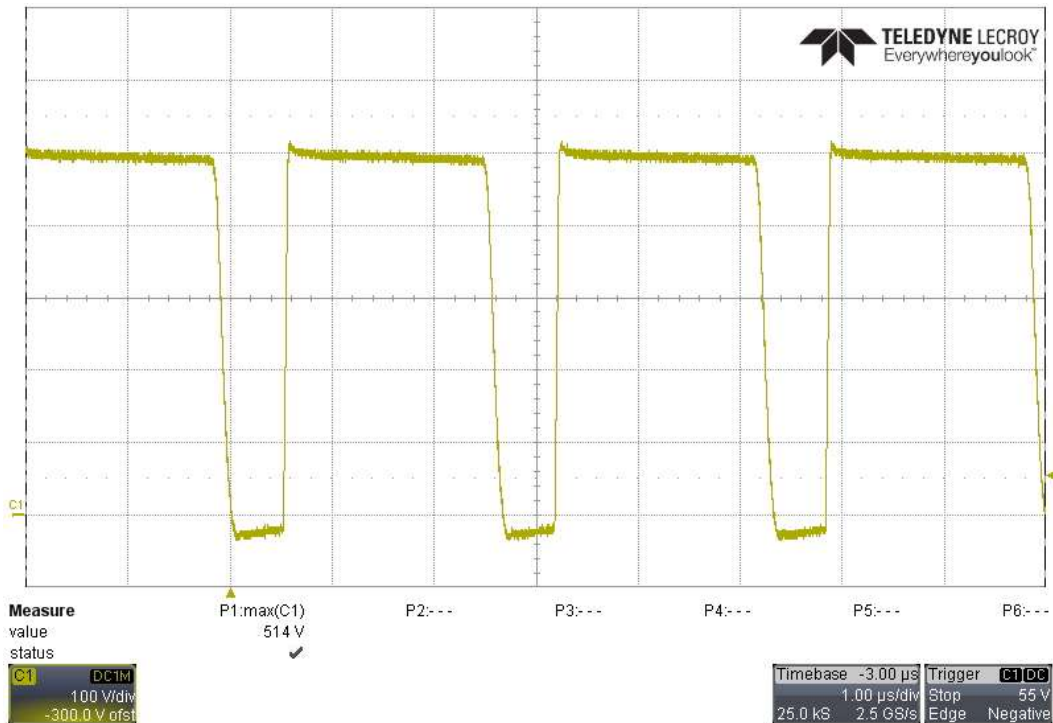




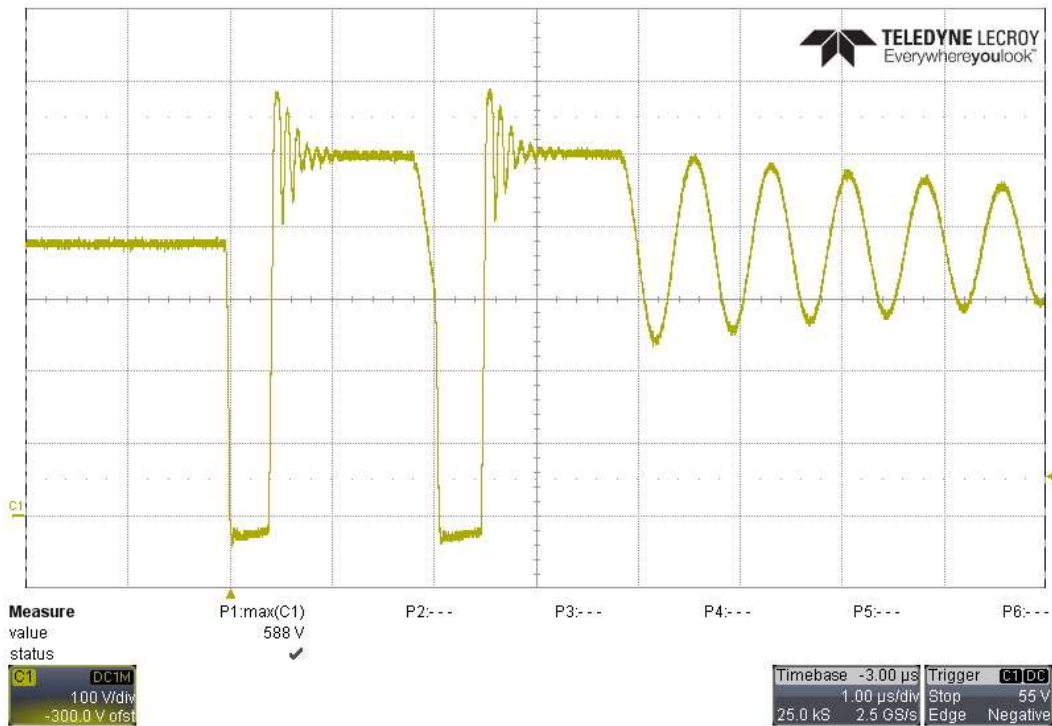
2.3 Switching Waveforms

Data taken on Rev C2 board.

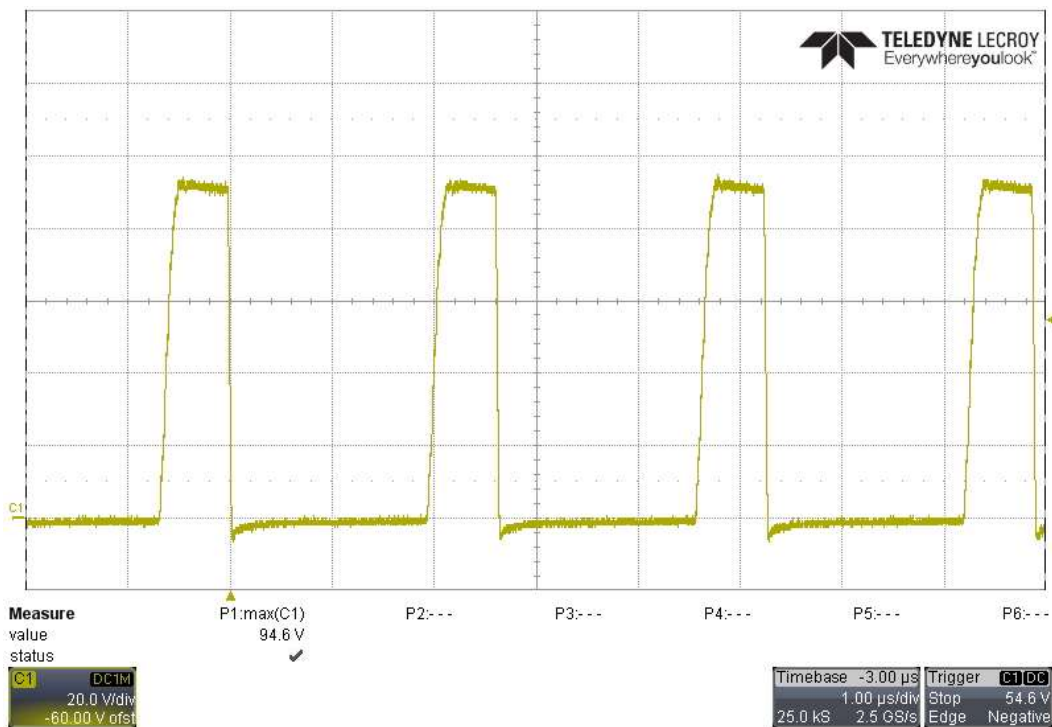
2.3.1 Primary Switch Node, 265VAC/50Hz Input, 20V/3.25A Output



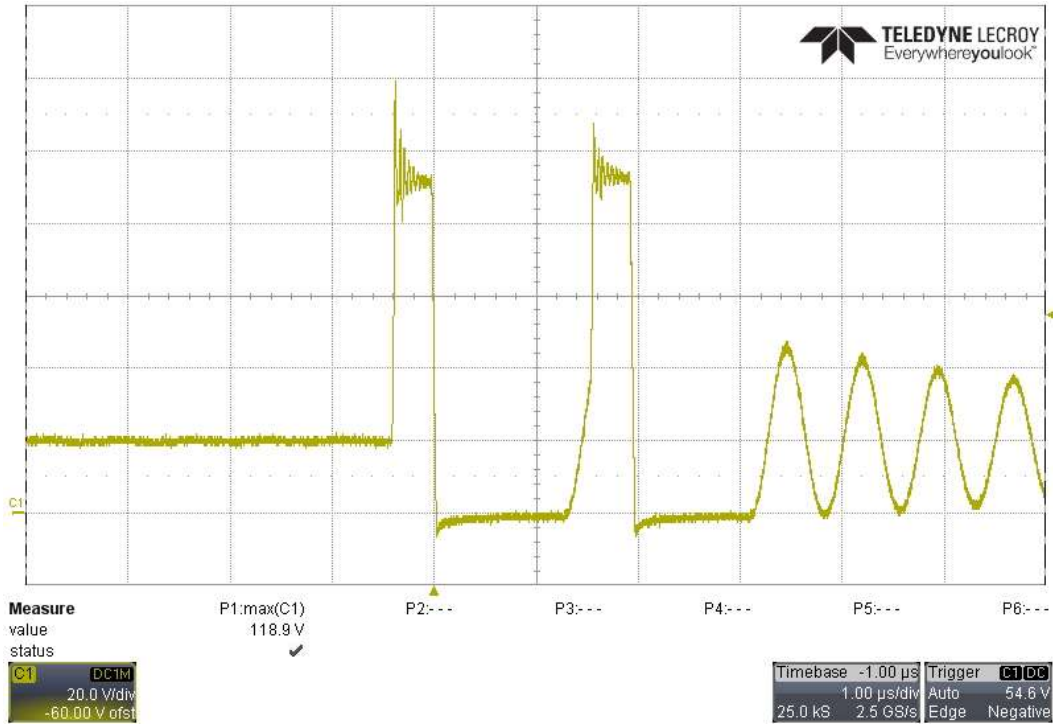
2.3.2 Primary Switch Node, 265VAC/50Hz Input, 20V/300mA Output



2.3.3 Vds of SR FET (Q2), 265VAC/50Hz Input, 20V/3.25A Output



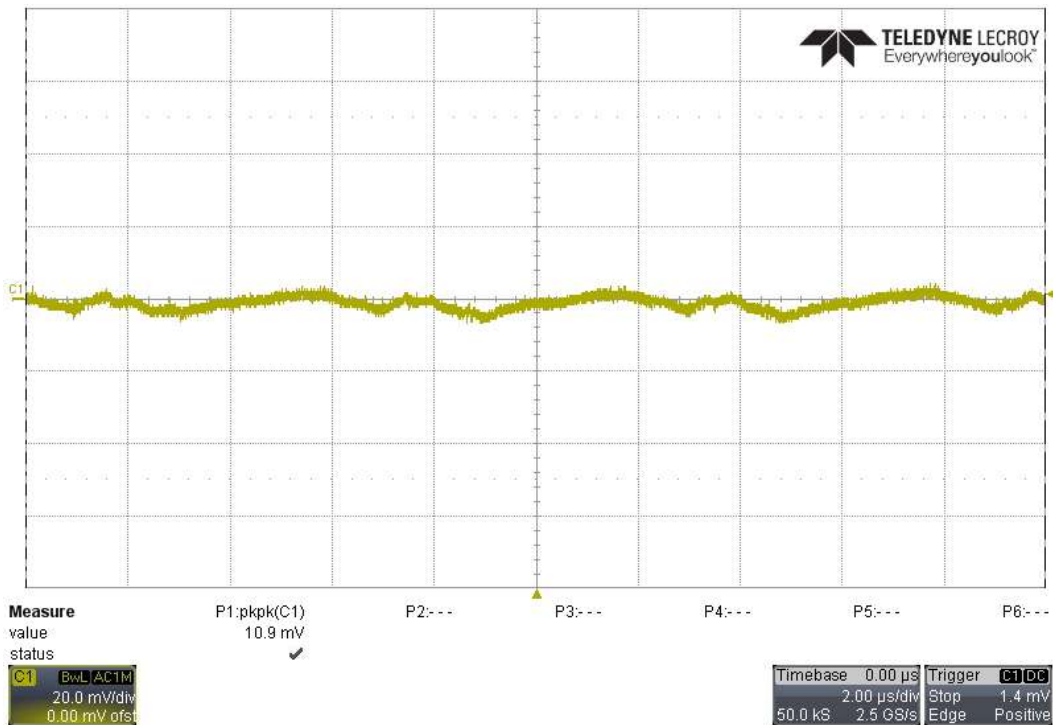
2.3.4 Vds of SR FET (Q2), 265VAC/50Hz Input, 20V/300mA Output



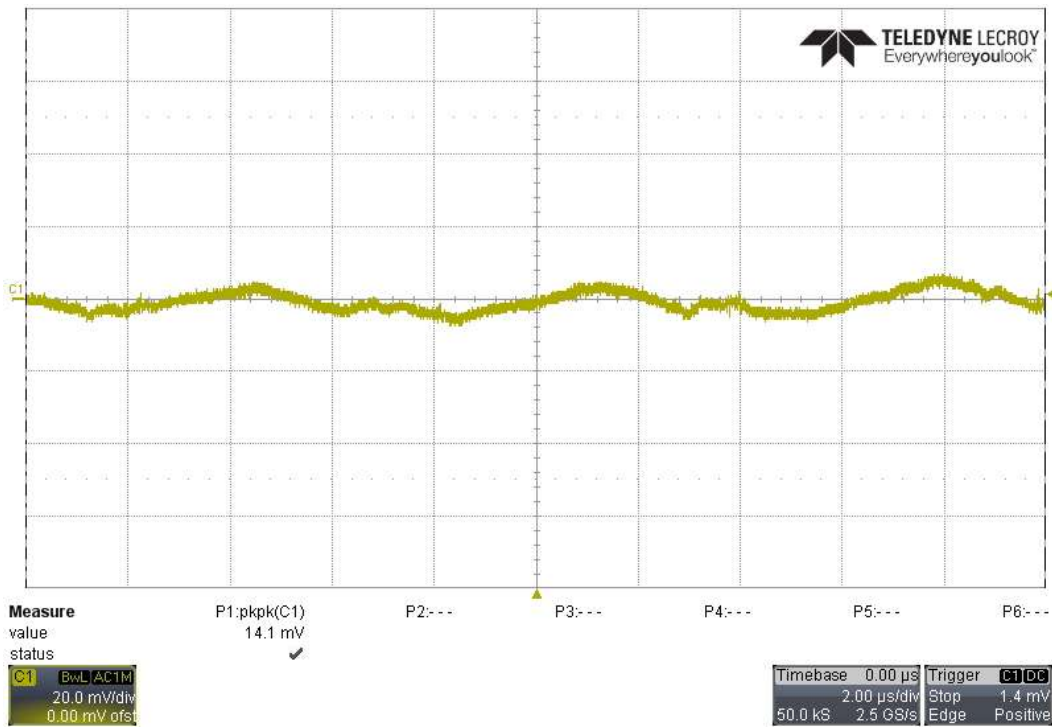
2.4 Output Voltage Ripple at Maximum Load Current

Data taken on Rev C2 board.

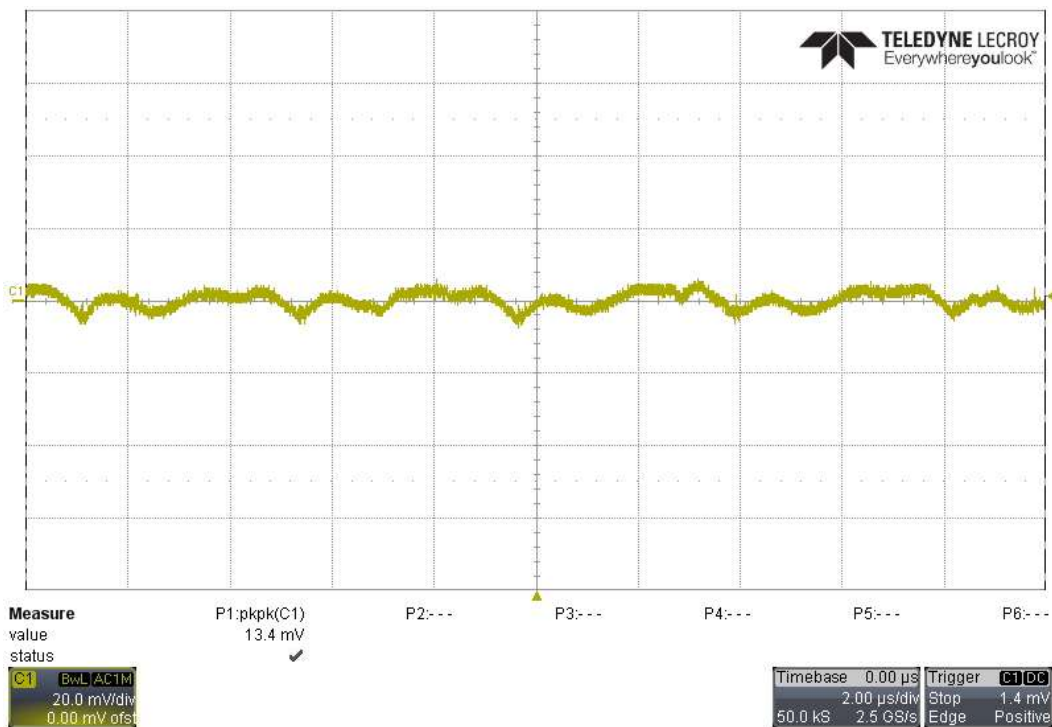
2.4.1 5V/3A Output, 115VAC/60Hz Input



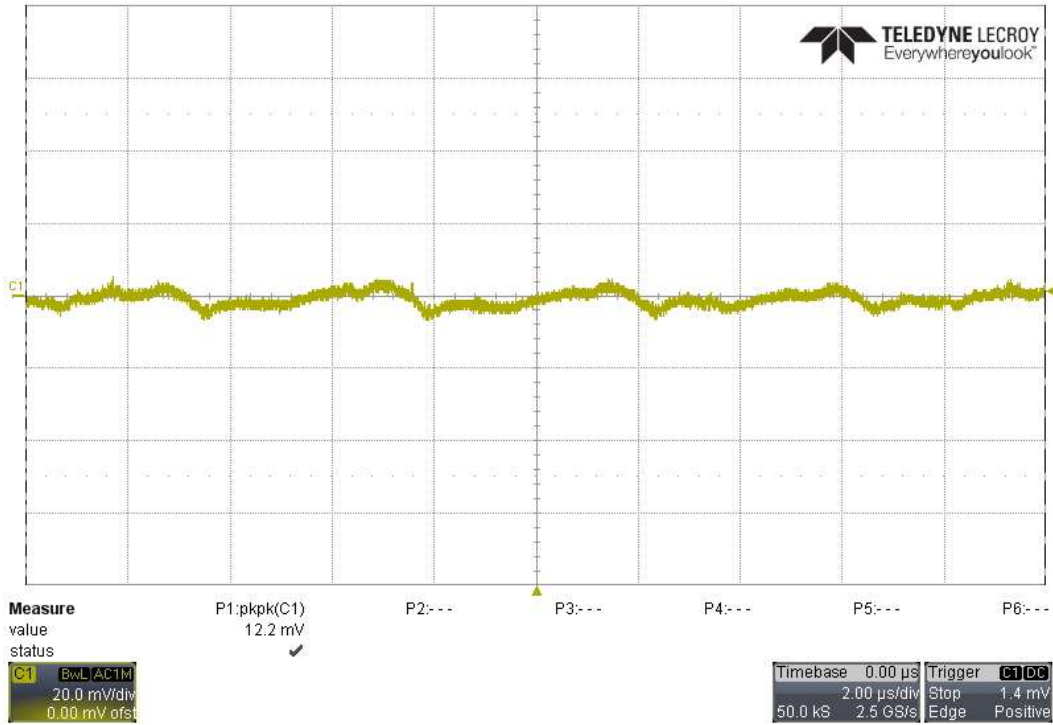
2.4.2 5V/3A Output, 230VAC/50Hz Input



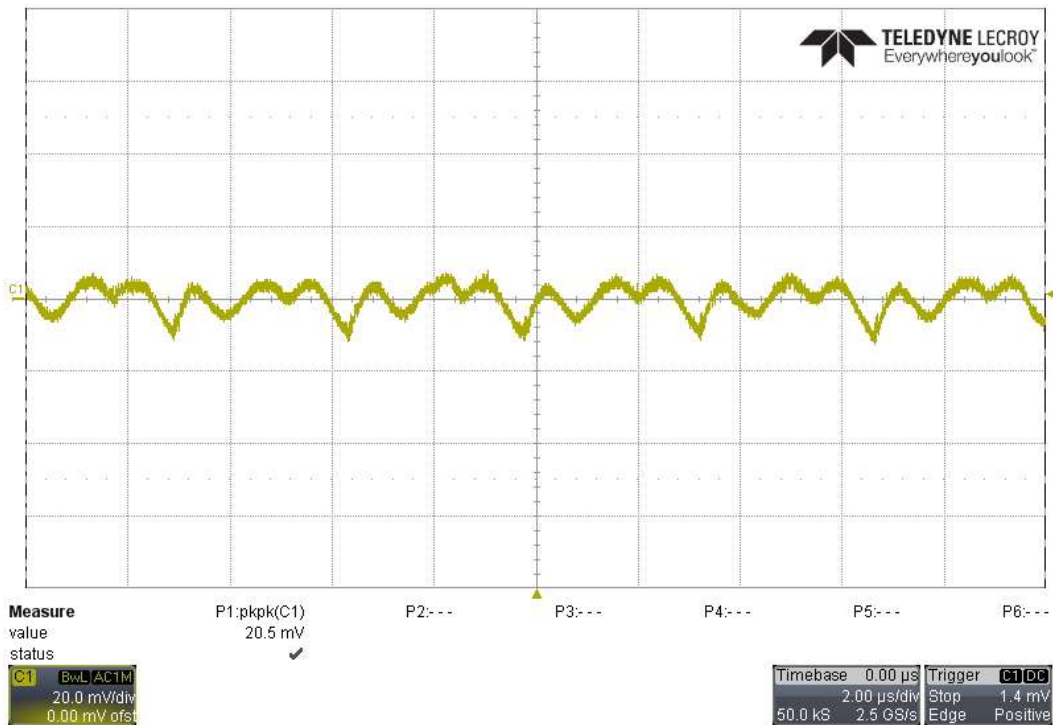
2.4.3 9V/3A Output, 115VAC/60Hz Input



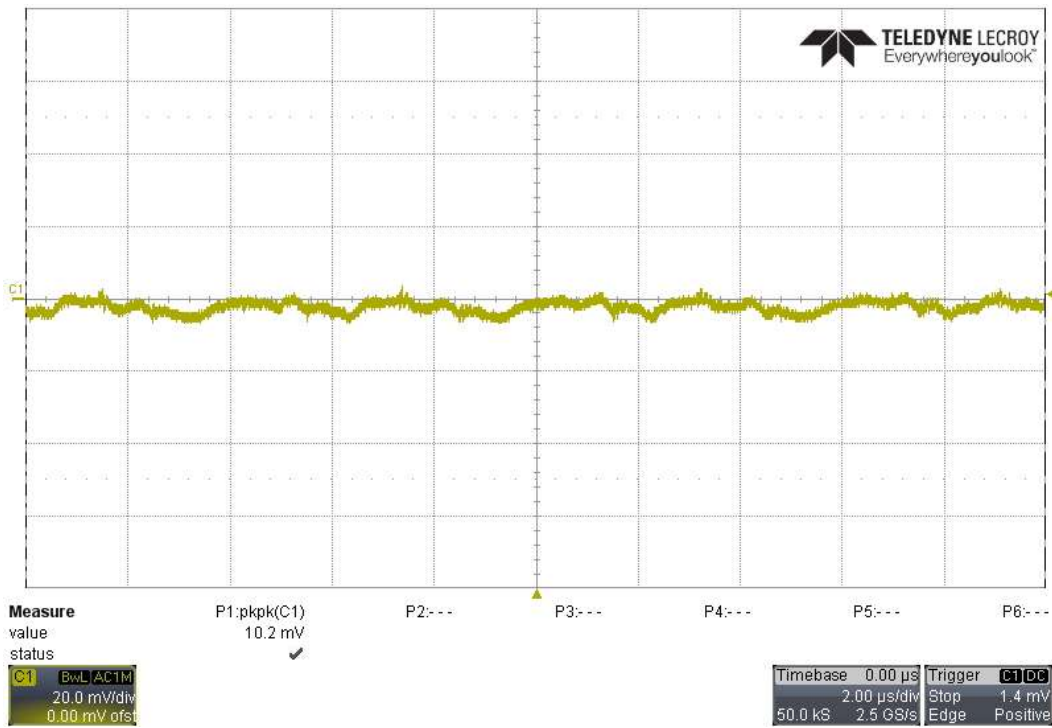
2.4.4 9V/3A Output, 230VAC/50Hz Input



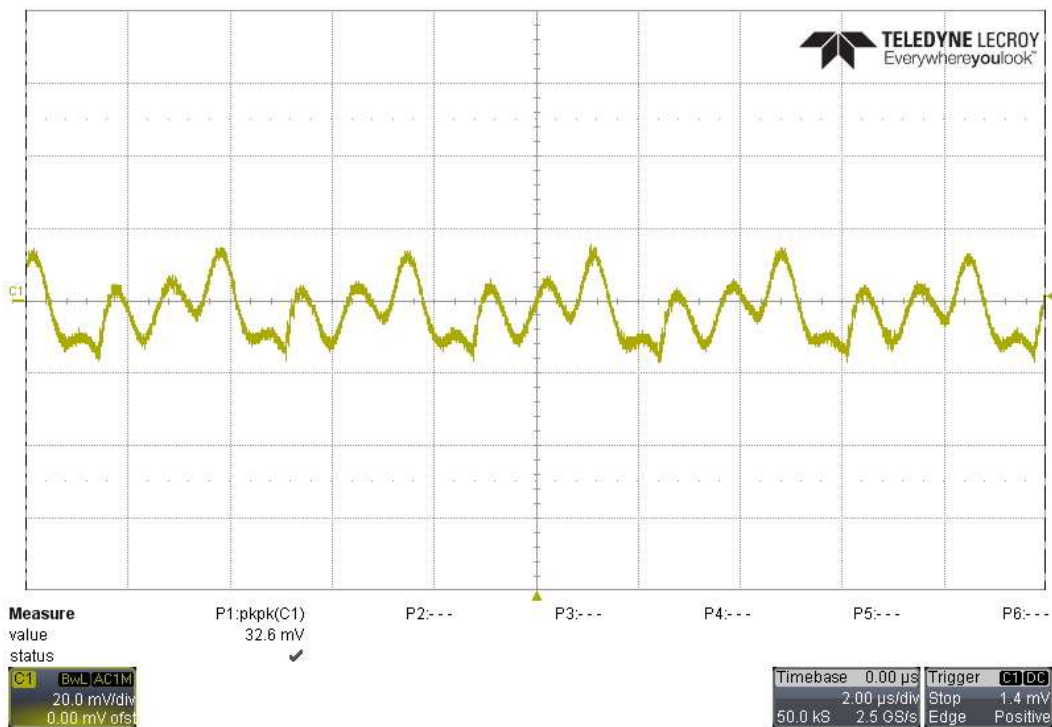
2.4.5 15V/3A Output, 115VAC/60Hz Input



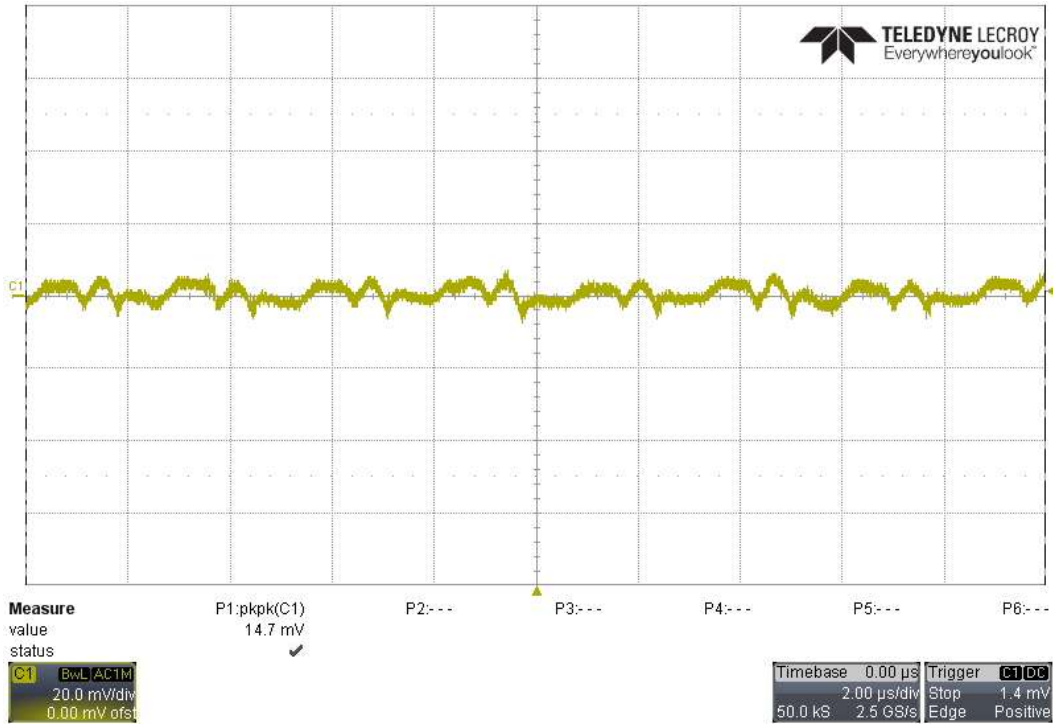
2.4.6 15V/3A Output, 230VAC/50Hz Input



2.4.7 20V/3.25A Output, 115VAC/60Hz Input



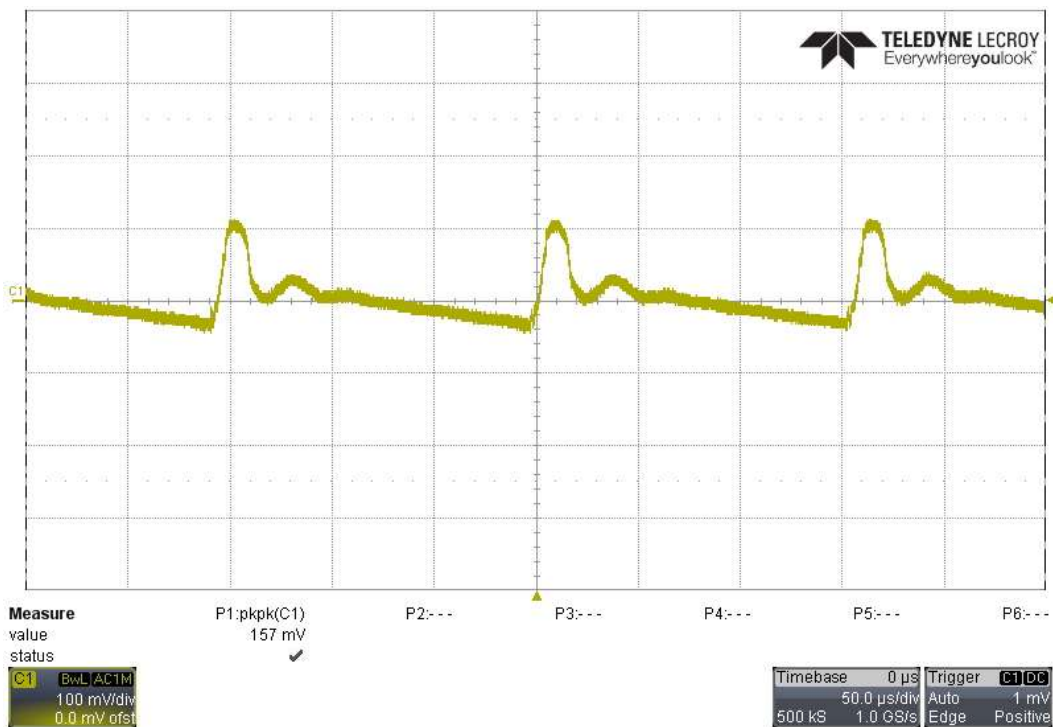
2.4.8 20V/3.25A Output, 230VAC/50Hz Input



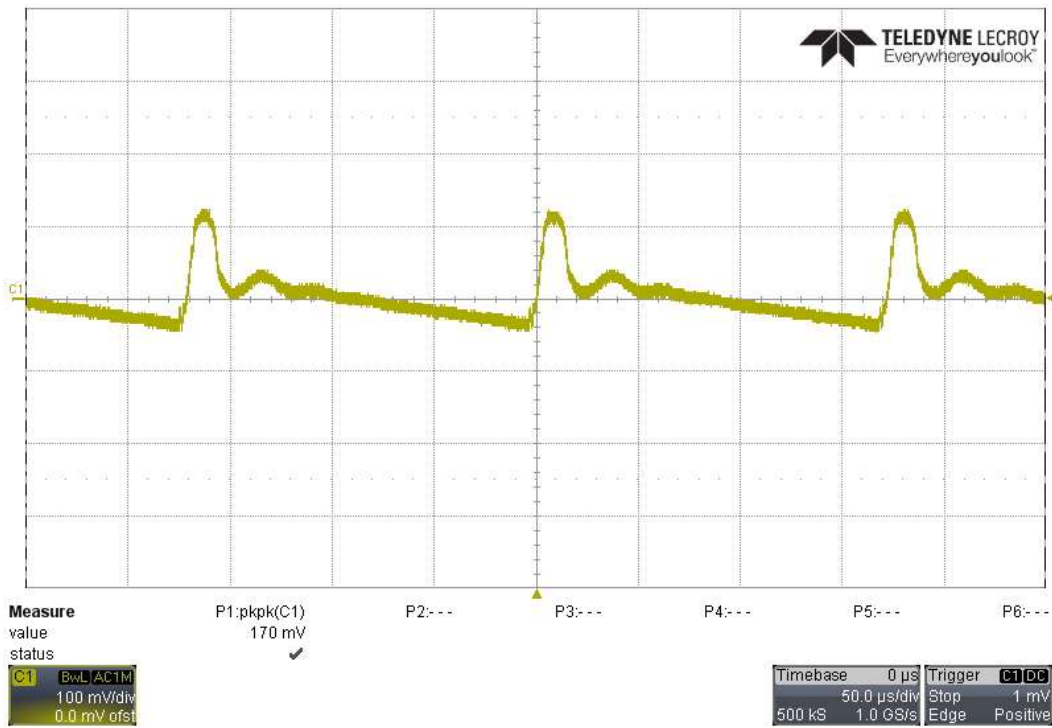
2.5 Output Voltage Ripple during Low Power Mode

Data taken on Rev C2 board.

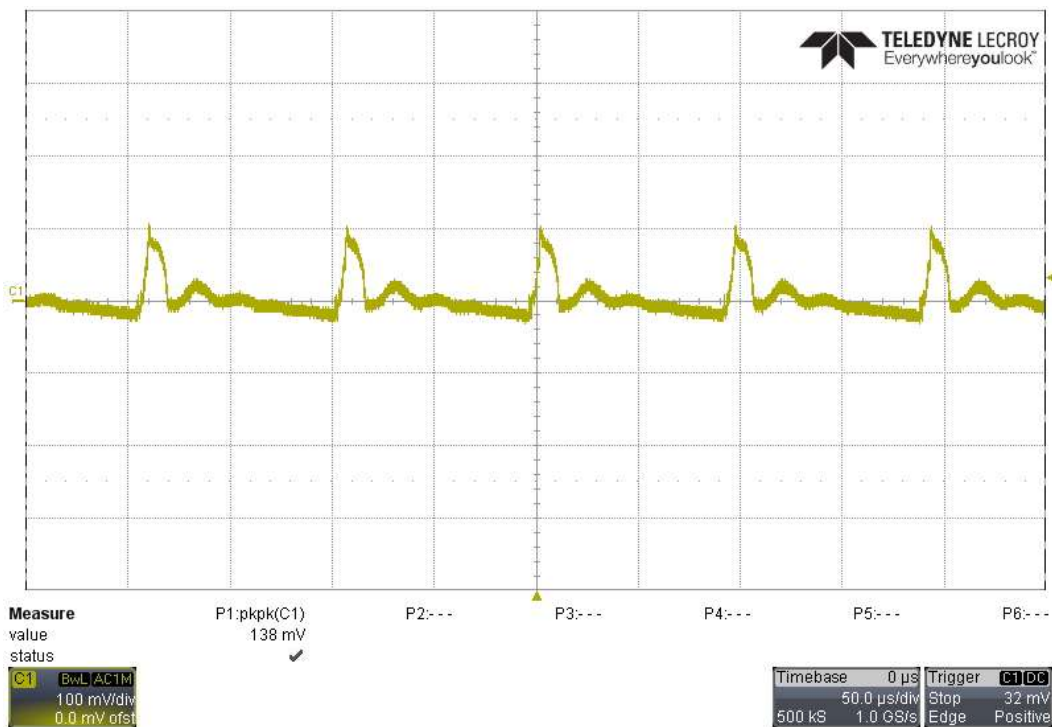
2.5.1 5V/300mA Output, 115VAC/60Hz Input



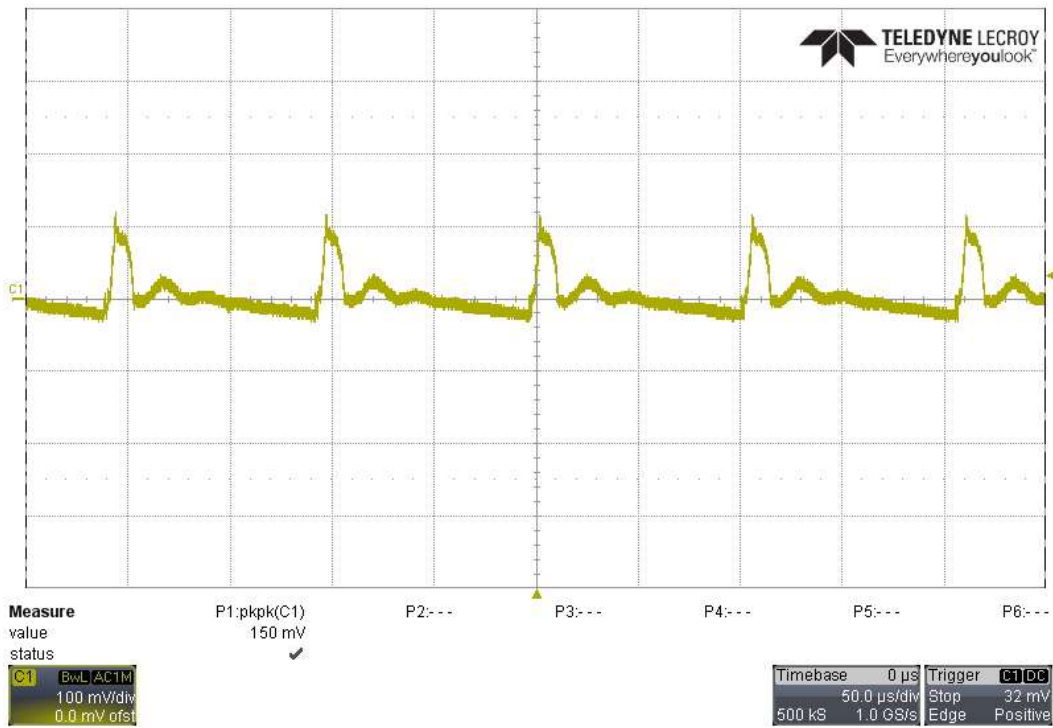
2.5.2 5V/300mA Output, 230VAC/50Hz Input



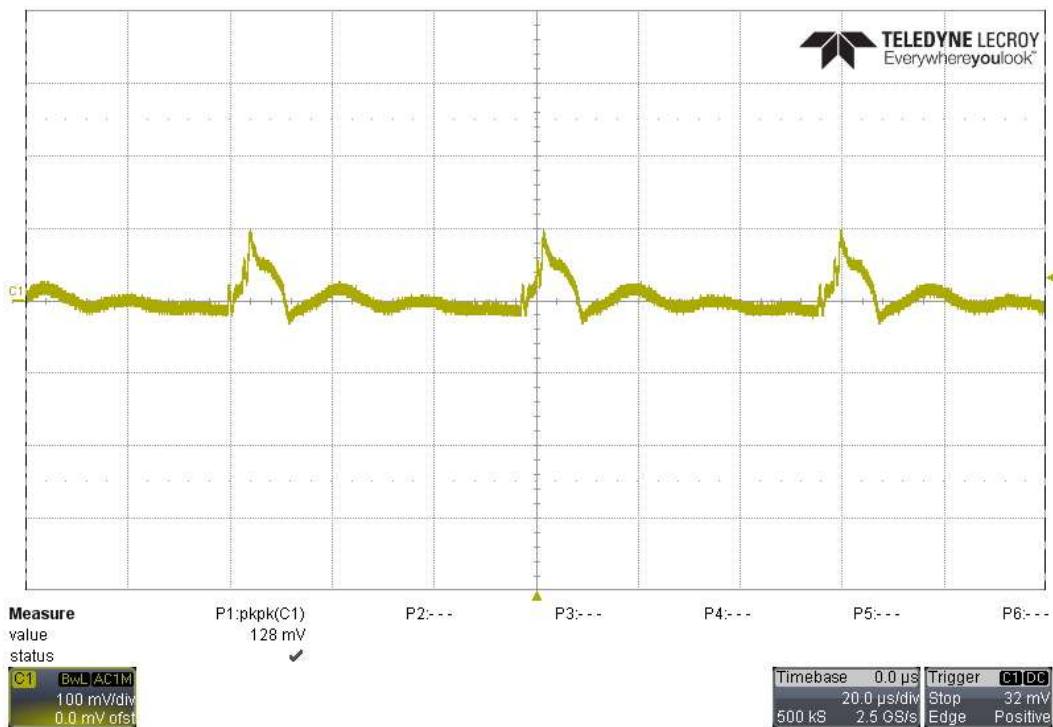
2.5.3 9V/300mA Output, 115VAC/60Hz Input



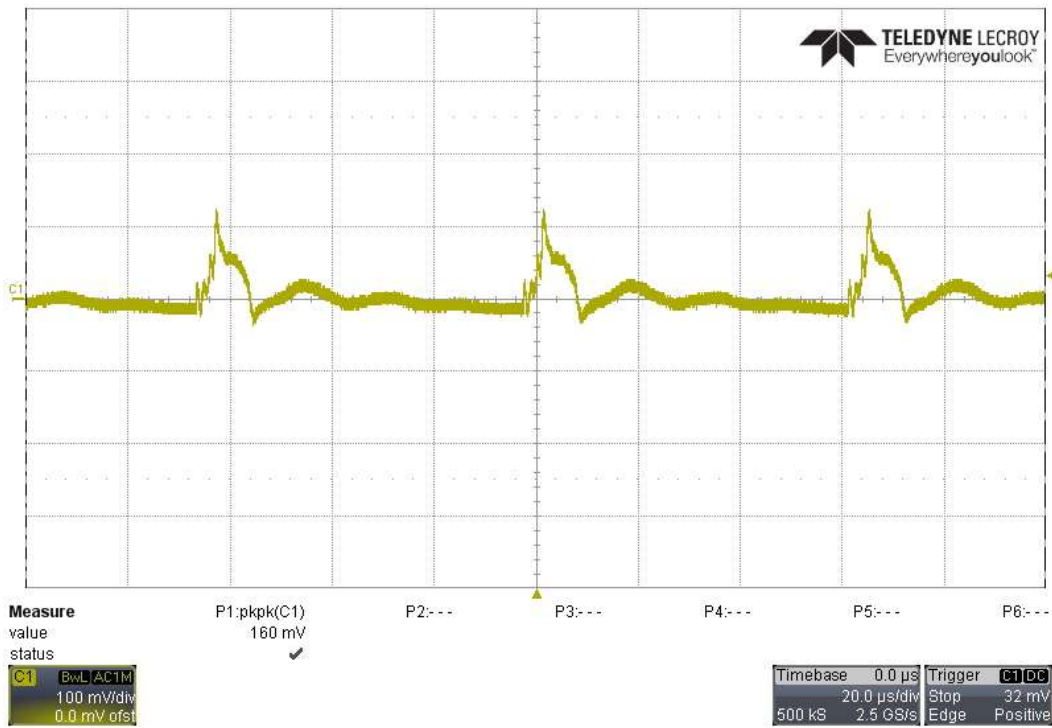
2.5.4 9V/300mA Output, 230VAC/50Hz Input



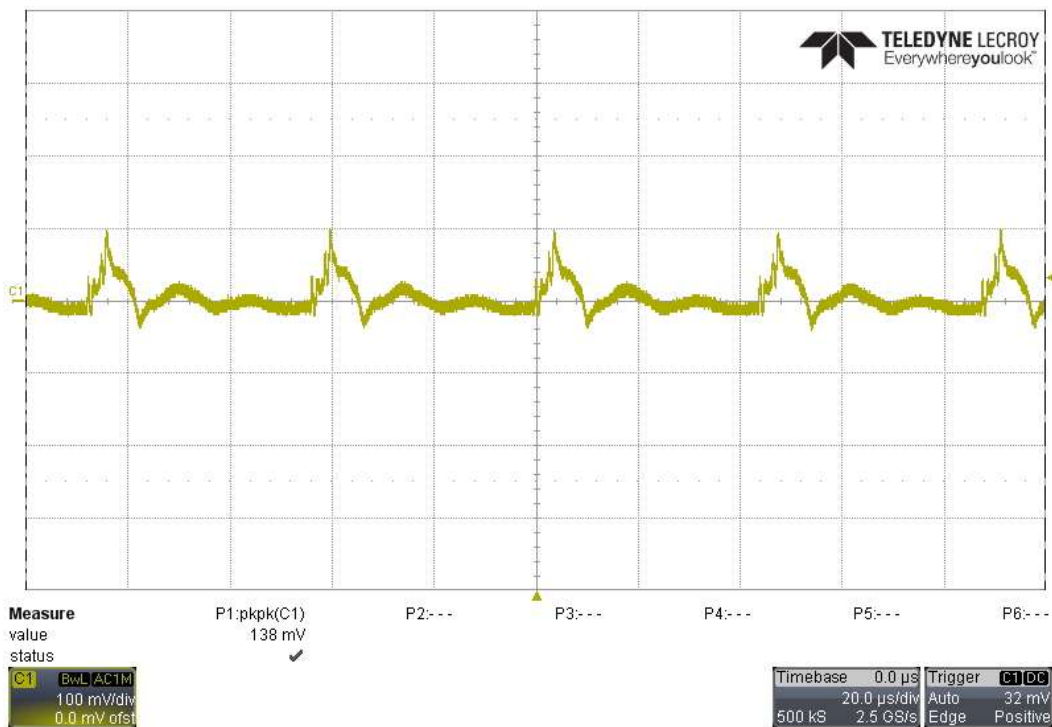
2.5.5 15V/300mA Output, 115VAC/60Hz Input



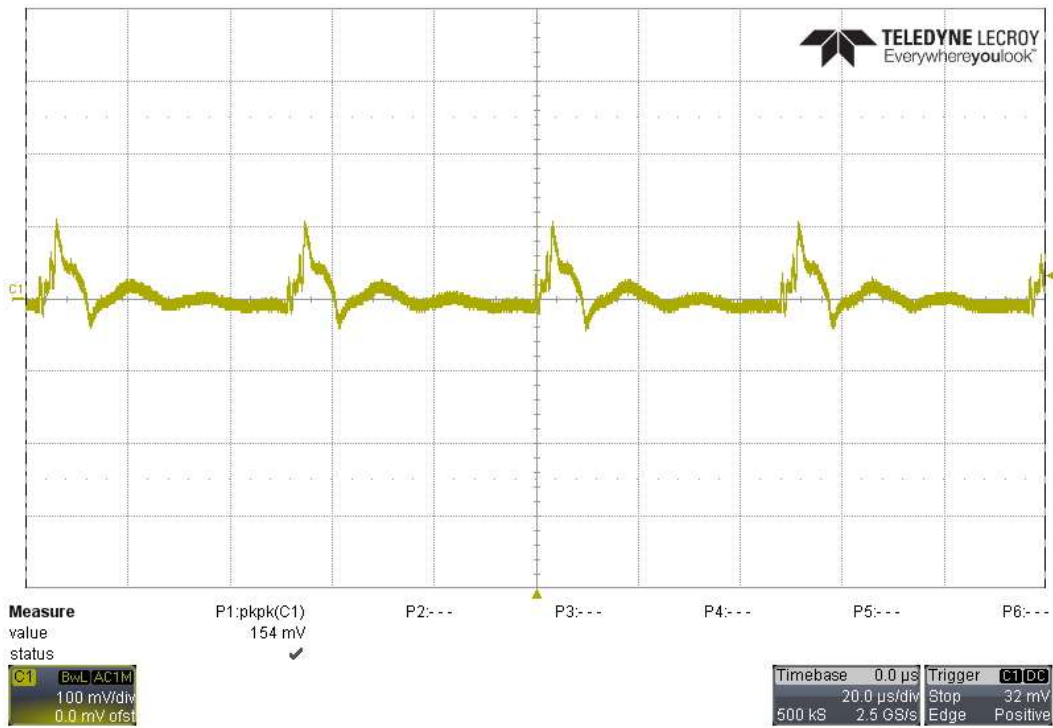
2.5.6 15V/300mA Output, 230VAC/50Hz Input



2.5.7 20V/300mA Output, 115VAC/60Hz Input

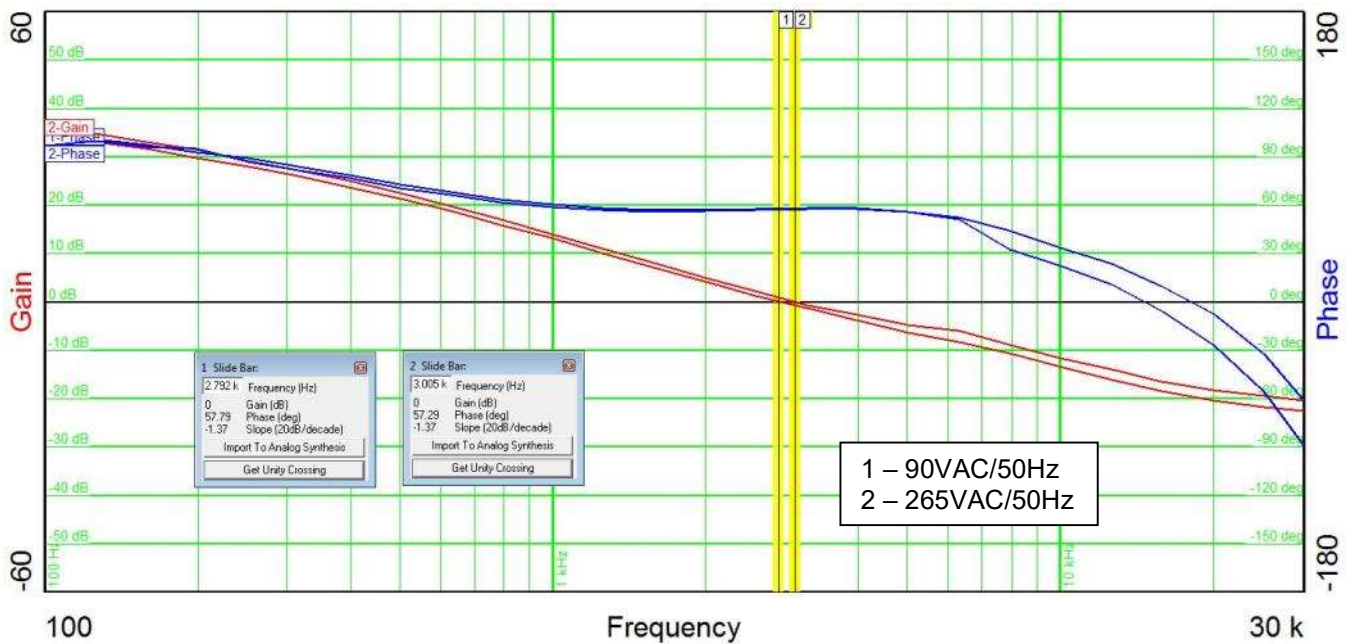


2.5.8 20V/300mA Output, 230VAC/50Hz Input

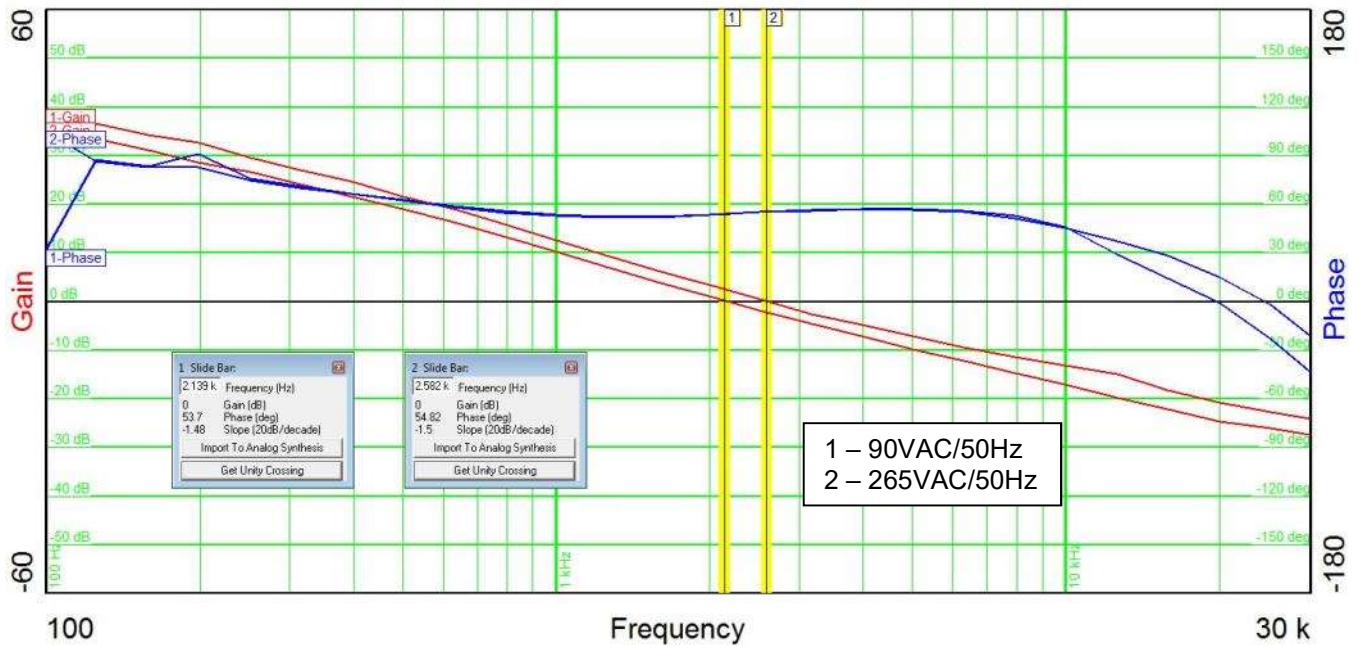


2.6 Bode Plot

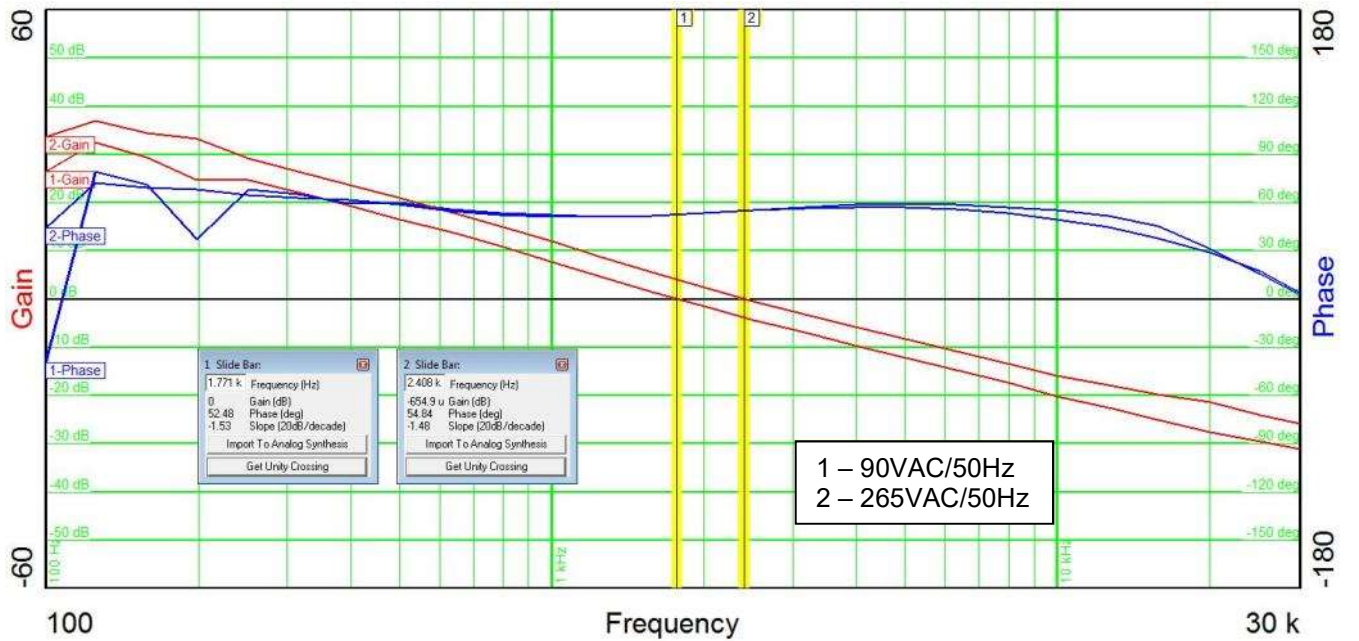
2.6.1 5V/3A Output



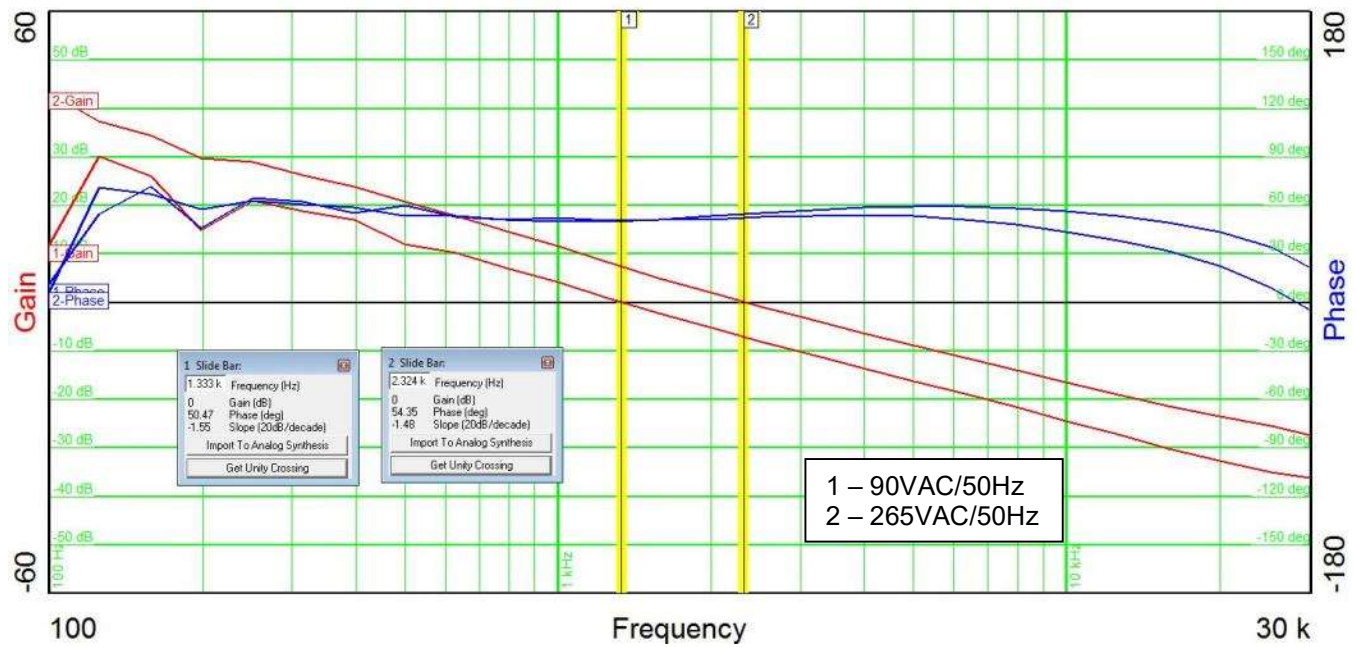
2.6.2 9V/3A Output



2.6.3 15V/3A Output

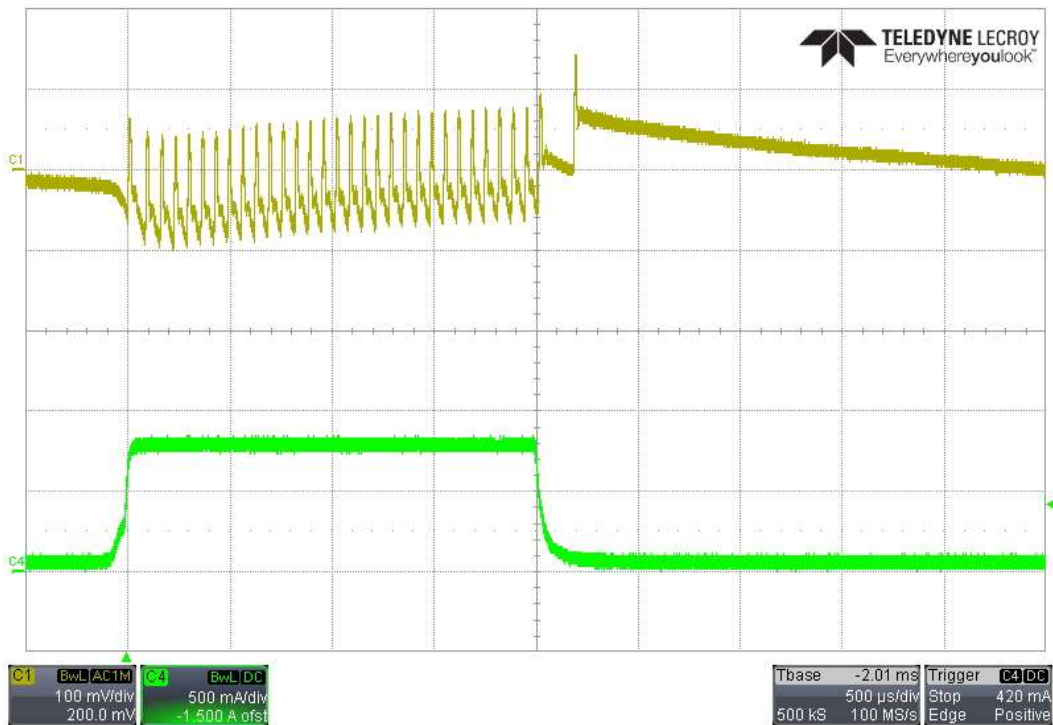


2.6.4 20V/3.25A Output

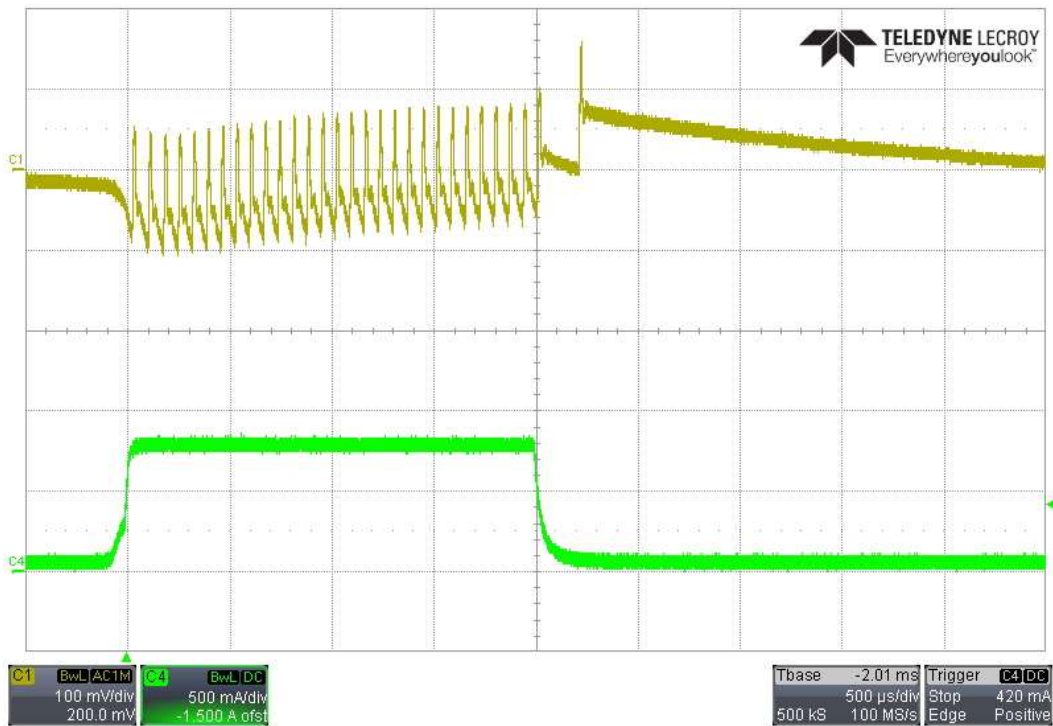


2.7 5V Output Load Transients

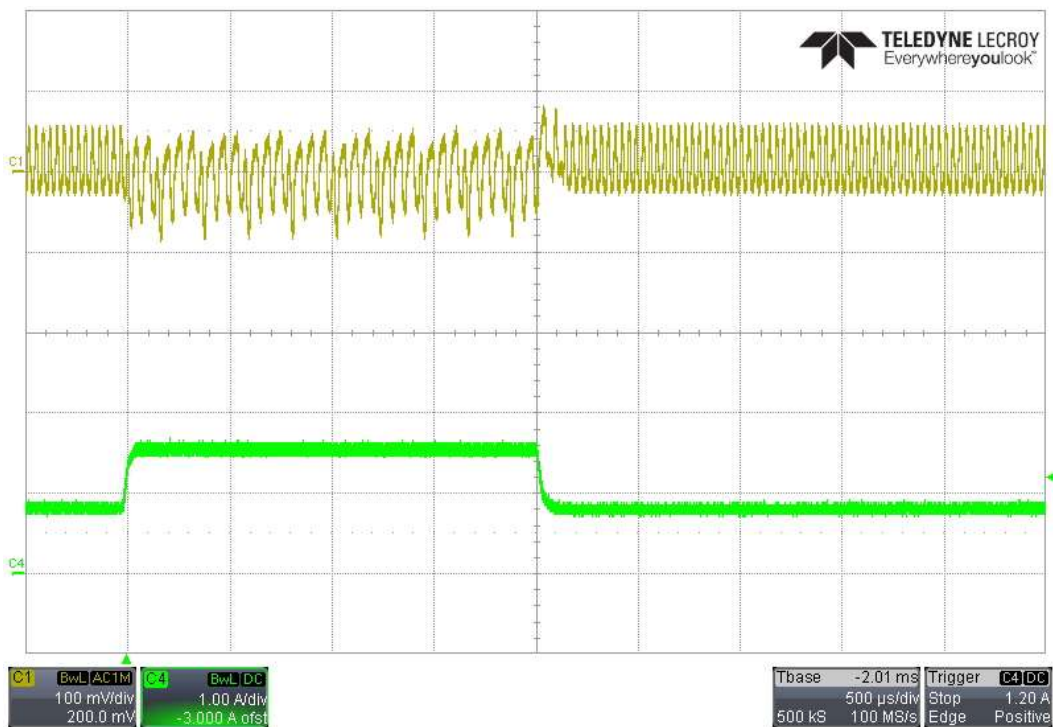
2.7.1 5V Output, 0A to 750mA Load Step, 115VAC/60Hz Input



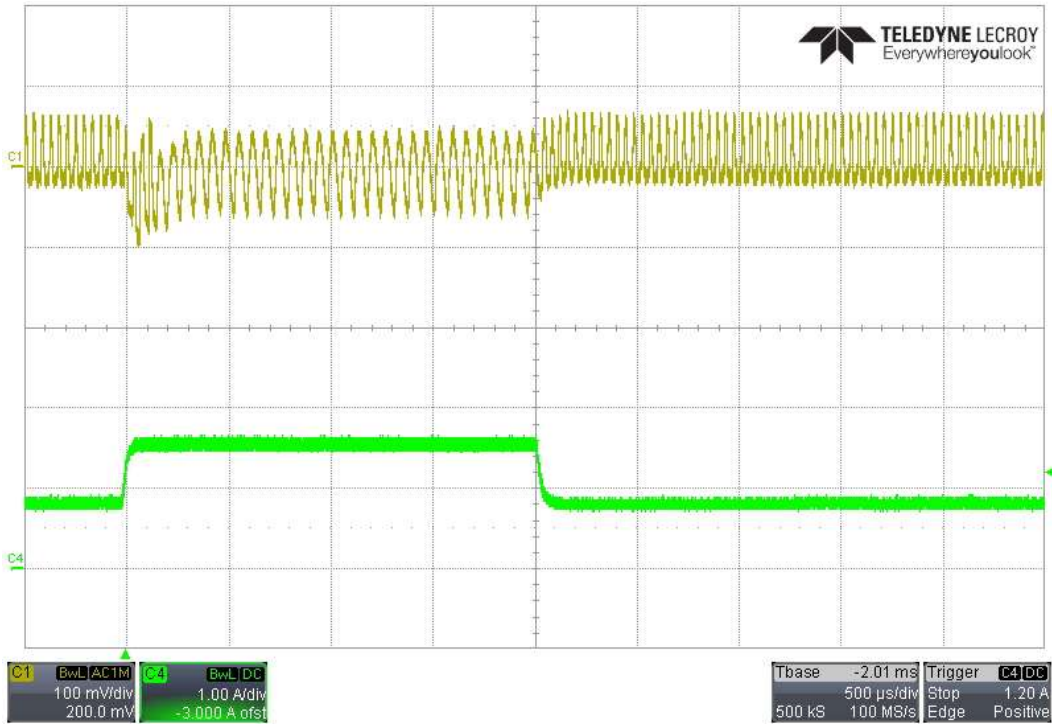
2.7.2 5V Output, 0A to 750mA Load Step, 230VAC/50Hz Input



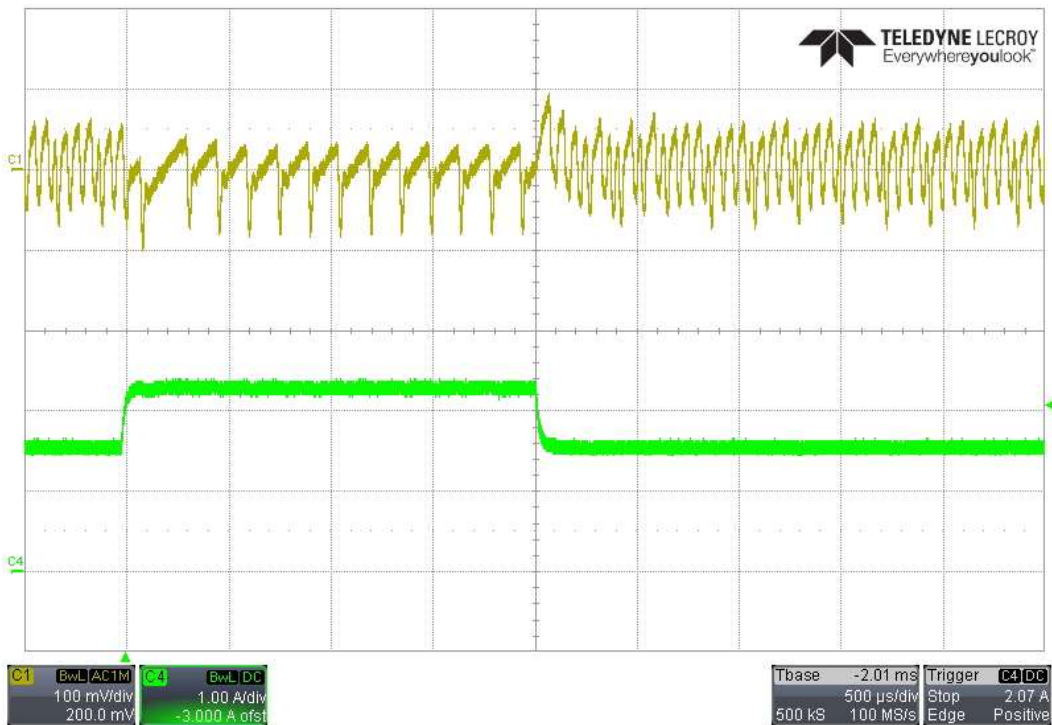
2.7.3 5V Output, 750mA to 1.5A Load Step, 115VAC/60Hz Input



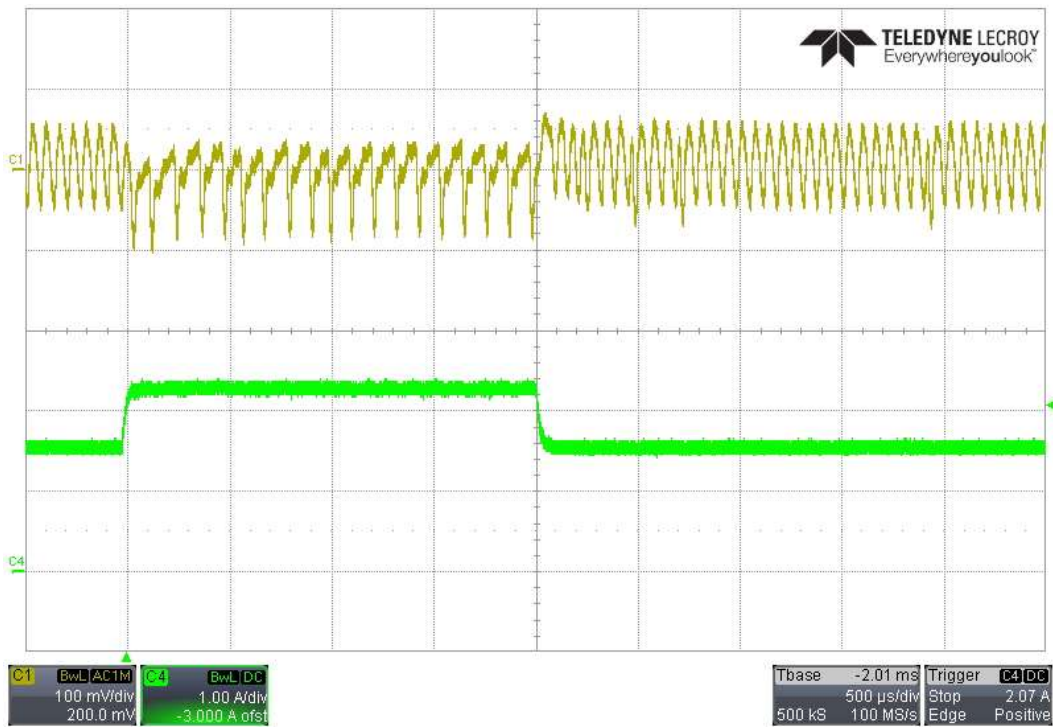
2.7.4 5V Output, 750mA to 1.5A Load Step, 230VAC/50Hz Input



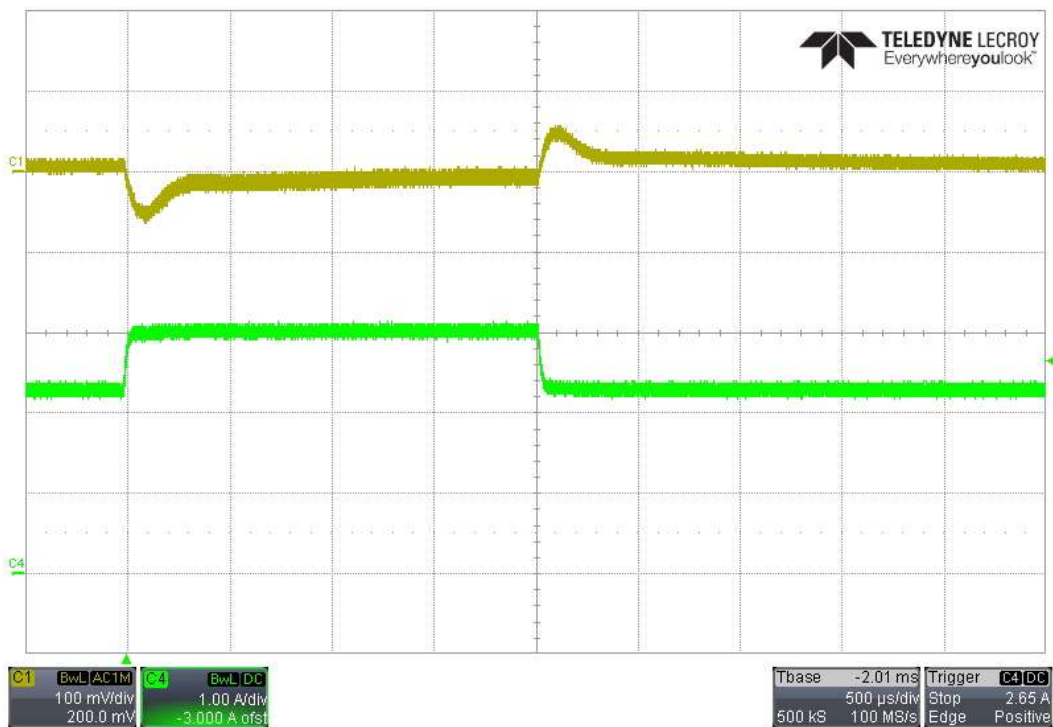
2.7.5 5V Output, 1.5A to 2.25A Load Step, 115VAC/60Hz Input



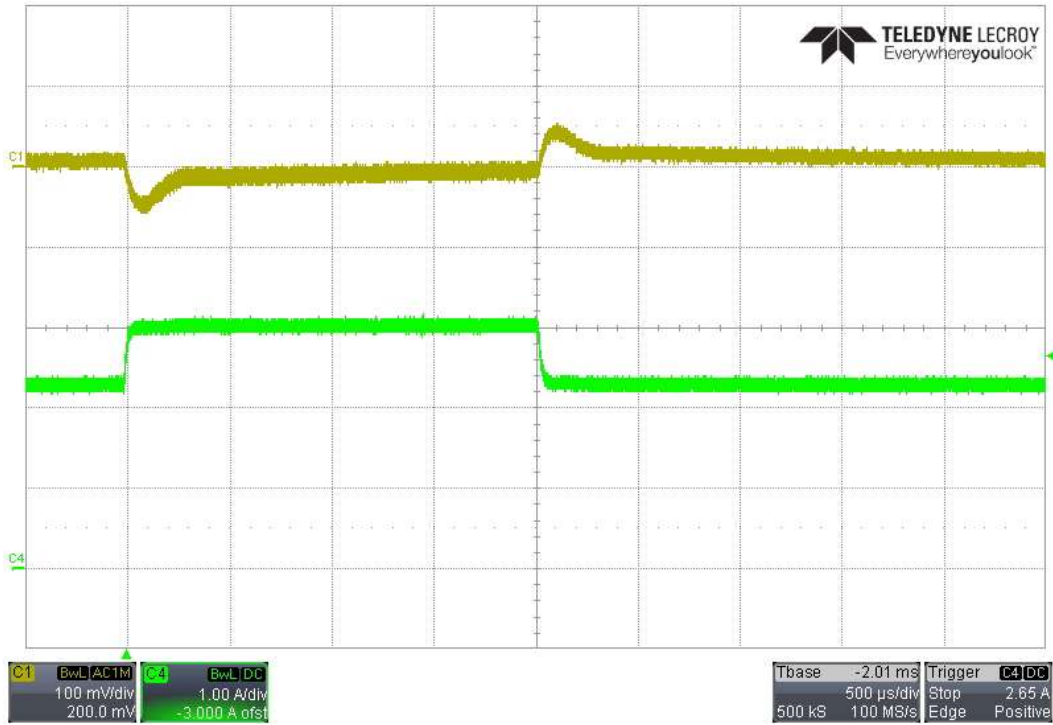
2.7.6 5V Output, 1.5A to 2.25A Load Step, 230VAC/50Hz Input



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

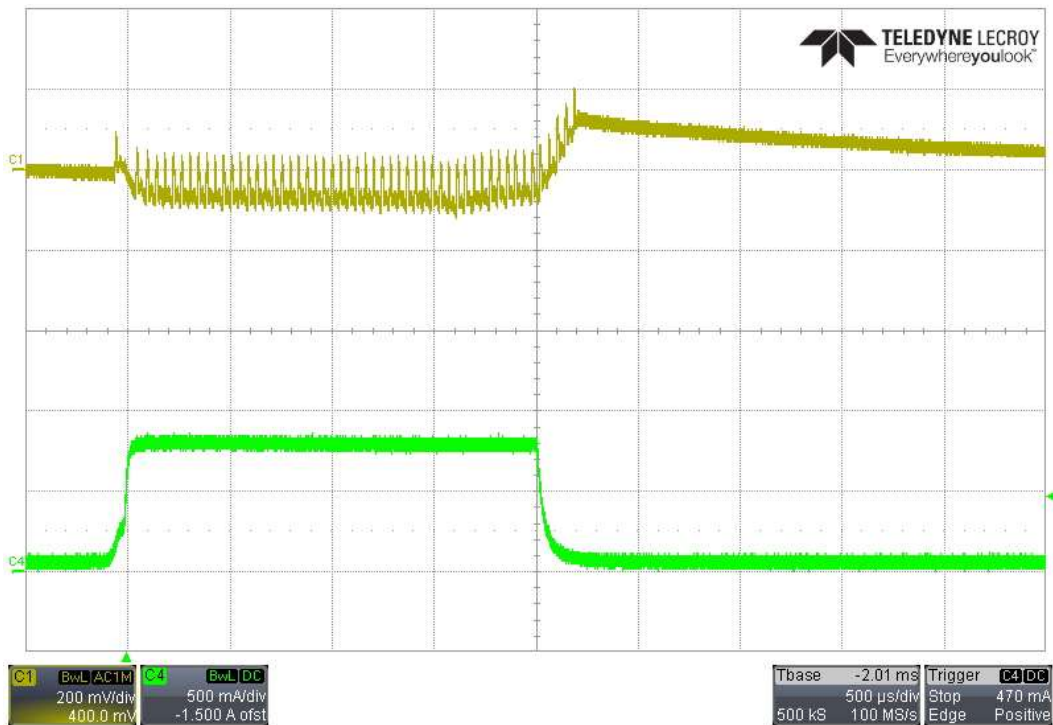


2.7.8 5V Output, 2.25A to 3.0A Load Step, 230VAC/50Hz Input

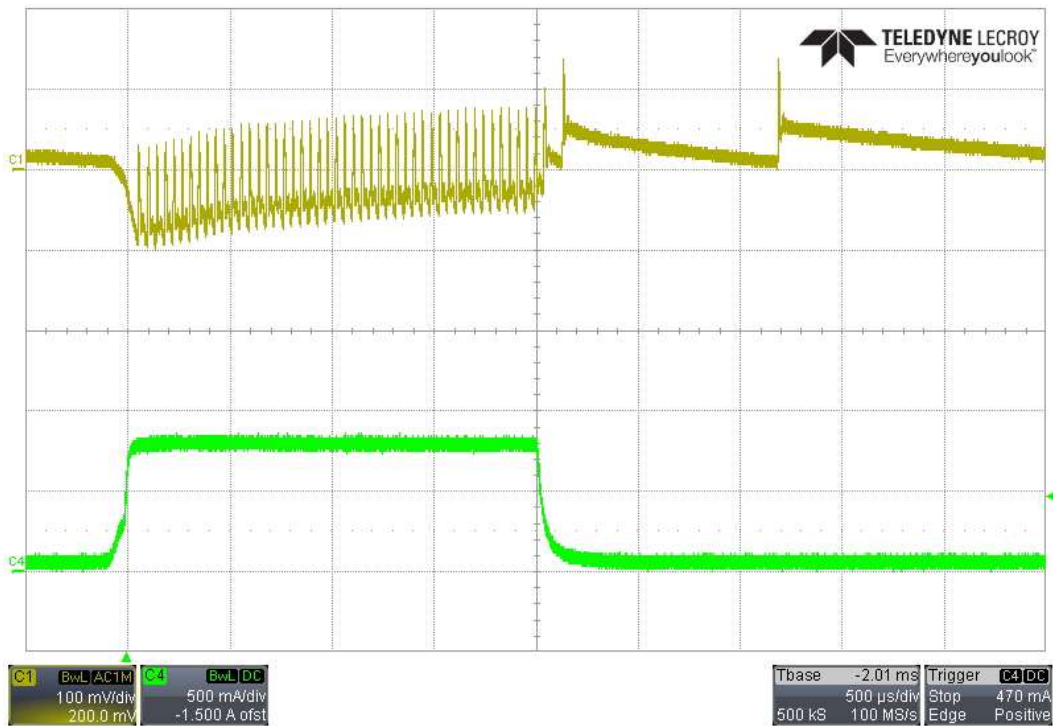


2.8 9V Output Load Transients

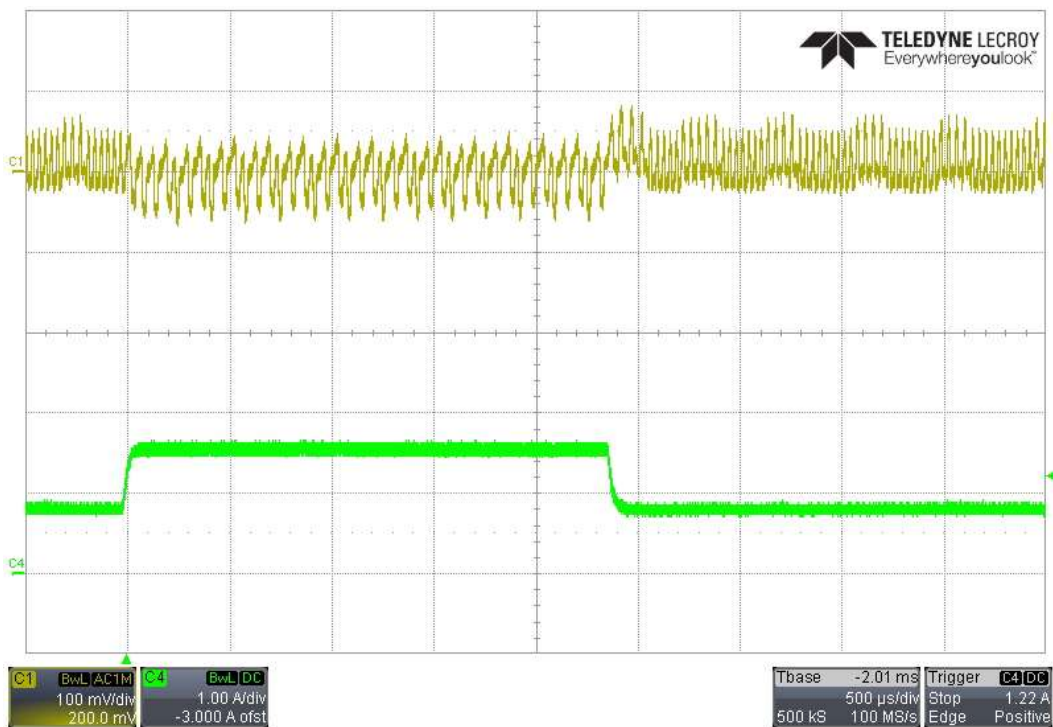
2.8.1 9V Output, 0A to 750mA Load Step, 115VAC/60Hz Input



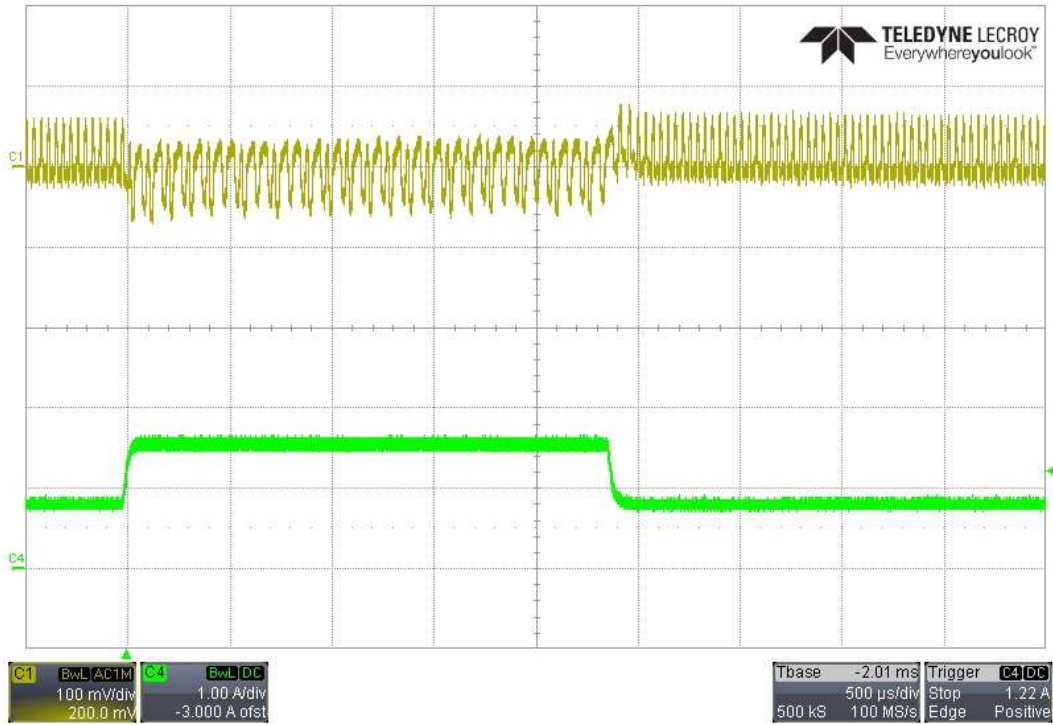
2.8.2 9V Output, 0A to 750mA Load Step, 230VAC/50Hz Input



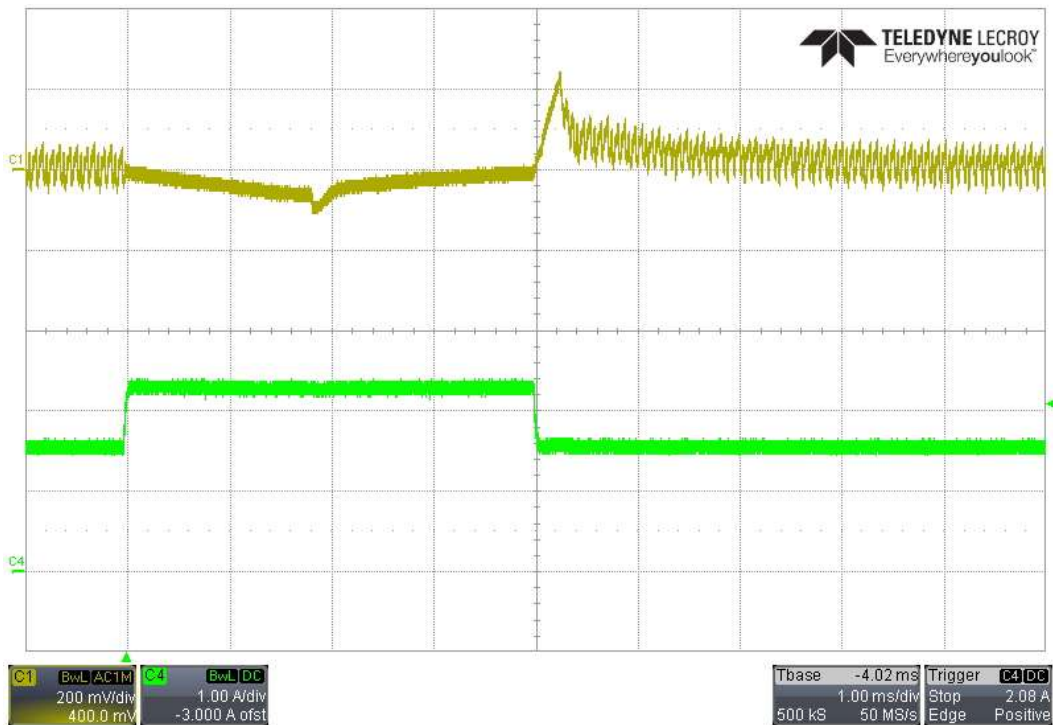
2.8.3 9V Output, 750mA to 1.5A Load Step, 115VAC/60Hz Input



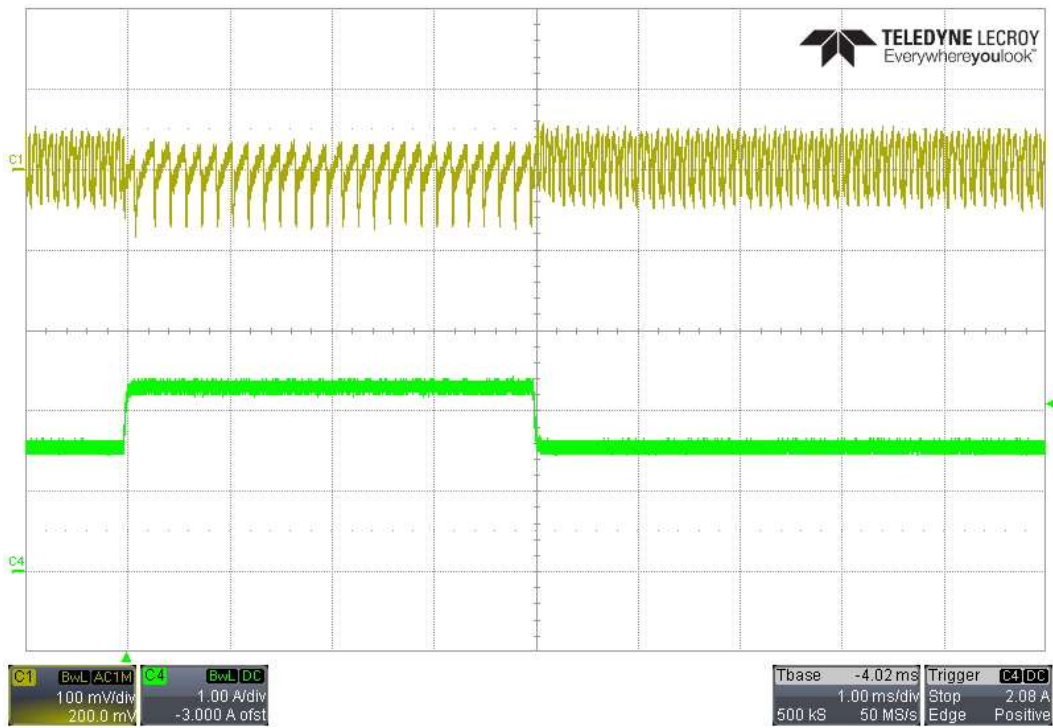
2.8.4 9V Output, 750mA to 1.5A Load Step, 230VAC/50Hz Input



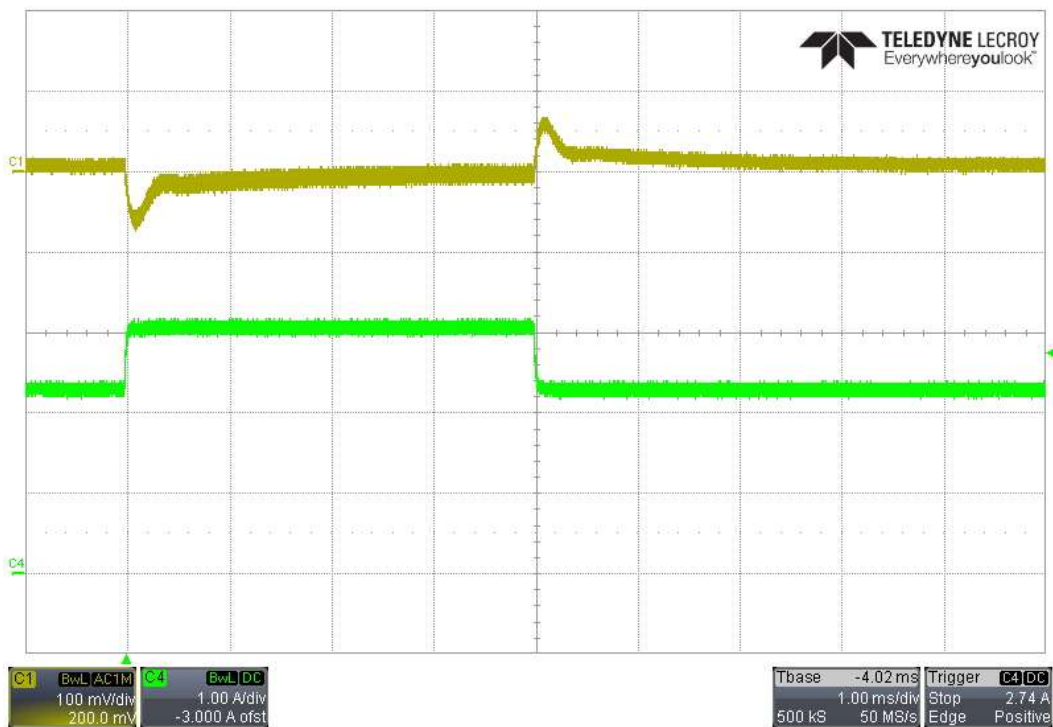
2.8.5 9V Output, 1.5A to 2.25A Load Step, 115VAC/60Hz Input



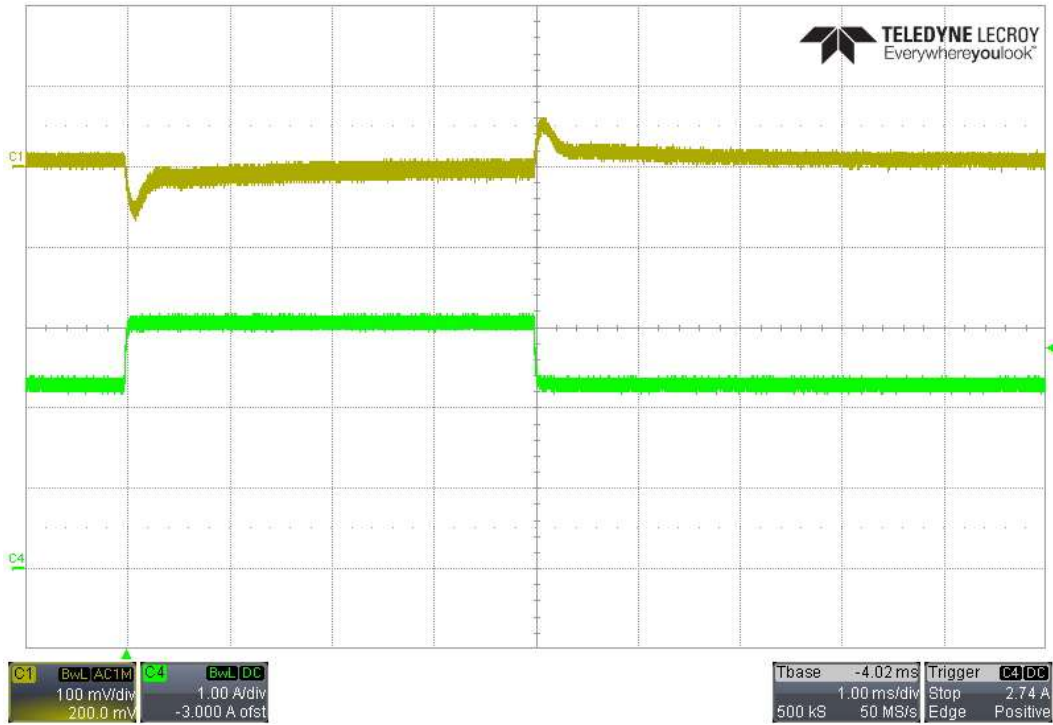
2.8.6 9V Output, 1.5A to 2.25A Load Step, 230VAC/50Hz Input



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

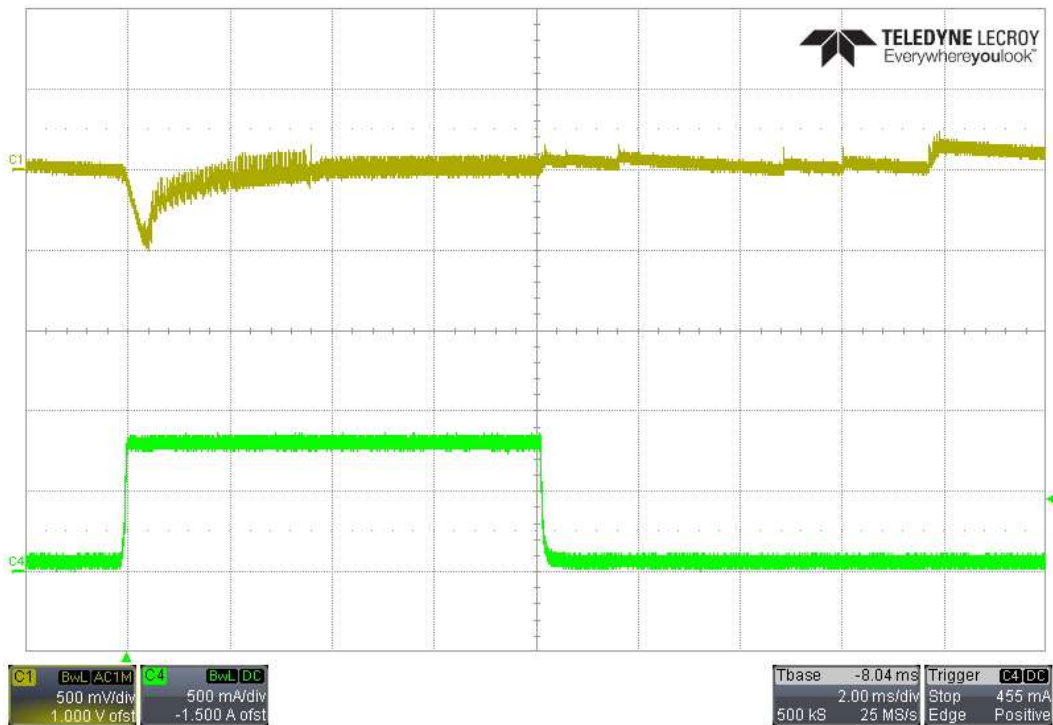


2.8.8 9V Output, 2.25A to 3.0A Load Step, 230VAC/50Hz Input

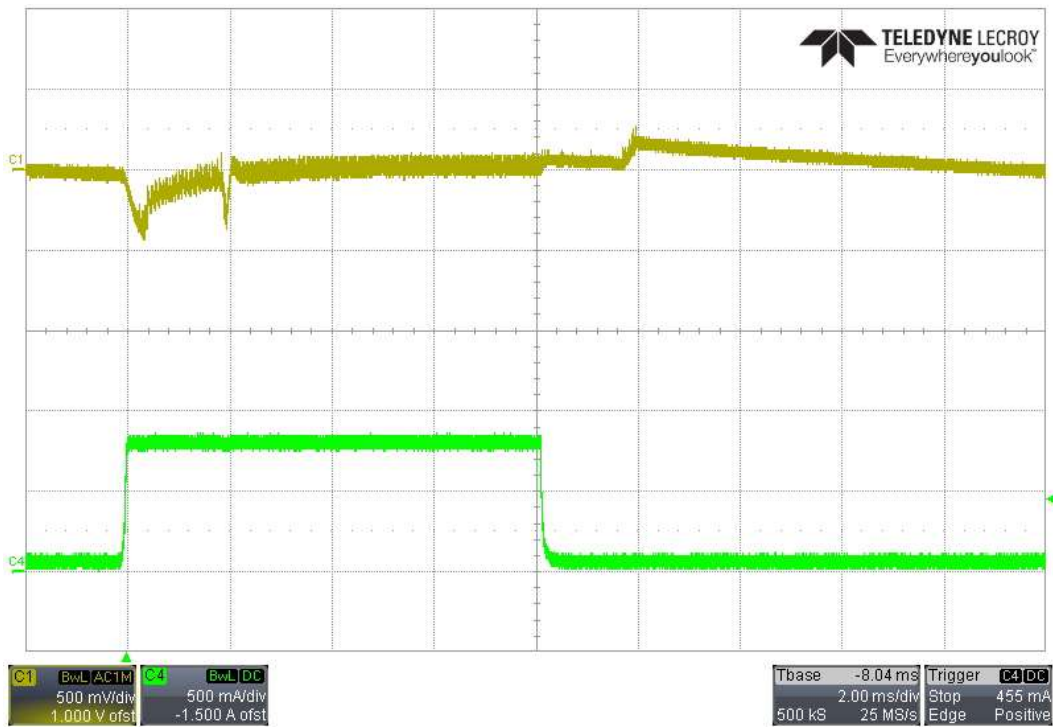


2.9 15V Output Load Transients

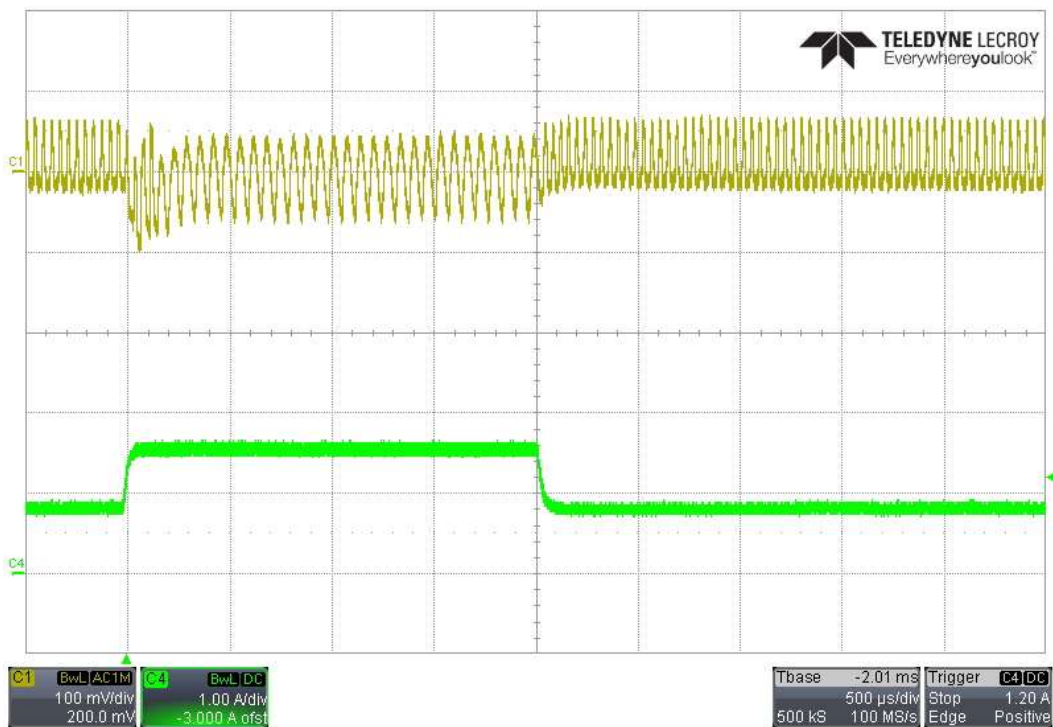
2.9.1 15V Output, 0A to 750mA Load Step, 115VAC/60Hz Input



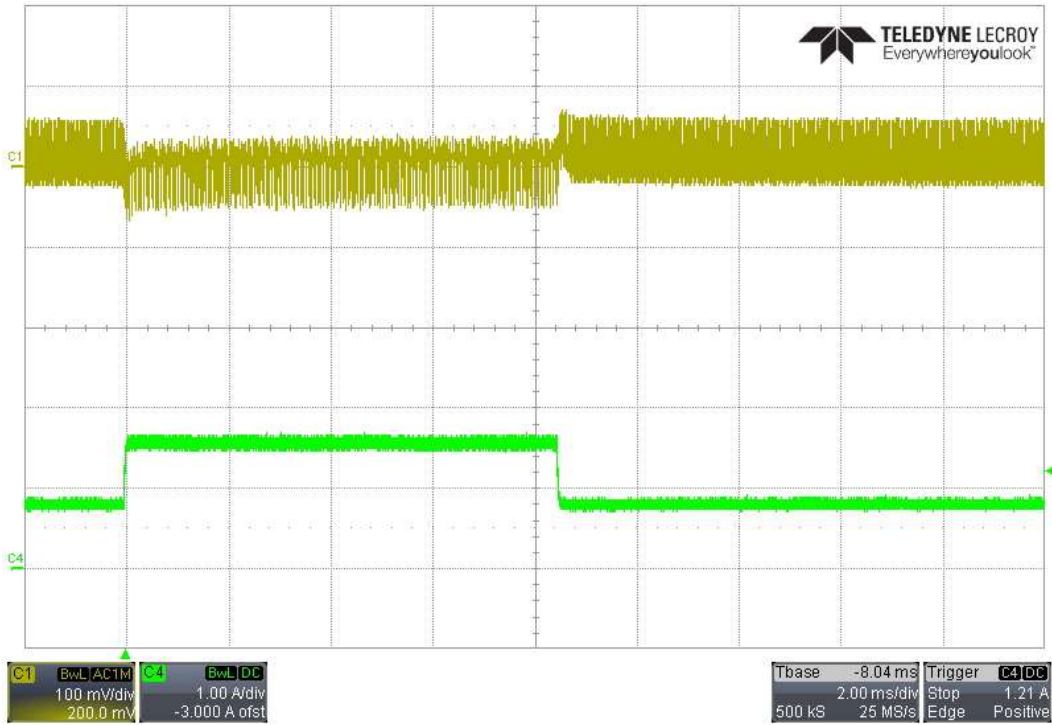
2.9.2 15V Output, 0A to 750mA Load Step, 230VAC/50Hz Input



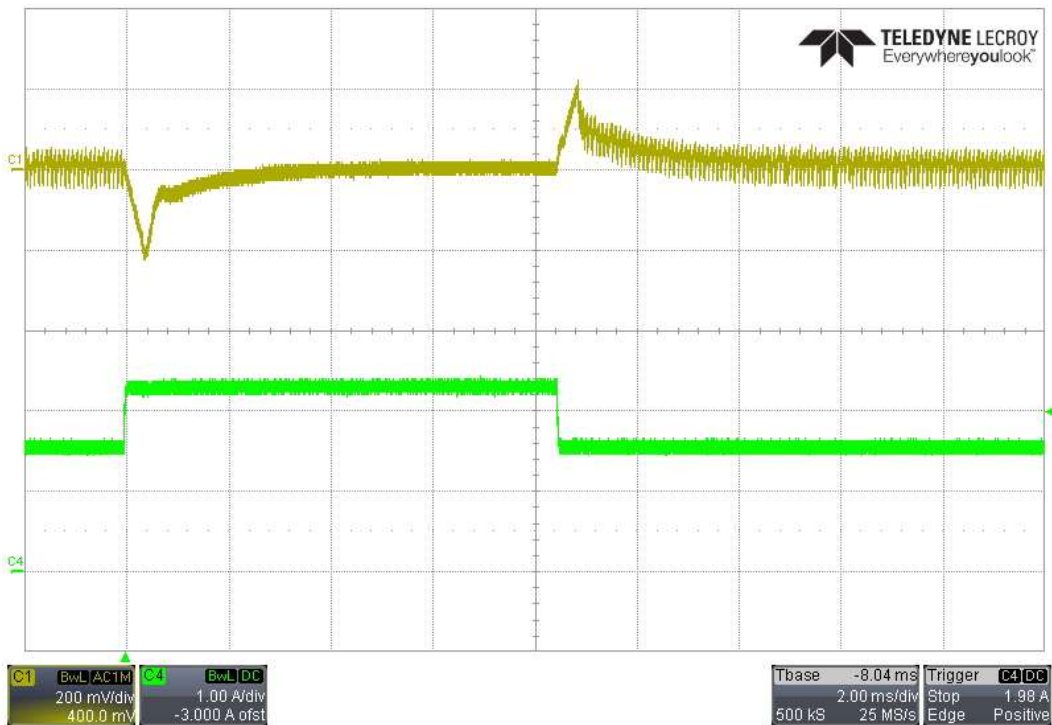
2.9.3 15V Output, 750mA to 1.5A Load Step, 115VAC/60Hz Input



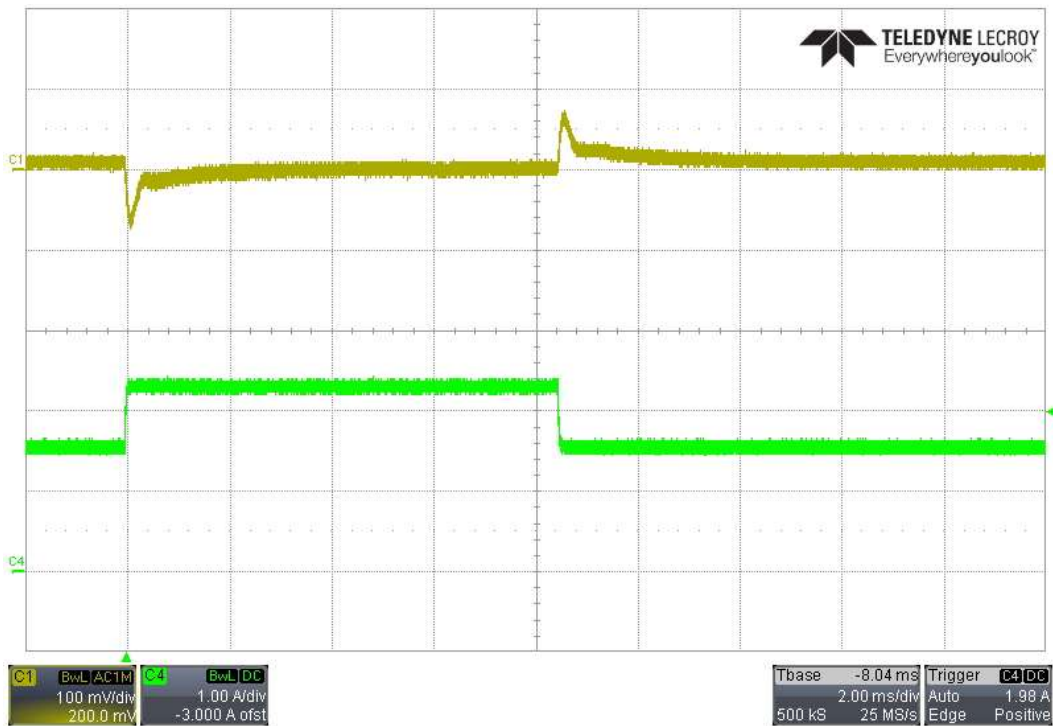
2.9.4 15V Output, 750mA to 1.5A Load Step, 230VAC/50Hz Input



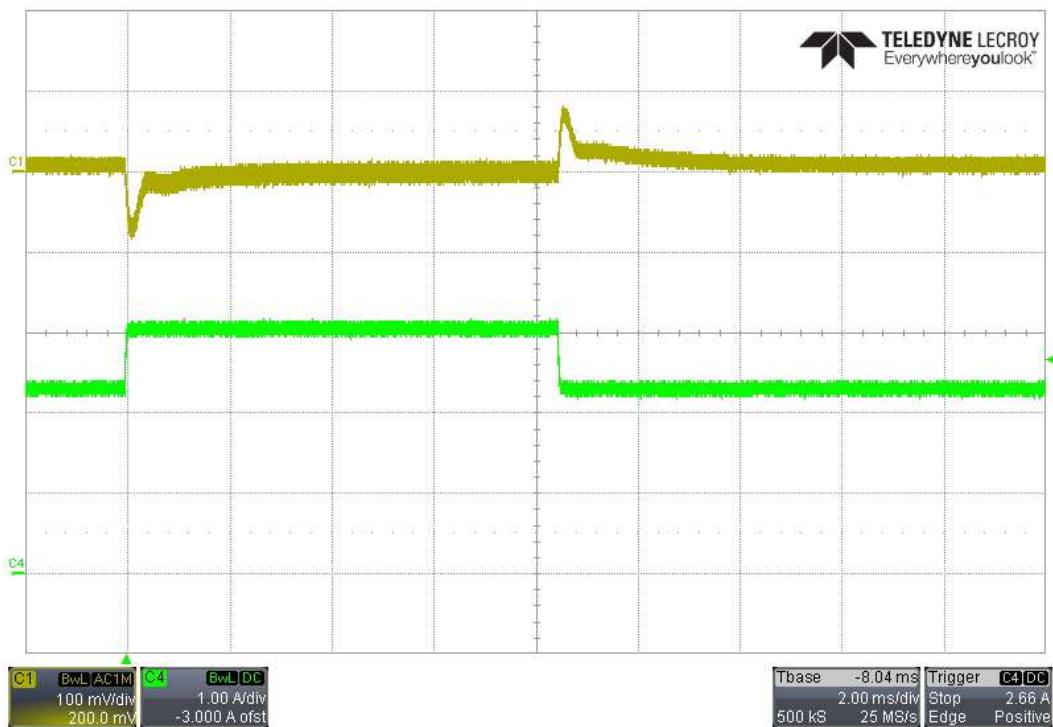
2.9.5 15V Output, 1.5A to 2.25A Load Step, 115VAC/60Hz Input



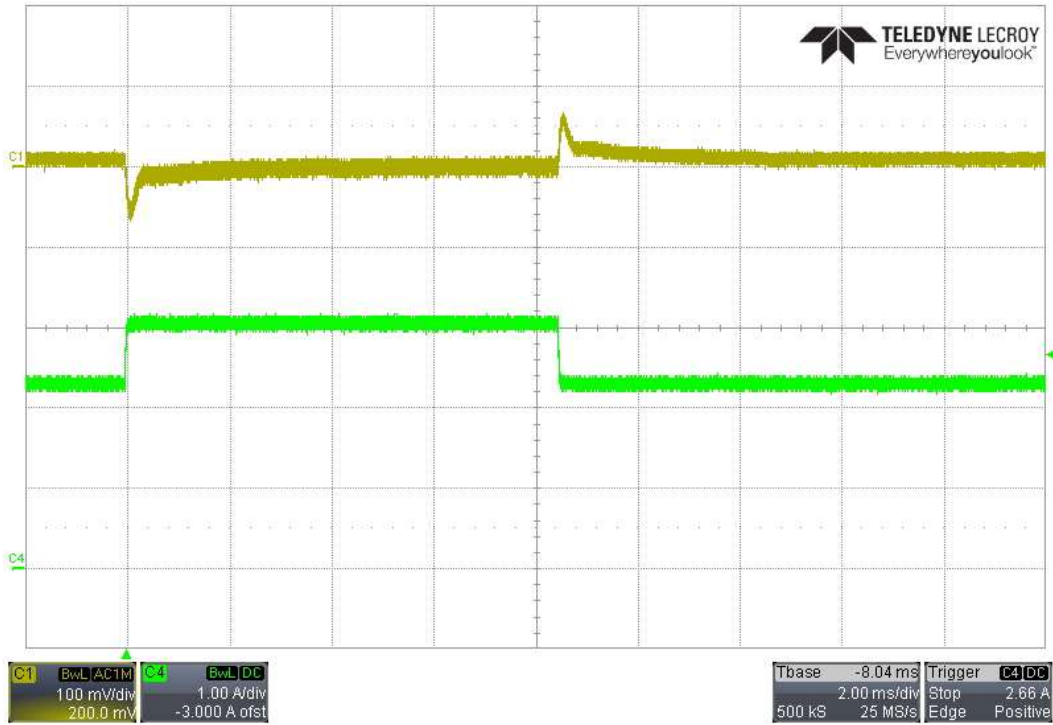
2.9.6 15V Output, 1.5A to 2.25A Load Step, 230VAC/50Hz Input



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

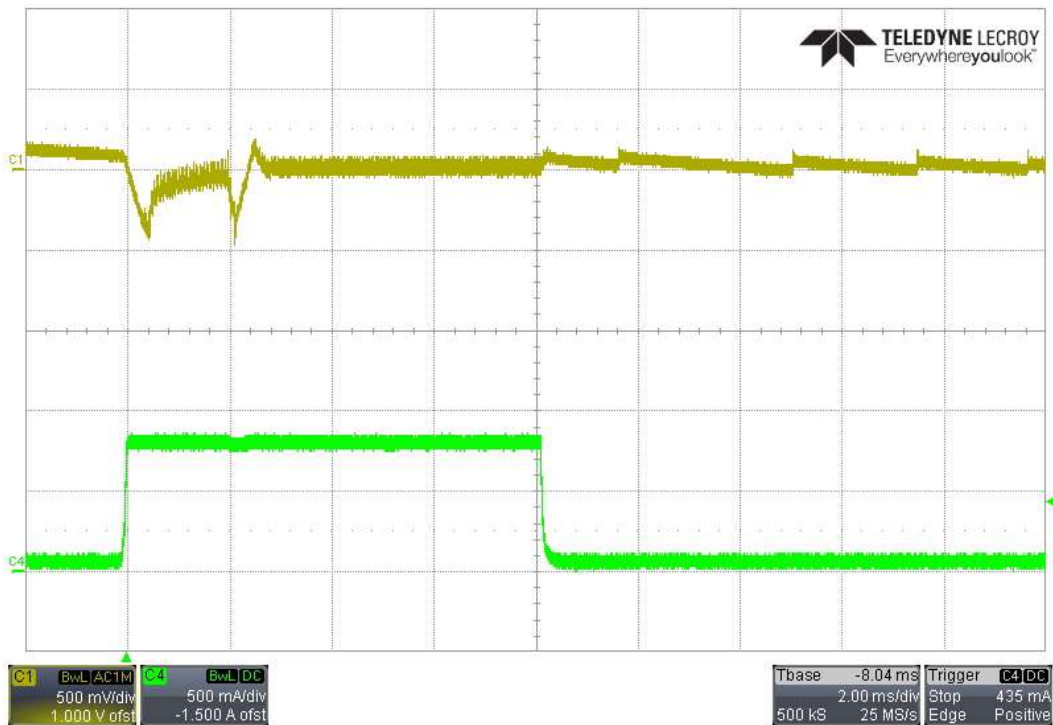


2.9.8 15V Output, 2.25A to 3.0A Load Step, 230VAC/50Hz Input

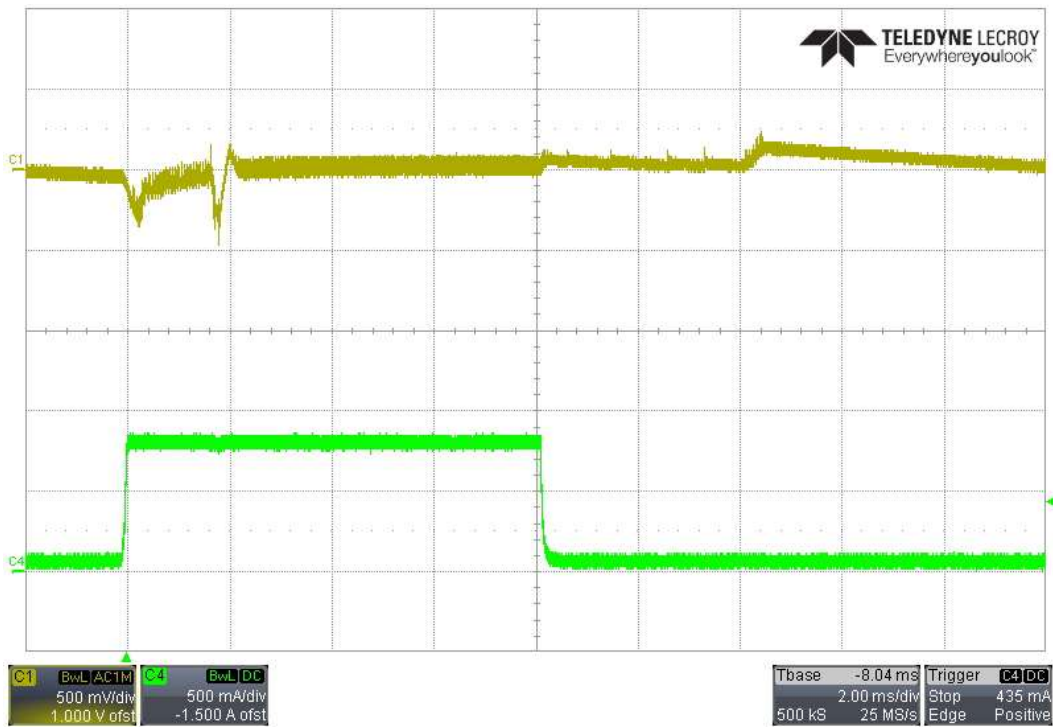


2.10 20V Output Load Transients

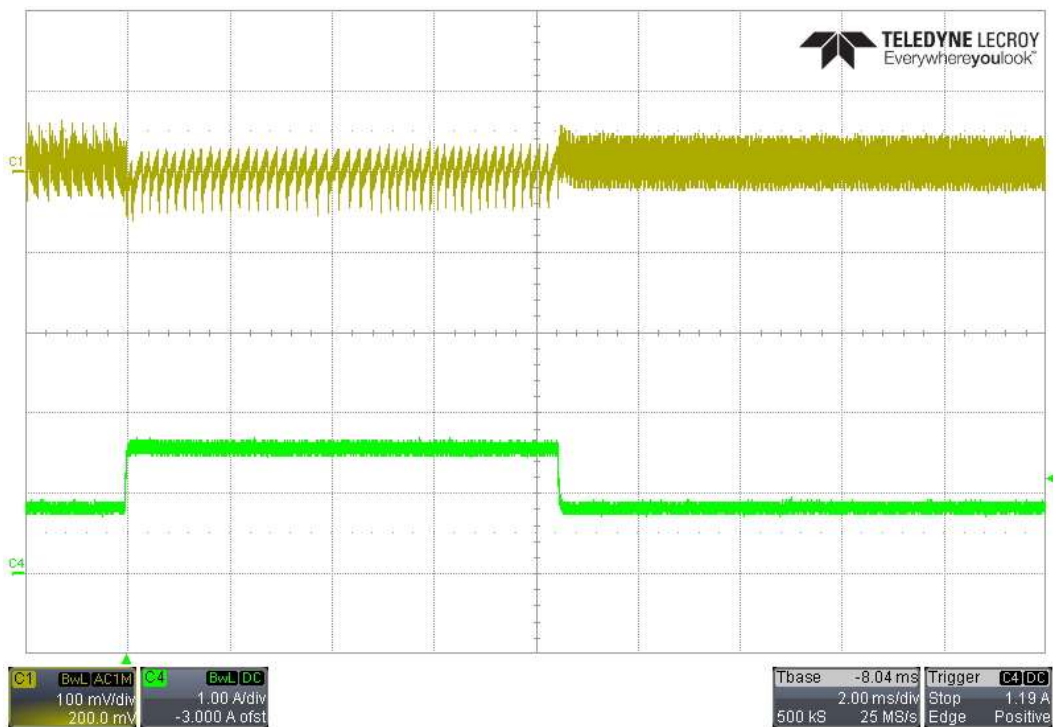
2.10.1 20V Output, 0A to 750mA Load Step, 115VAC/60Hz Input



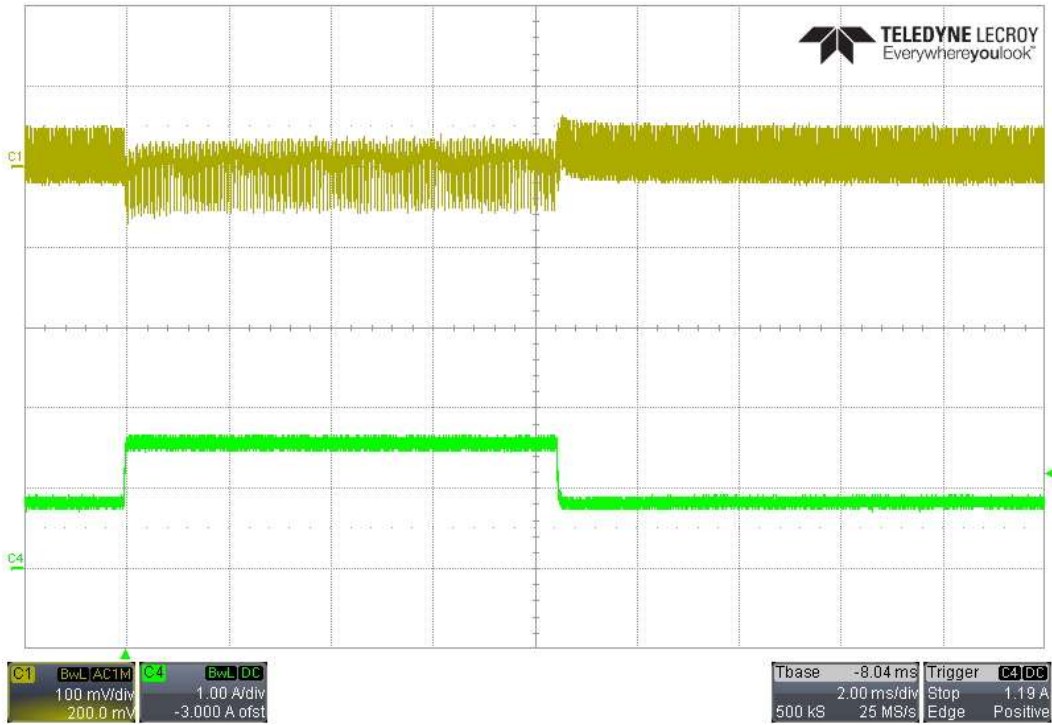
2.10.2 20V Output, 0A to 750mA Load Step, 230VAC/50Hz Input



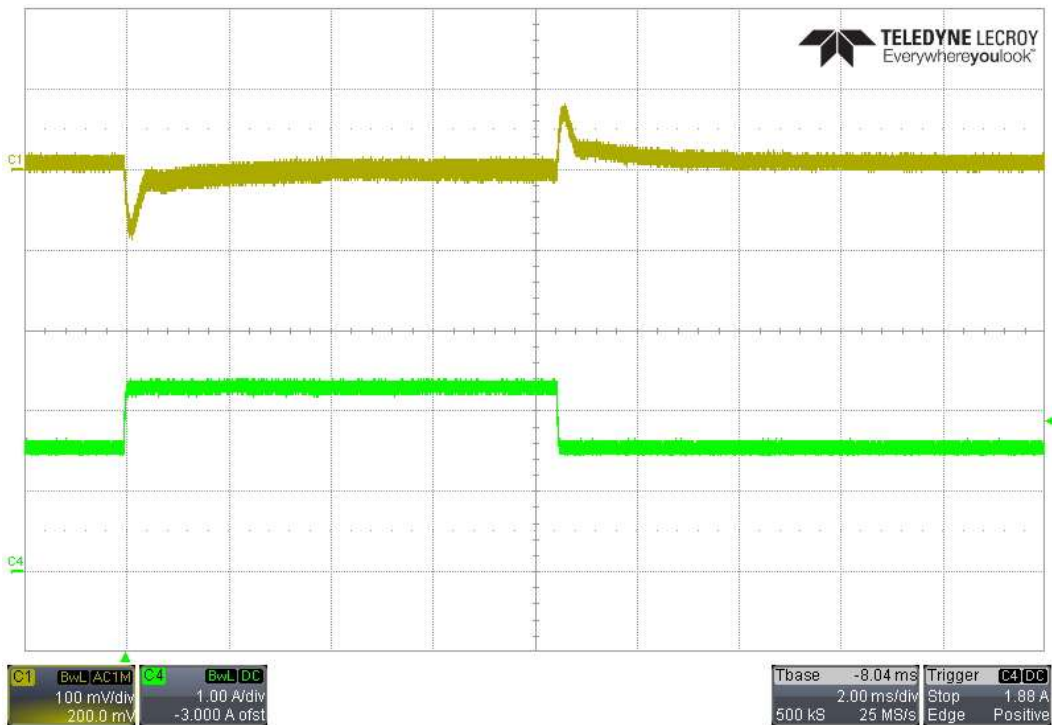
2.10.3 20V Output, 750mA to 1.5A Load Step, 115VAC/60Hz Input



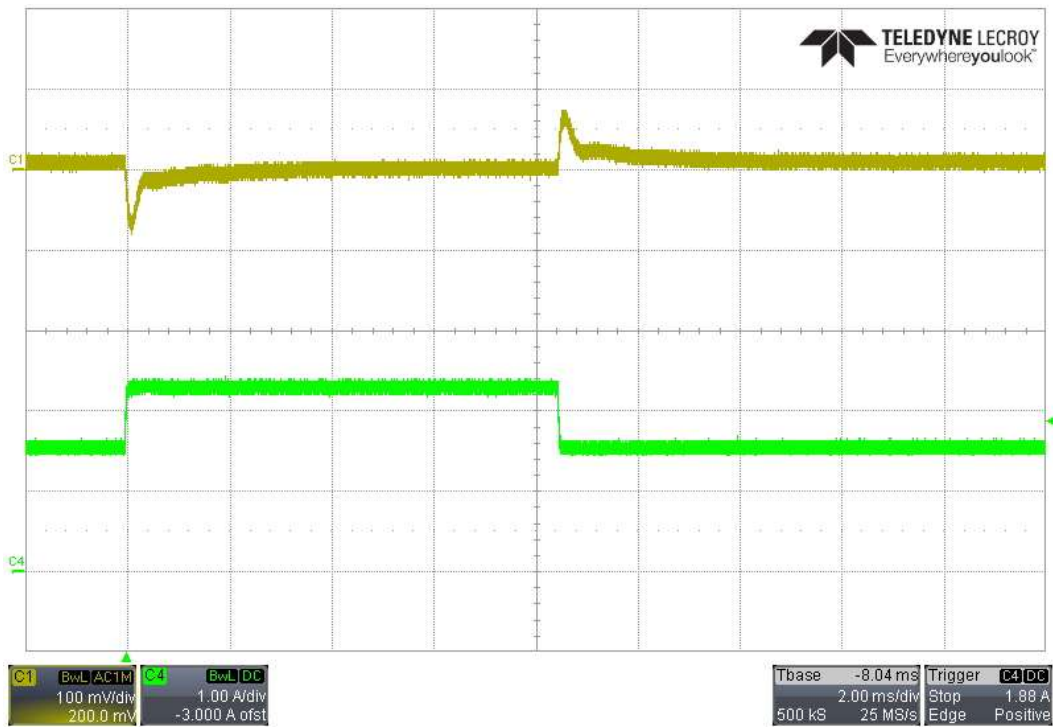
2.10.4 20V Output, 750mA to 1.5A Load Step, 230VAC/50Hz Input



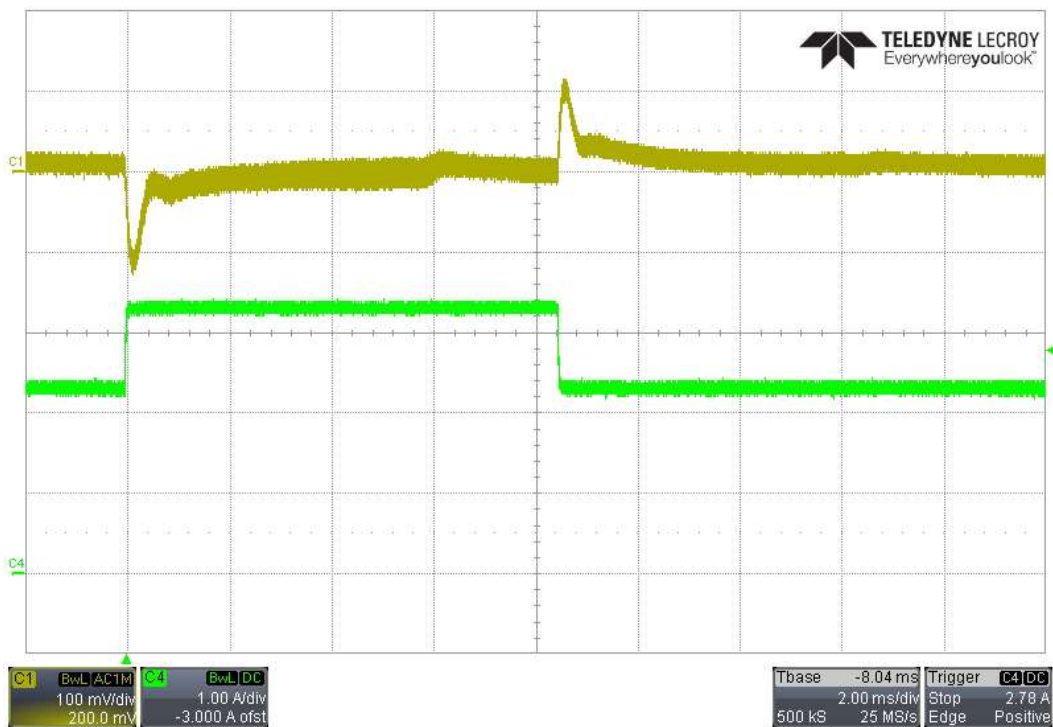
2.10.5 20V Output, 1.5A to 2.25A Load Step, 115VAC/60Hz Input



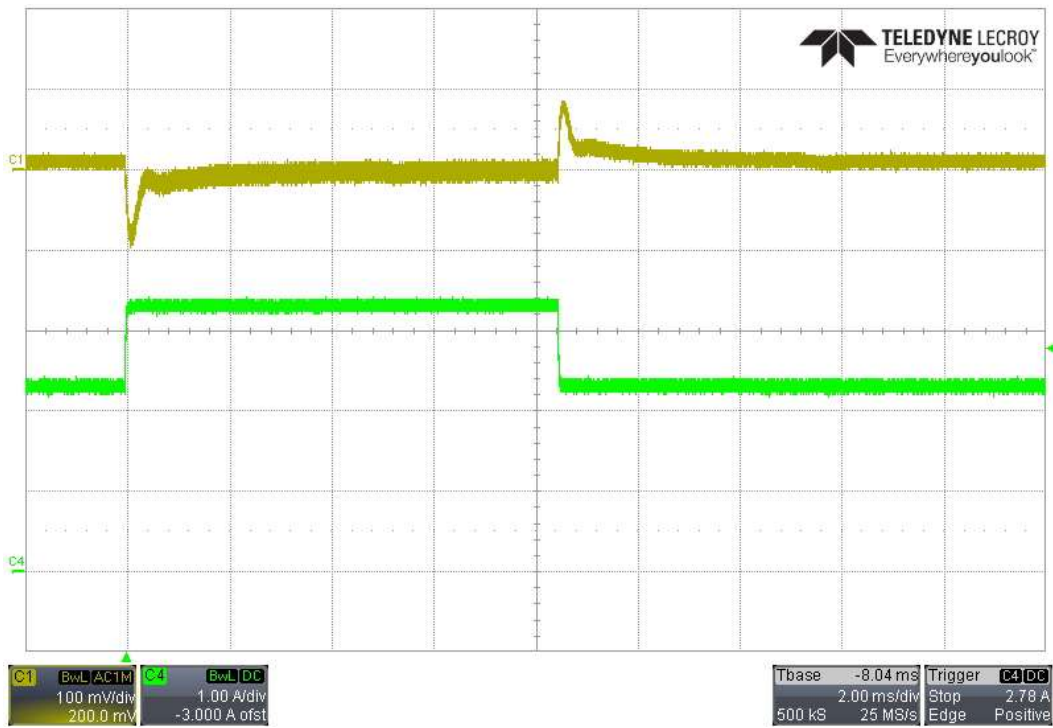
2.10.6 20V Output, 1.5A to 2.25A Load Step, 230VAC/50Hz Input



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

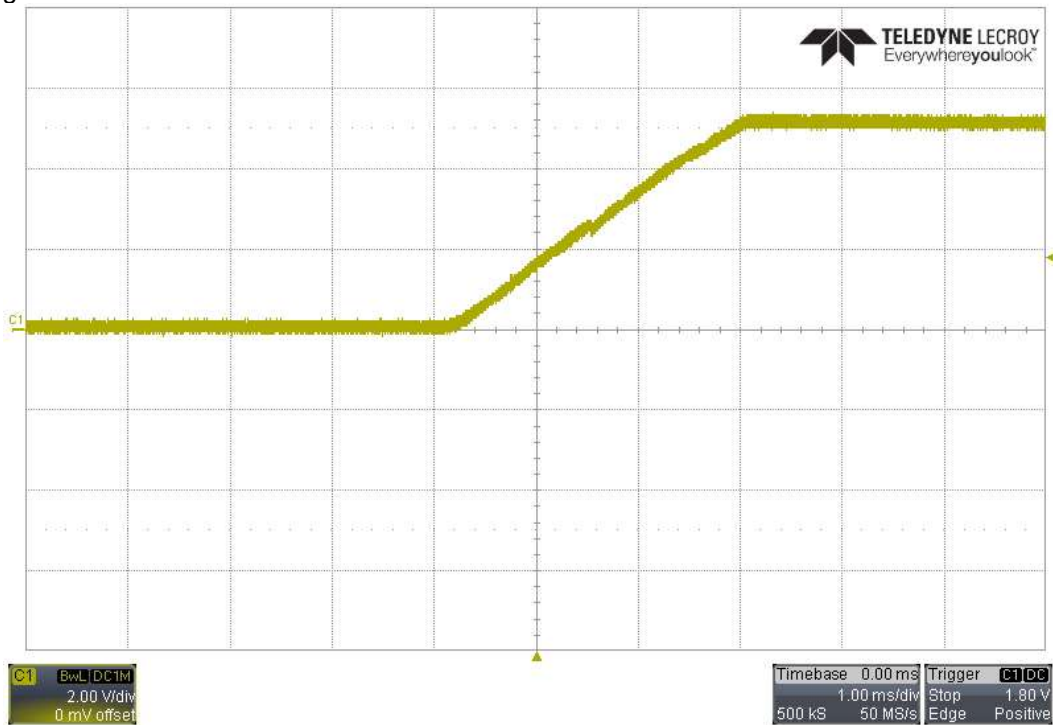


2.10.8 20V Output, 2.25A to 3.25A Load Step, 230VAC/50Hz Input



2.11 Startup

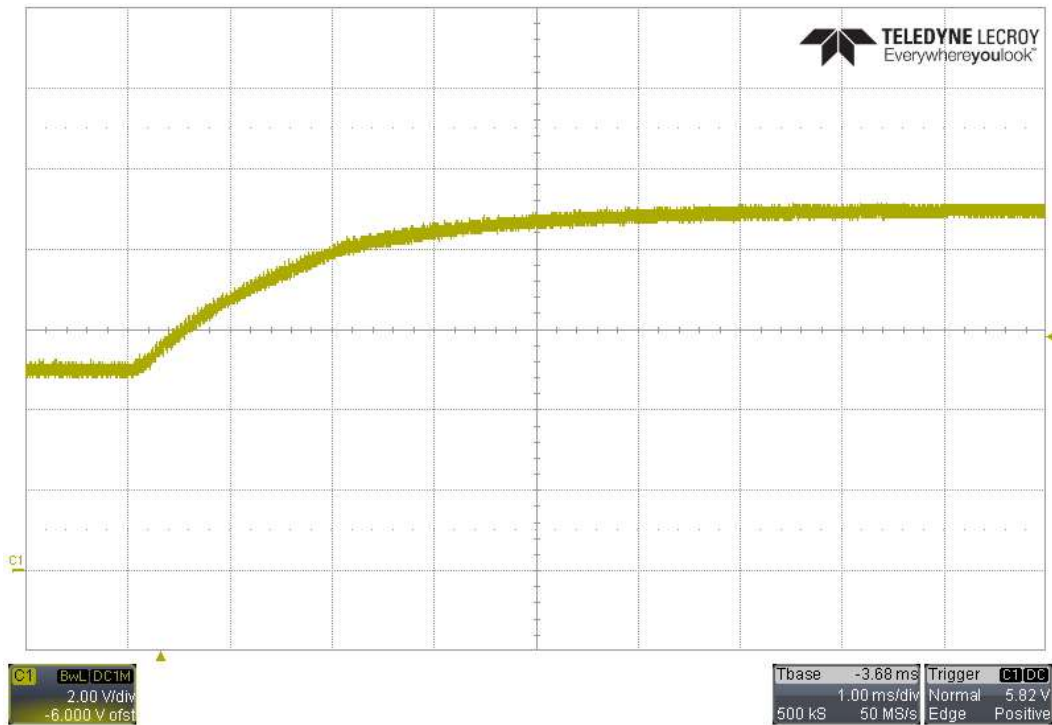
Output voltage measured at connector when USB-C cable inserted with no load.



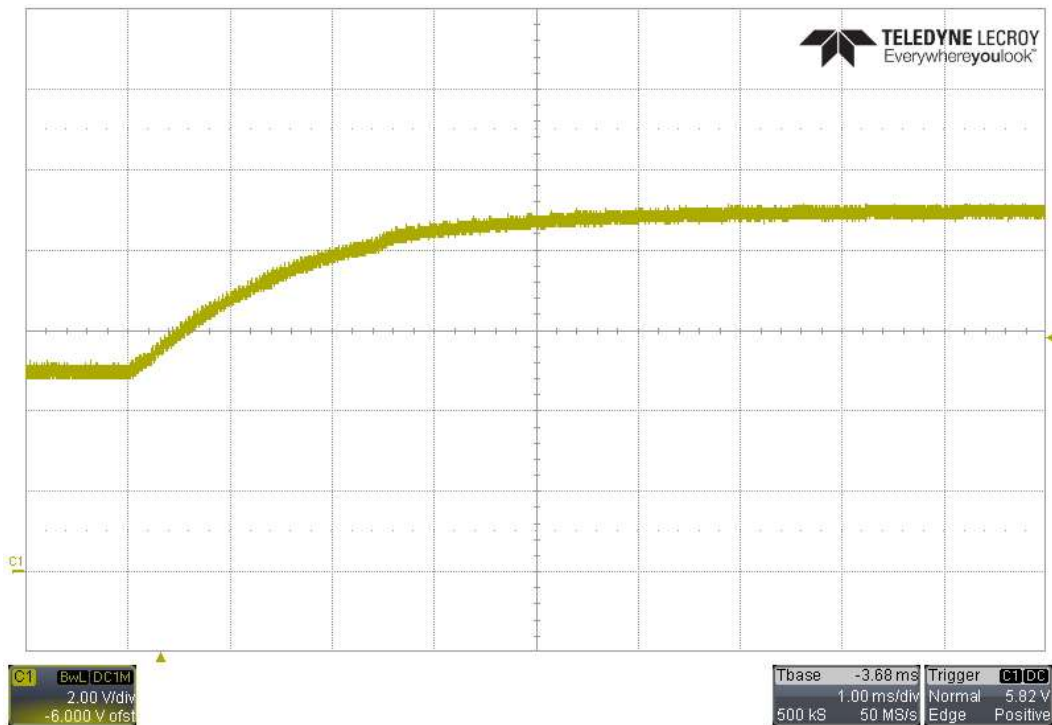
2.12 Voltage Transitions

Data taken on Rev C2 board.

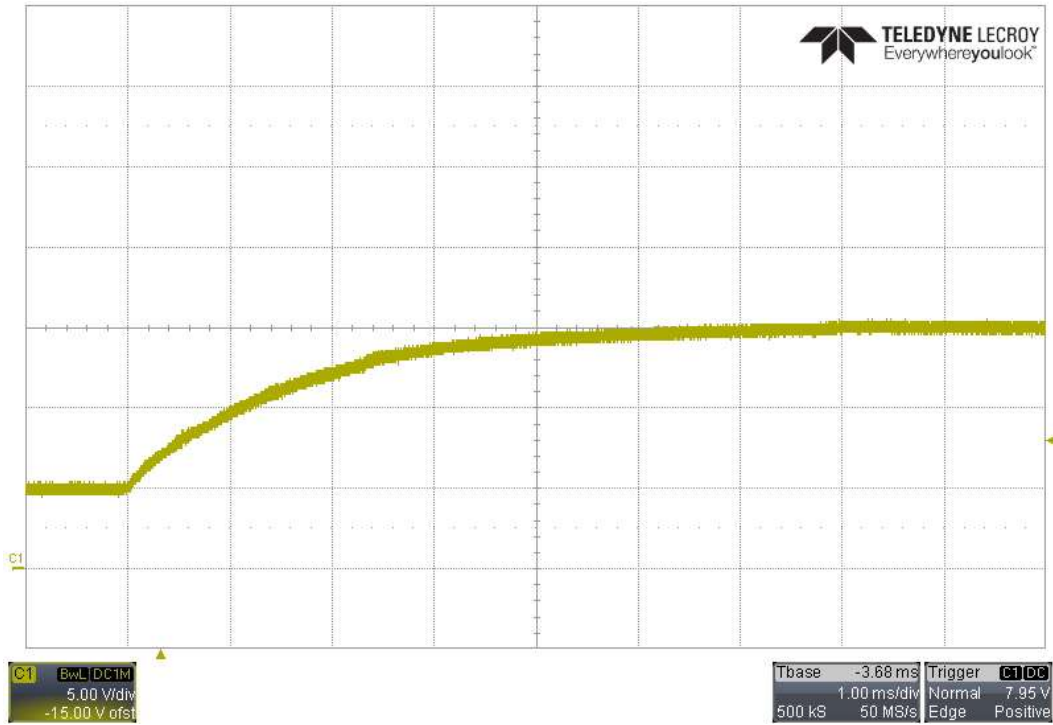
2.12.1 5V to 9V, 115VAC/60Hz Input, No Load



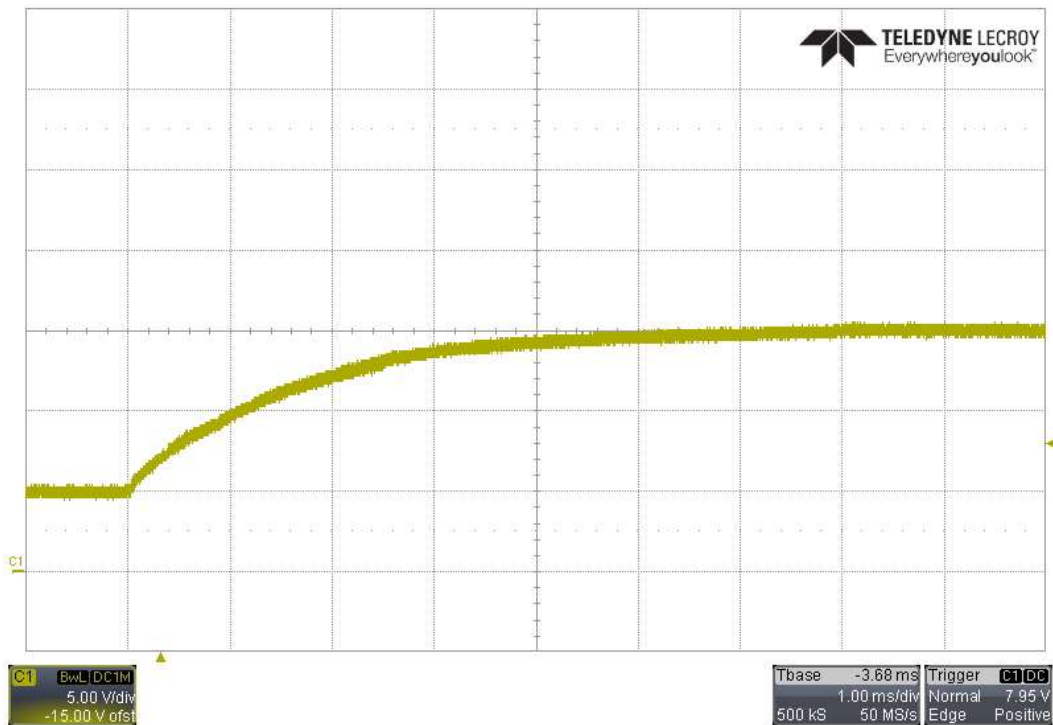
2.12.2 5V to 9V, 230VAC/50Hz Input, No Load



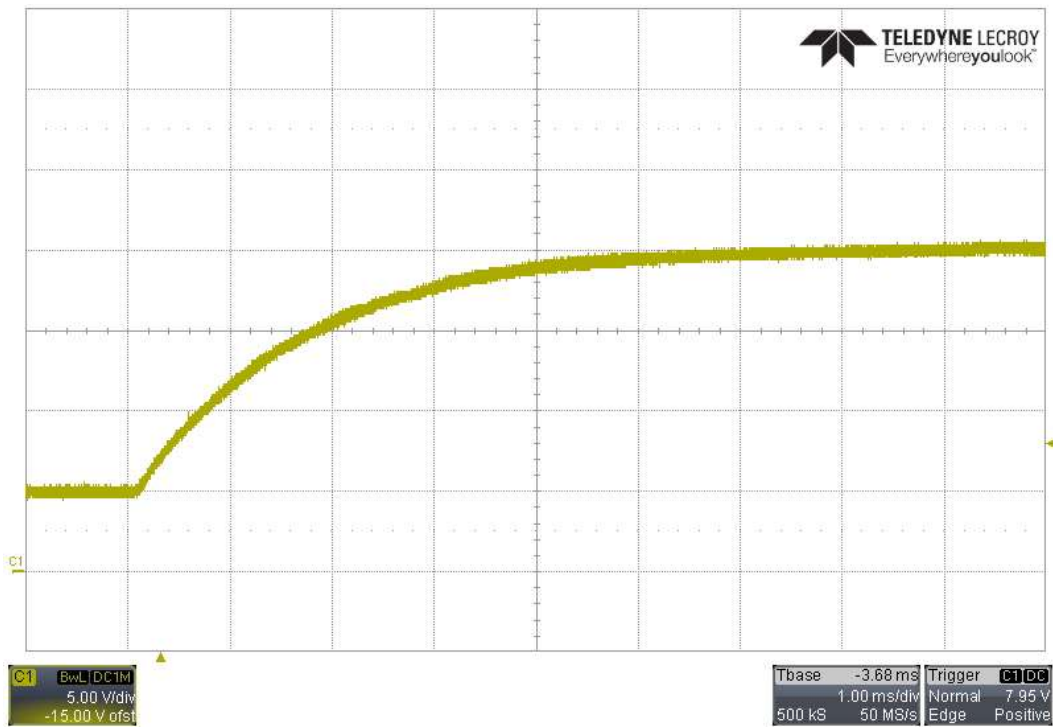
2.12.3 5V to 15V, 115VAC/60Hz Input, No Load



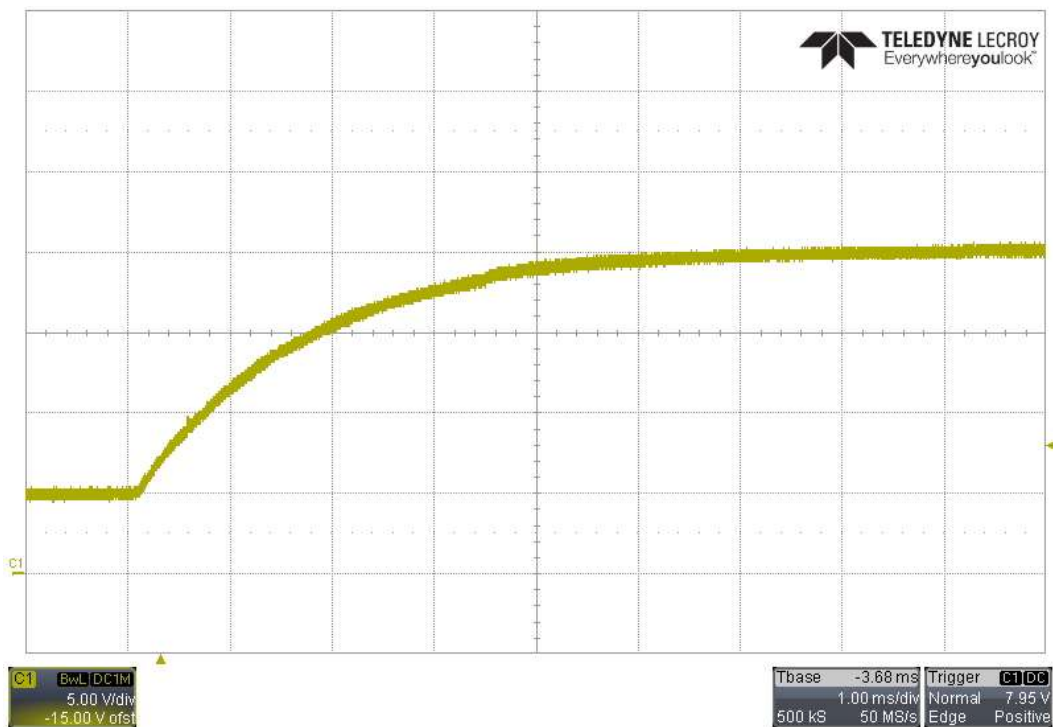
2.12.4 5V to 15V, 230VAC/50Hz Input, No Load



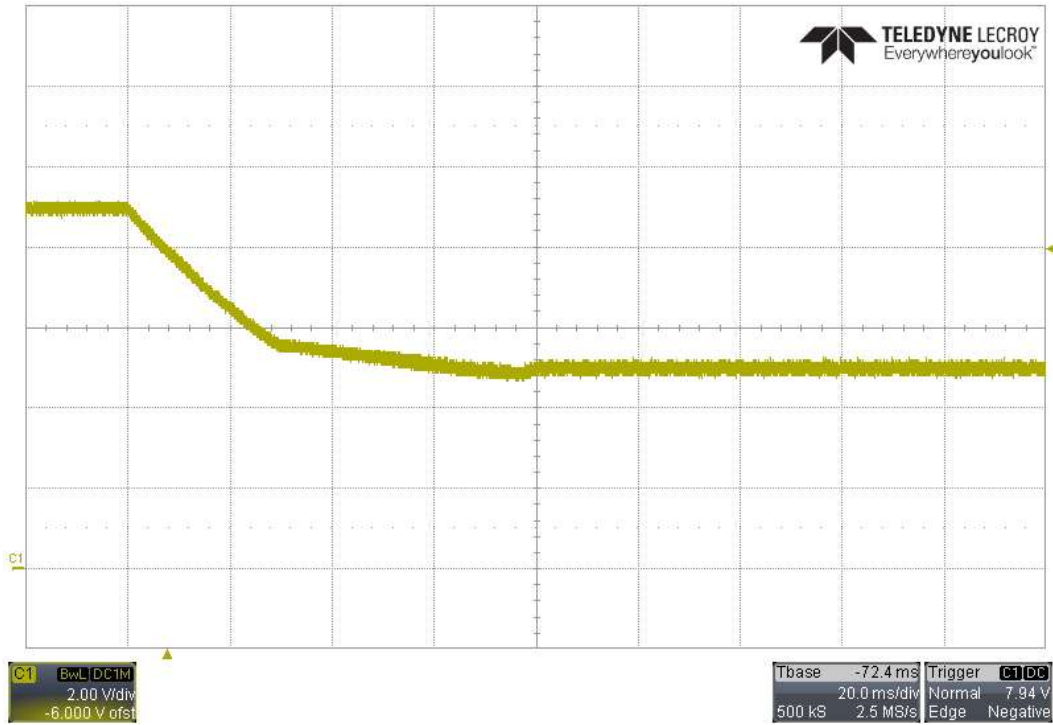
2.12.5 5V to 20V, 115VAC/60Hz Input, No Load



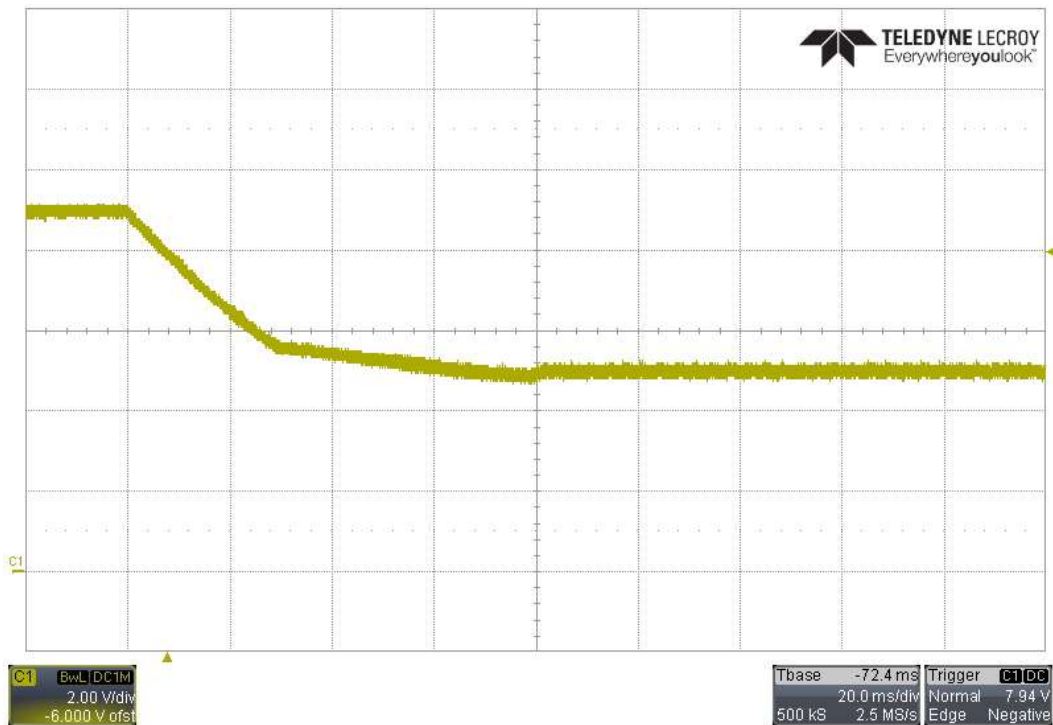
2.12.6 5V to 20V, 230VAC/50Hz Input, No Load



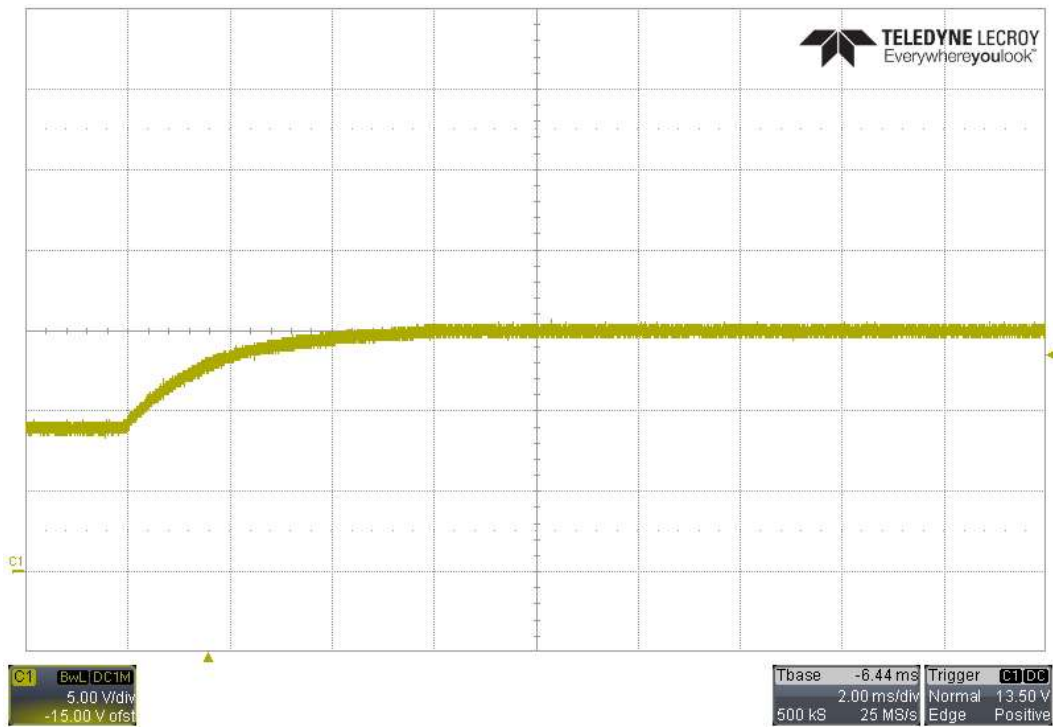
2.12.7 9V to 5V, 115VAC/60Hz Input, No Load



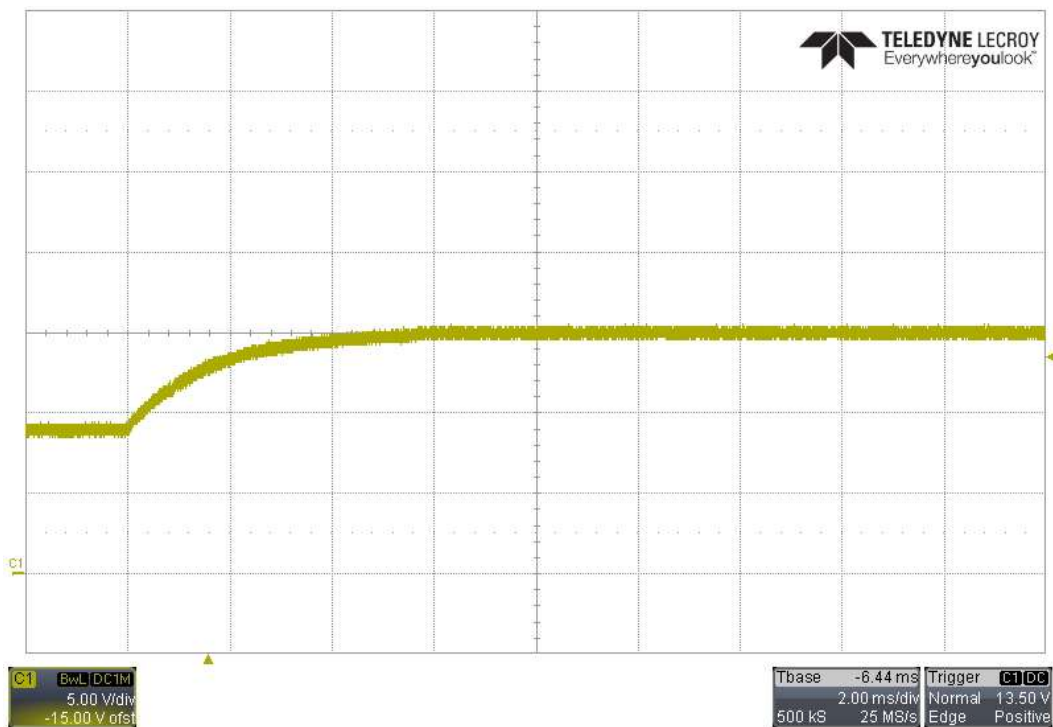
2.12.8 9V to 5V, 230VAC/50Hz Input, No Load



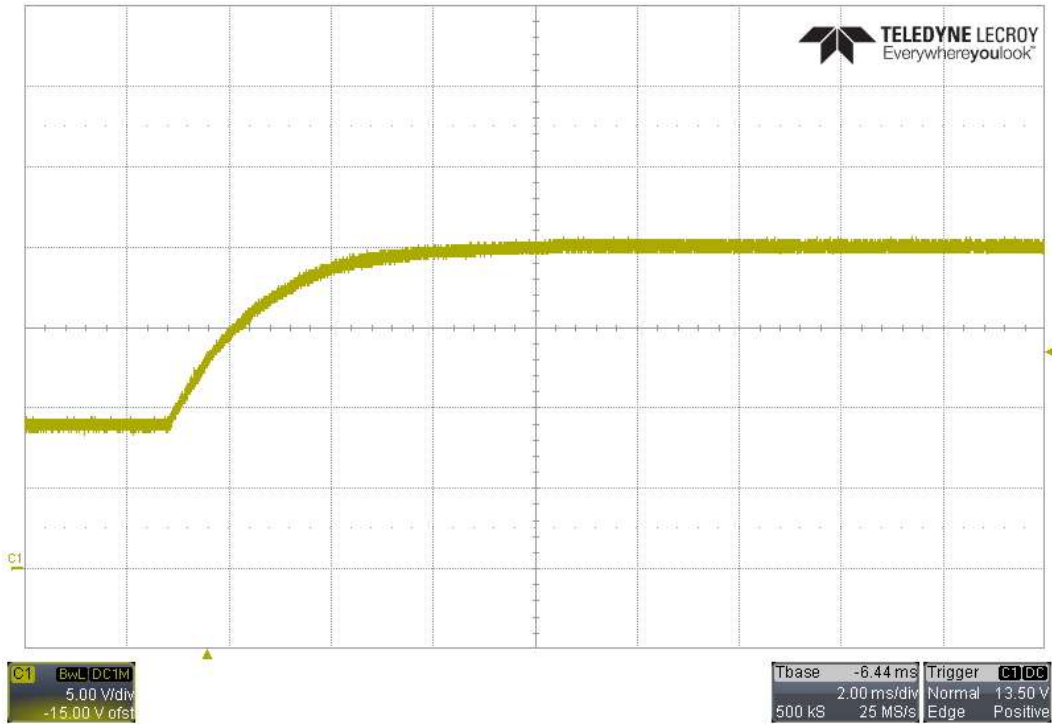
2.12.9 9V to 15V, 115VAC/60Hz Input, No Load



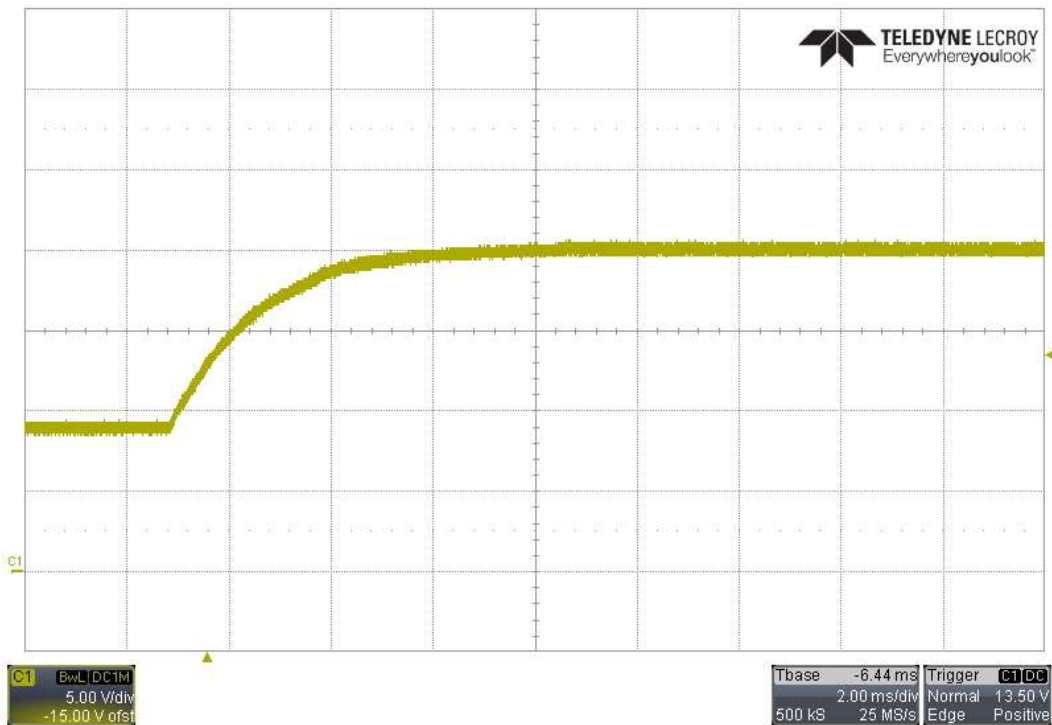
2.12.10 9V to 15V, 230VAC/50Hz Input, No Load



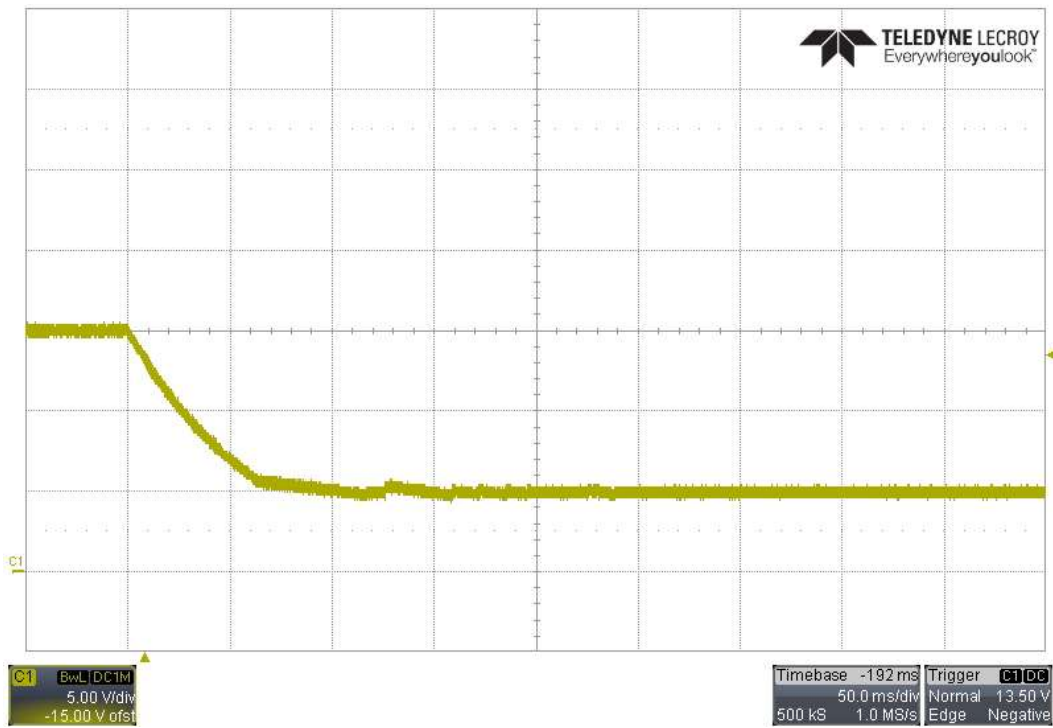
2.12.11 9V to 20V, 115VAC/60Hz Input, No Load



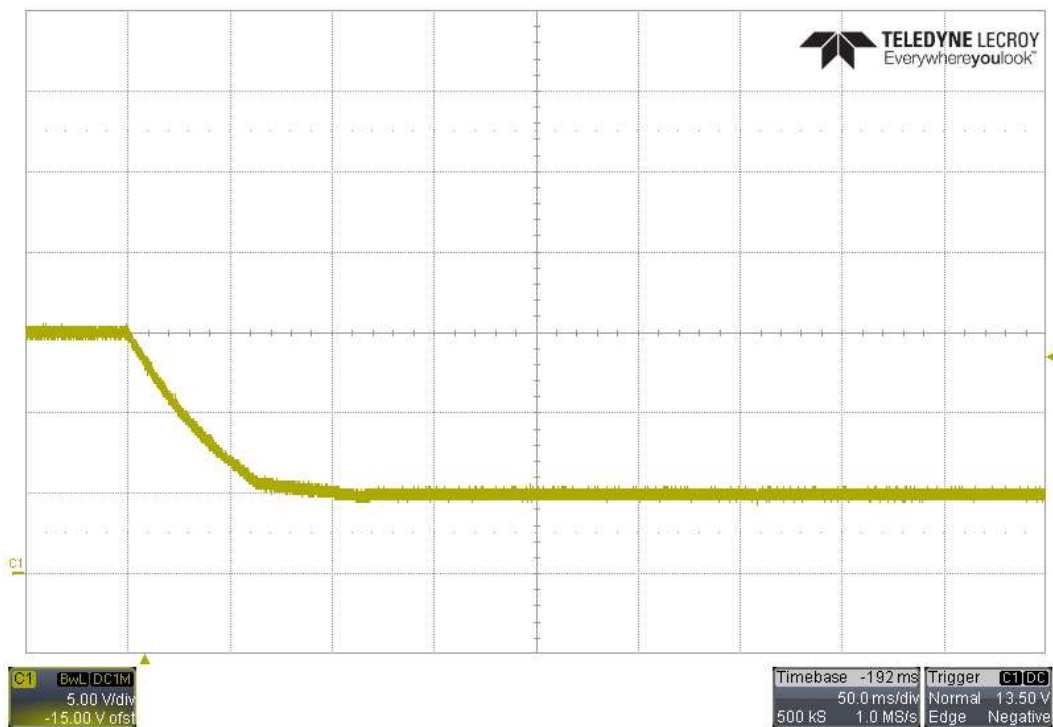
2.12.12 9V to 20V, 230VAC/50Hz Input, No Load



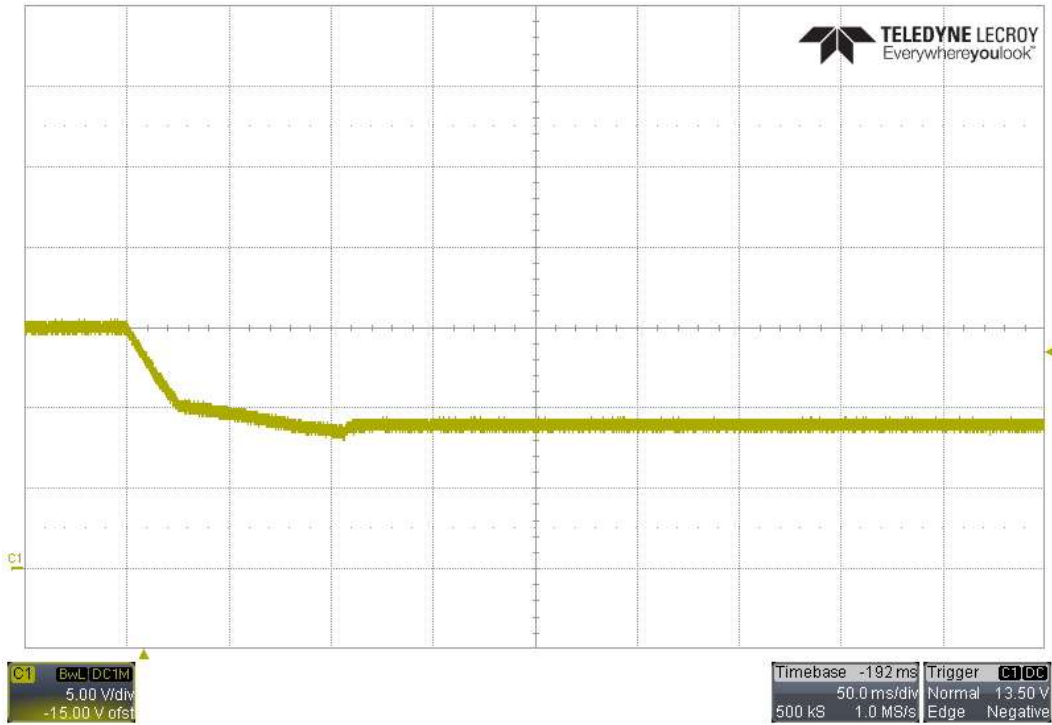
2.12.13 15V to 5V, 115VAC/60Hz Input, No Load



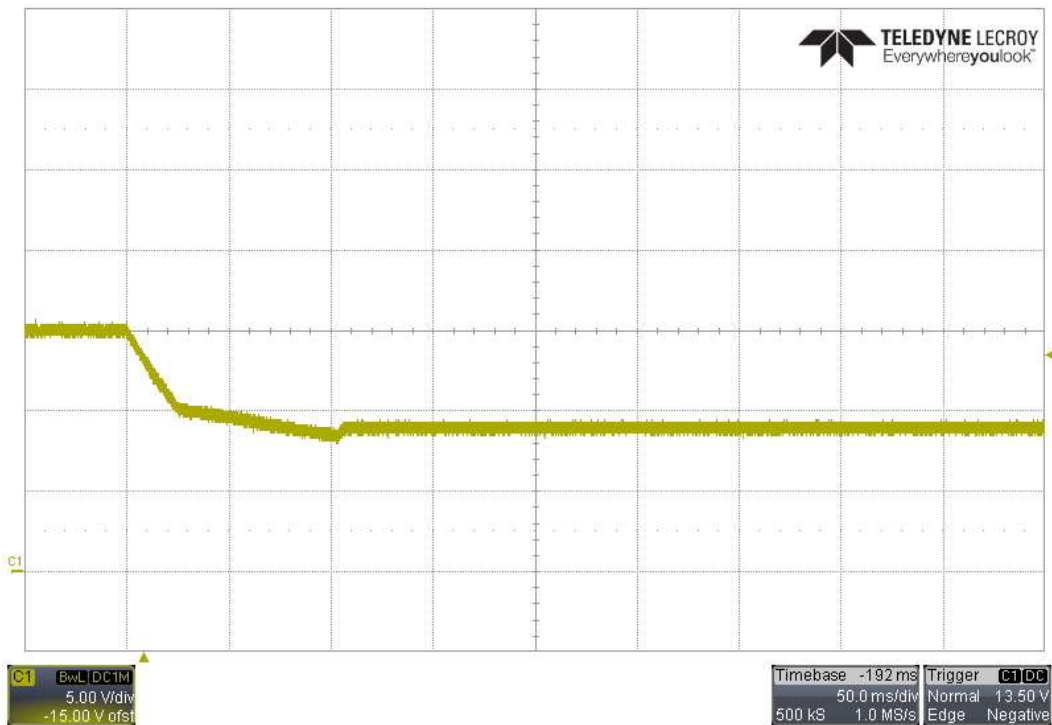
2.12.14 15V to 5V, 230VAC/50Hz Input, No Load



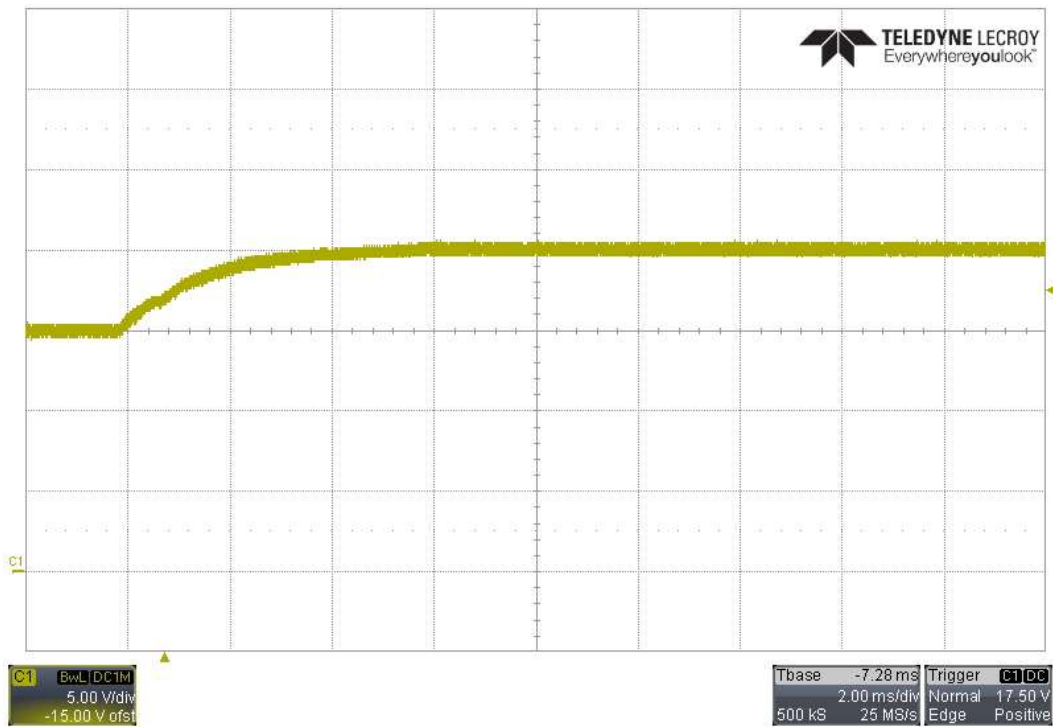
2.12.15 15V to 9V, 115VAC/60Hz Input, No Load



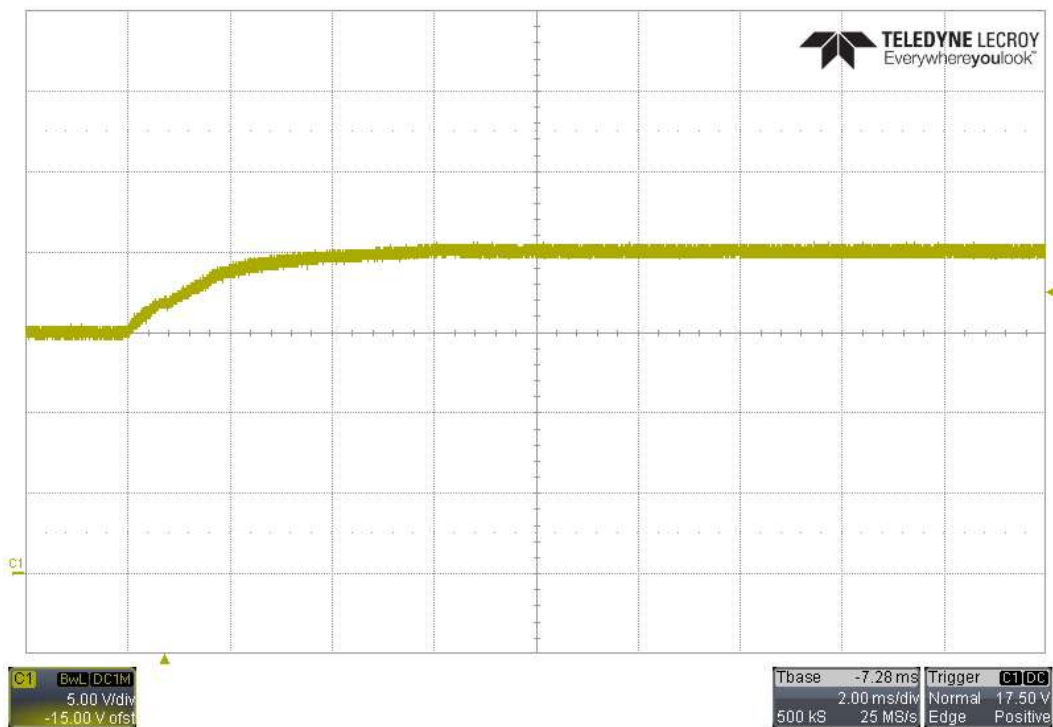
2.12.16 15V to 9V, 230VAC/50Hz Input, No Load



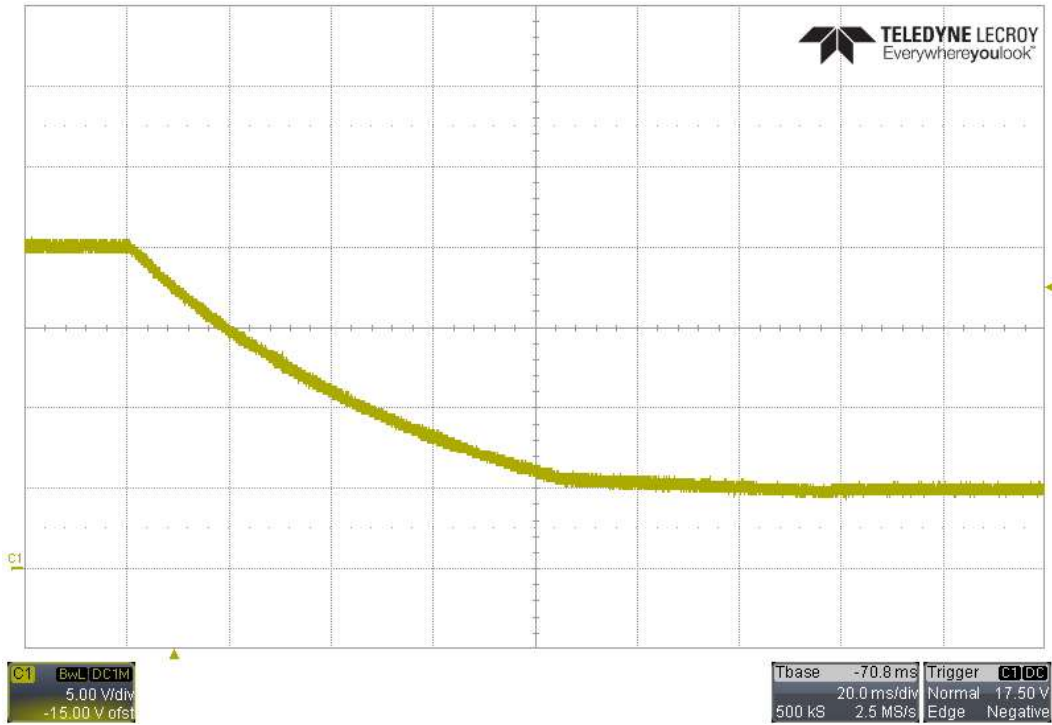
2.12.17 15V to 20V, 115VAC/60Hz Input, No Load



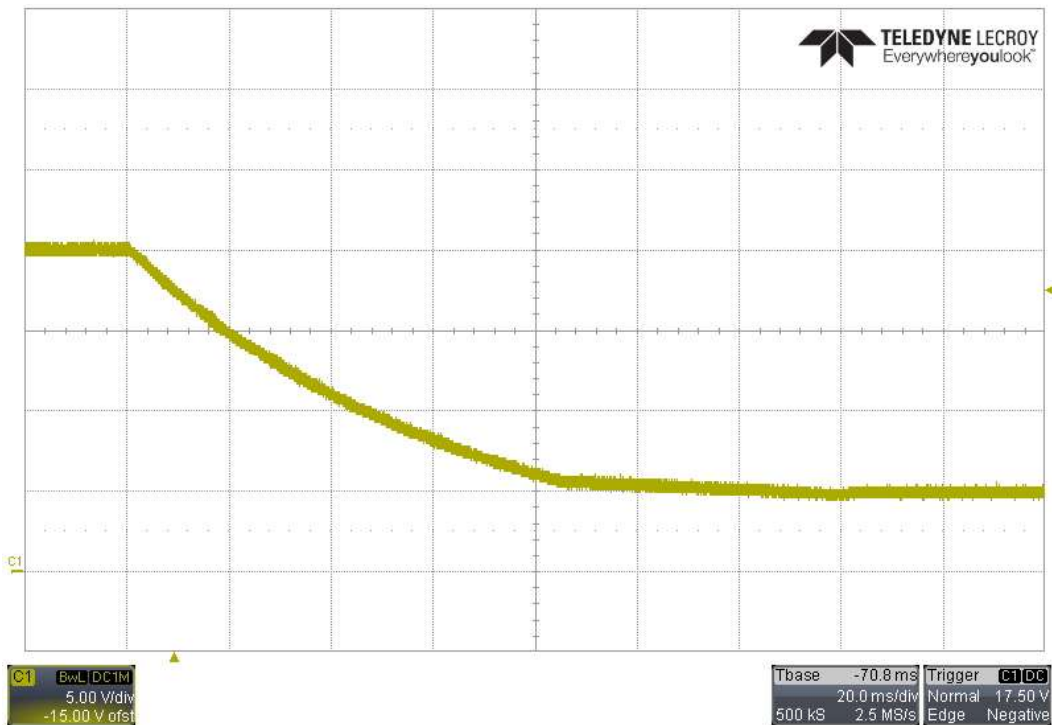
2.12.18 15V to 20V, 230VAC/50Hz Input, No Load



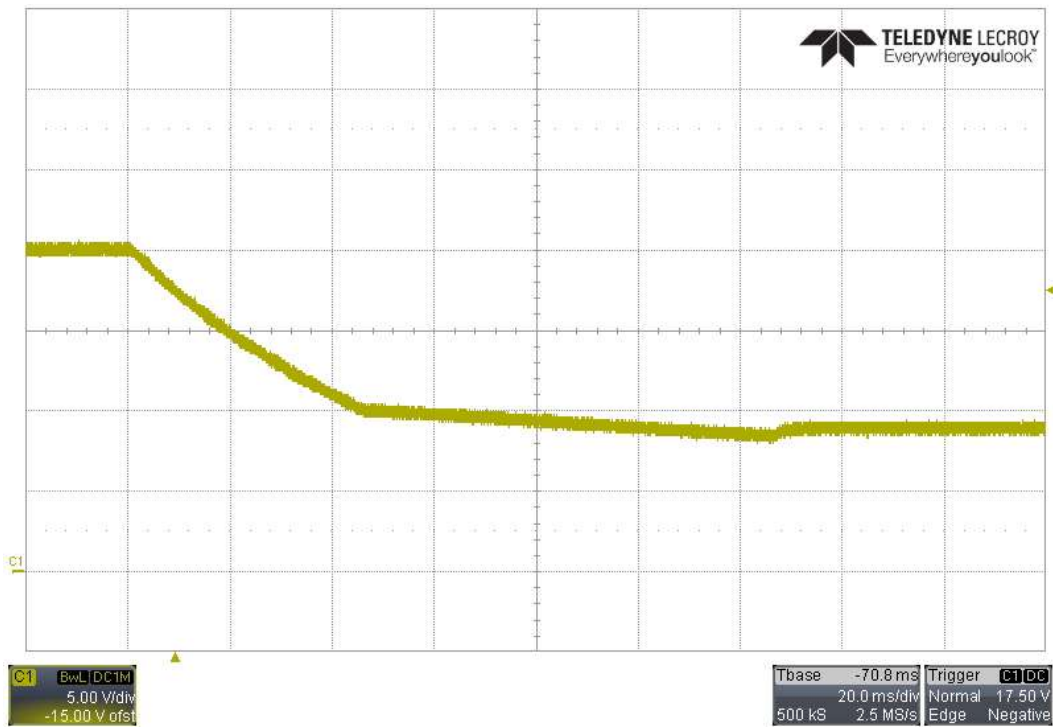
2.12.19 20V to 5V, 115VAC/60Hz Input, No Load



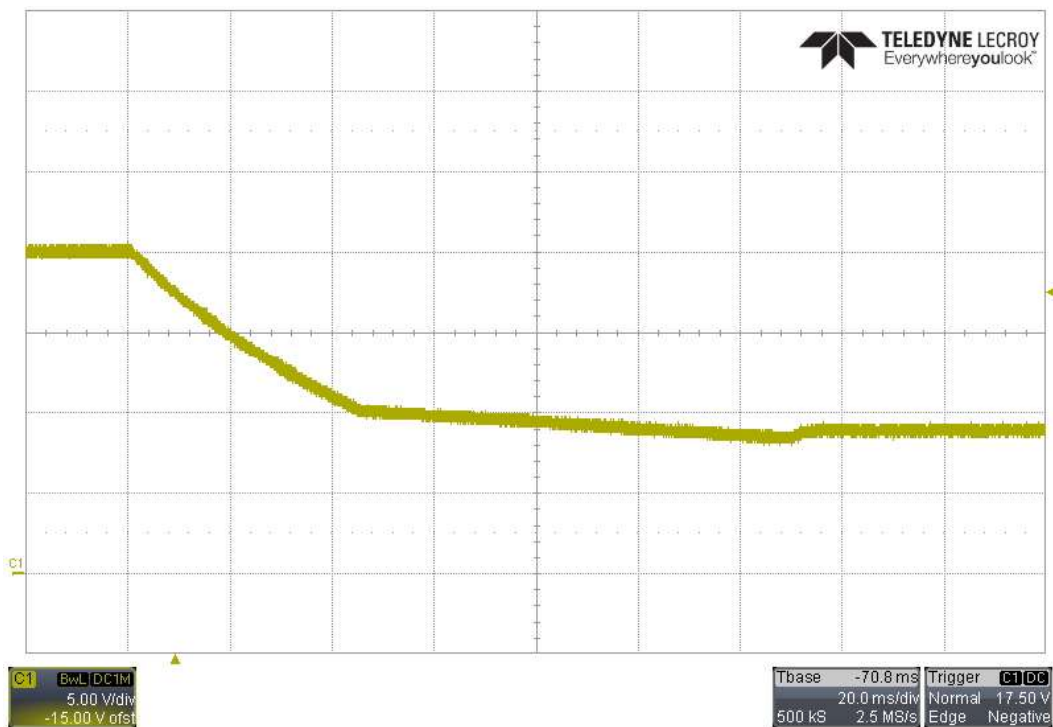
2.12.20 20V to 5V, 230VAC/50Hz Input, No Load



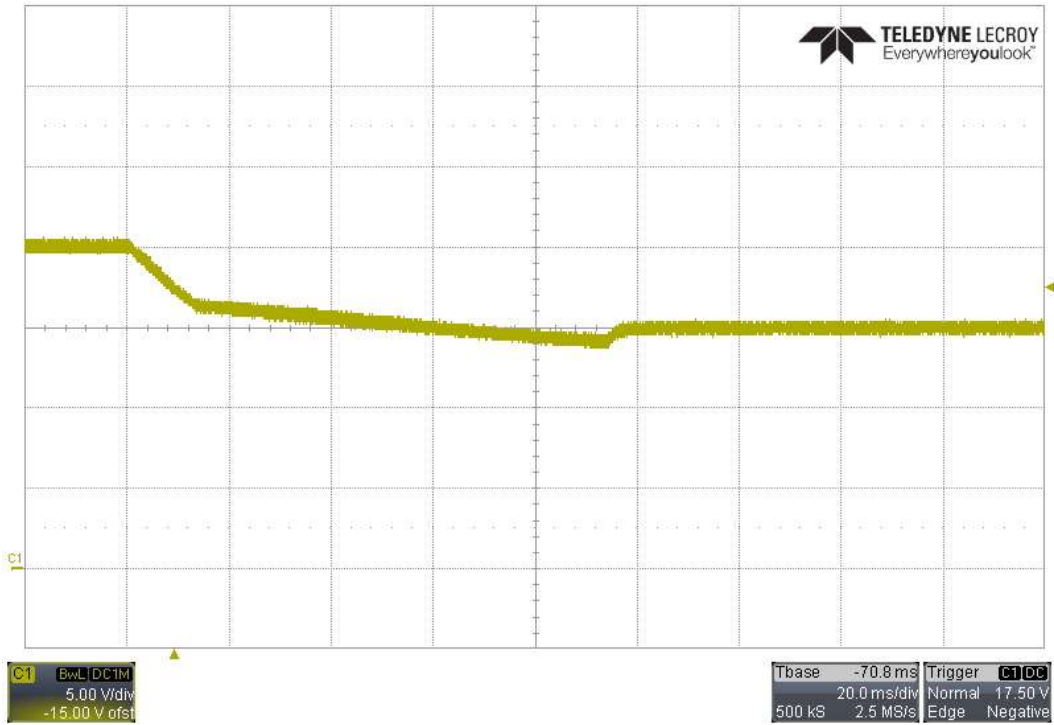
2.12.21 20V to 9V, 115VAC/60Hz Input, No Load



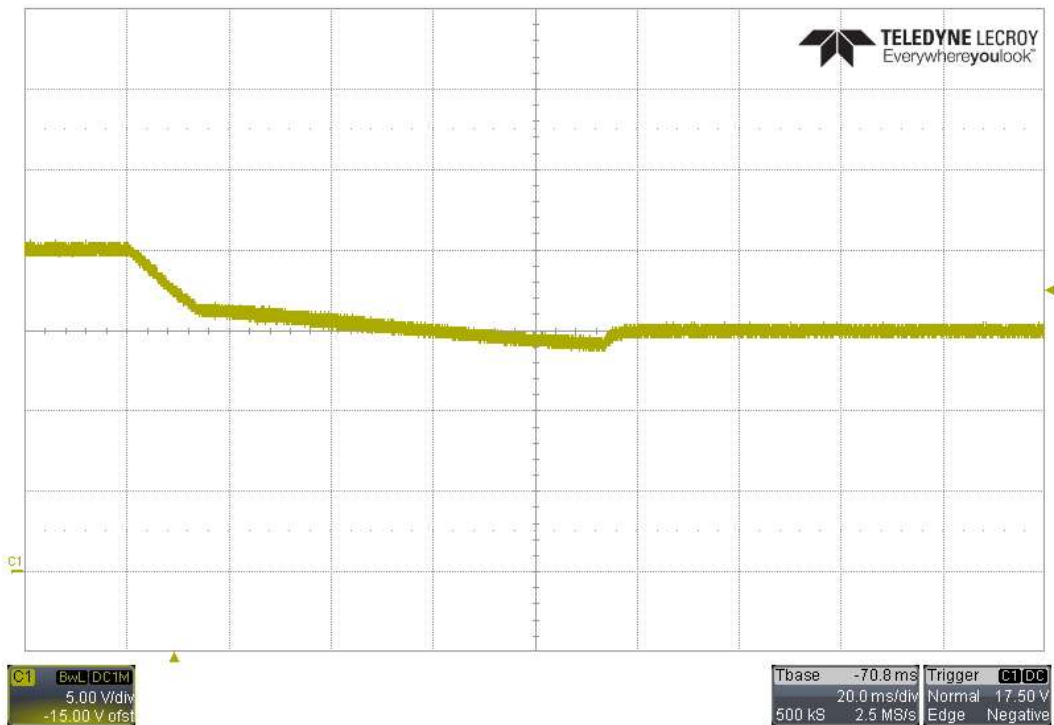
2.12.22 20V to 9V, 230VAC/50Hz Input, No Load



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



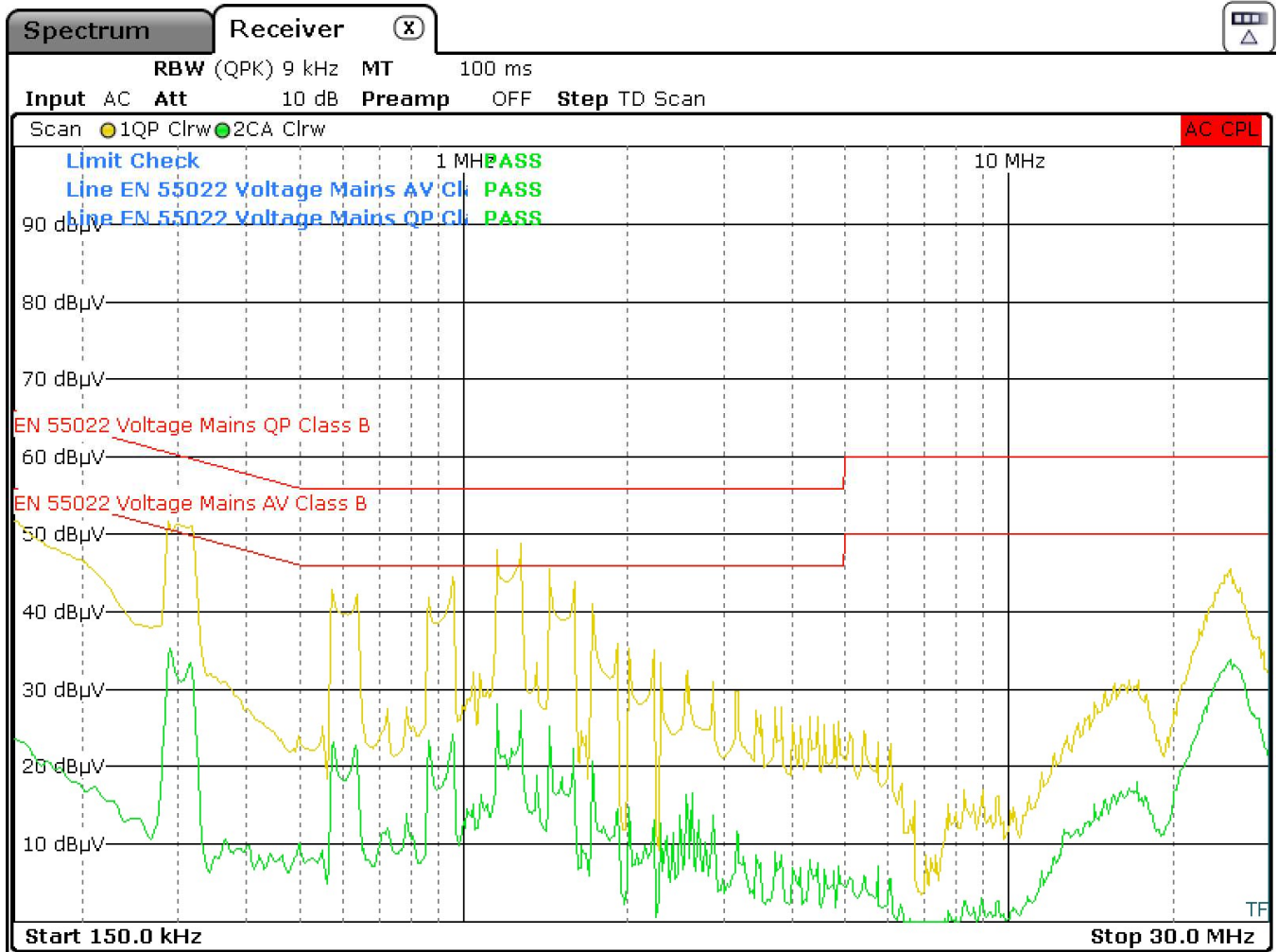
2.12.24 20V to 15V, 230VAC/50Hz Input, No Load



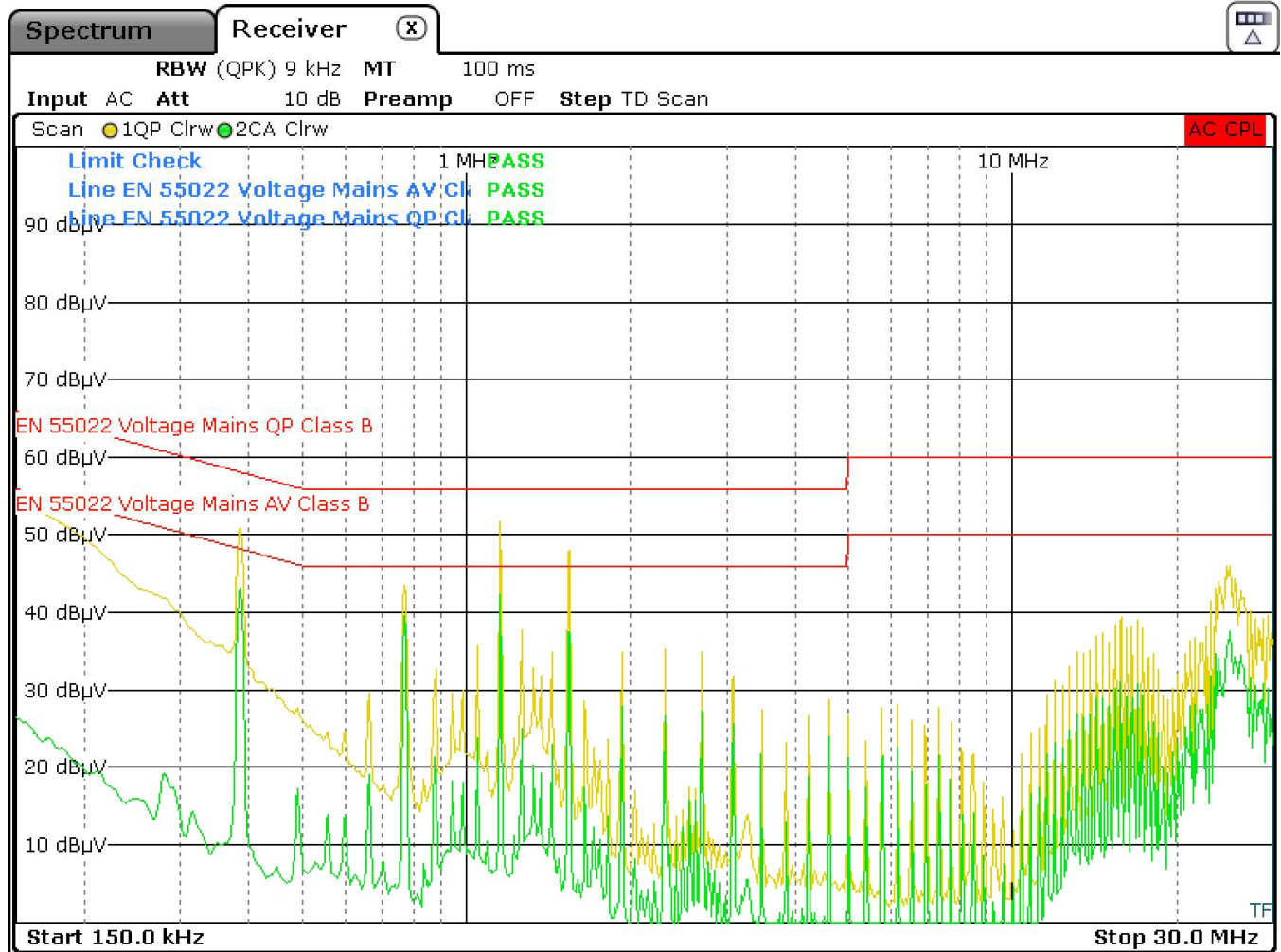
2.13 Conducted EMI

Data measured of Rev C2 board.

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



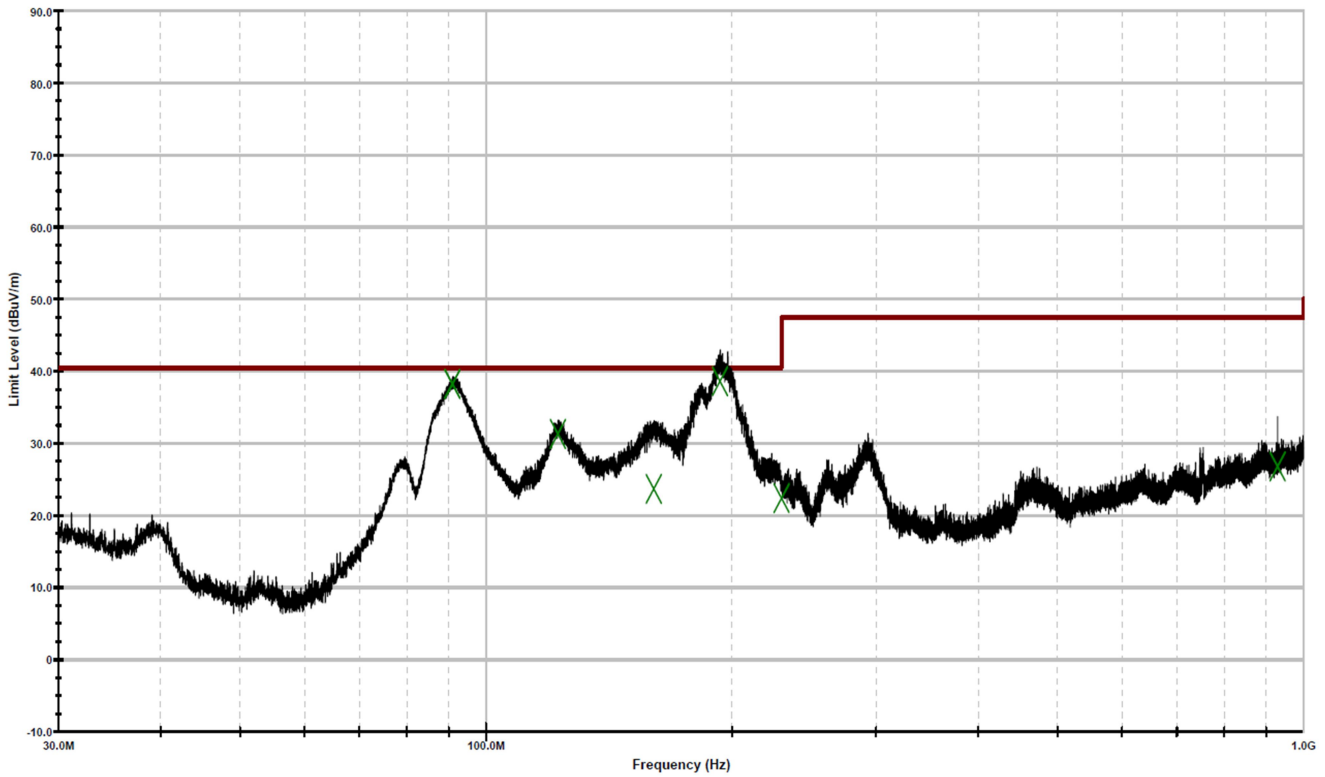
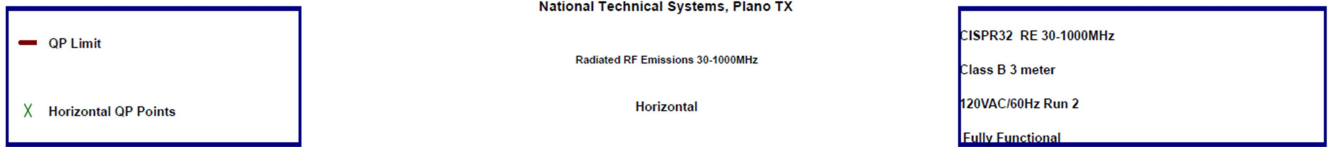
2.13.2 230VAC/50Hz Input, 20V/3.25A Output Tied to Earth Ground



Date: 24.SEP.2019 17:28:43

2.14 Radiated EMI

2.14.1 120VAC/60Hz Input, 20V/3.25A Output, 3M Horizontal Antenna



Frequency MHz	1 Limit dBuV/m	2 QP dBuV/m	3 QP Margin dB	4 Tower cm	5 Turntable Degrees
90.97 MHz	40.457	38.212	-2.245	329.800	353.000
122.43 MHz	40.457	31.283	-9.174	162.100	275.000
160.43 MHz	40.457	23.666	-16.791	116.800	359.200
193.27 MHz	40.457	38.581	-1.876	99.800	256.100
229.85 MHz	40.457	22.362	-18.095	99.700	359.000
929.67 MHz	47.457	26.743	-20.714	176.100	341.100
CISPR32 RE 30-1000MHz					
Class B 3 meter					
120VAC/60Hz Run 2					
Fully Functional					

2.14.2 120VAC/60Hz Input, 20V/3.25A Output, 3M Vertical Antenna

National Technical Systems, Plano TX

Radiated RF Emissions 30-1000MHz

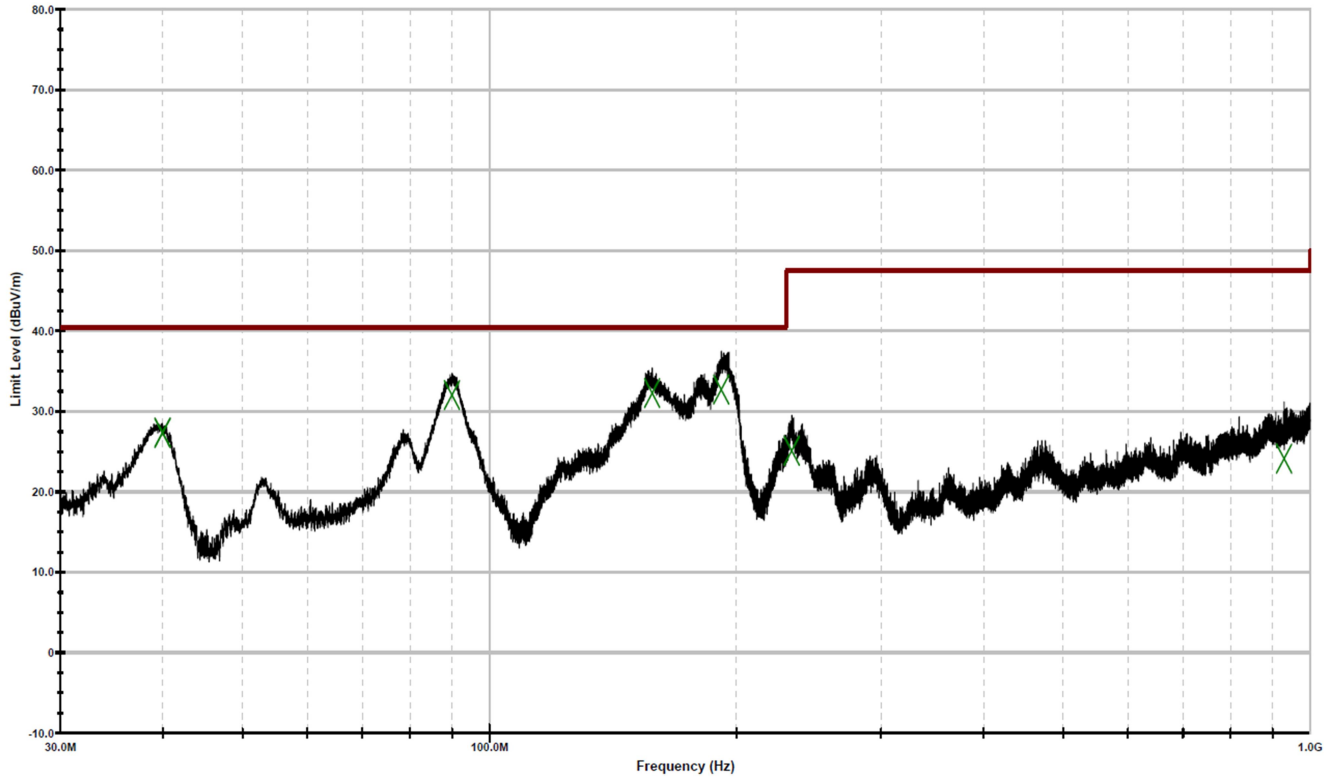
Vertical

CISPR32 RE 30-1000MHz

Class B 3 meter

120VAC/60Hz Run 2

Fully Functional



Frequency MHz	1 Limit dBuV/m	2 QP dBuV/m	3 QP Margin dB	4 Tower cm	5 Turntable Degrees
39.96 MHz	40.457	27.315	-13.142	100.100	42.000
90.02 MHz	40.457	32.000	-8.457	100.100	1.000
157.85 MHz	40.457	32.250	-8.207	100.100	99.200
191.58 MHz	40.457	32.685	-7.772	100.000	1.000
233.47 MHz	47.457	25.078	-22.379	99.900	1.000
929.62 MHz	47.457	24.099	-23.358	100.200	318.000
CISPR32 RE 30-1000MHz					
Class B 3 meter					
120VAC/60Hz Run 2					
Fully Functional					

2.14.3 230VAC/50Hz Input, 20V/3.25A Output, 3M Horizontal Antenna

— QP Limit

X Horizontal QP Points

National Technical Systems, Plano TX

Radiated RF Emissions 30-1000MHz

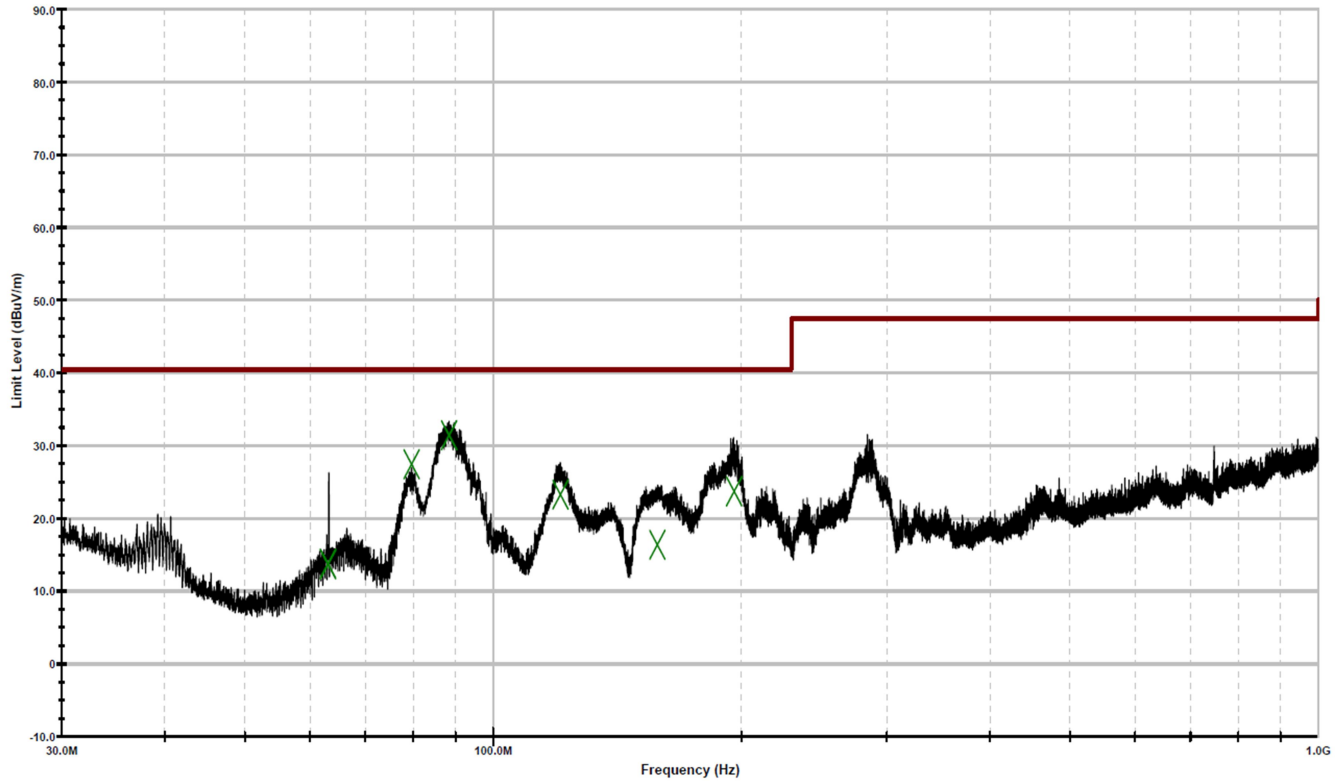
Horizontal

CISPR32 RE 30-1000MHz

Class B 3 meter

230VAC/50Hz

Fully Functional



Frequency MHz	1 Limit dBuV/m	2 QP dBuV/m	3 QP Margin dB	4 Tower cm	5 Turntable Degrees
63.08 MHz	40.457	13.716	-26.741	330.800	1.000
79.64 MHz	40.457	27.425	-13.032	254.000	1.000
88.43 MHz	40.457	31.408	-9.049	261.100	1.000
120.63 MHz	40.457	23.251	-17.206	349.900	288.200
158.12 MHz	40.457	16.331	-24.126	180.100	359.000
195.92 MHz	40.457	23.676	-16.781	166.400	49.100
CISPR32 RE 30-1000MHz					
Class B 3 meter					
230VAC/50Hz					
Fully Functional					

2.14.4 230VAC/50Hz Input, 20V/3.25A Output, 3M Vertical Antenna

— QP Limit

X Vertical QP Points

National Technical Systems, Plano TX

Radiated RF Emissions 30-1000MHz

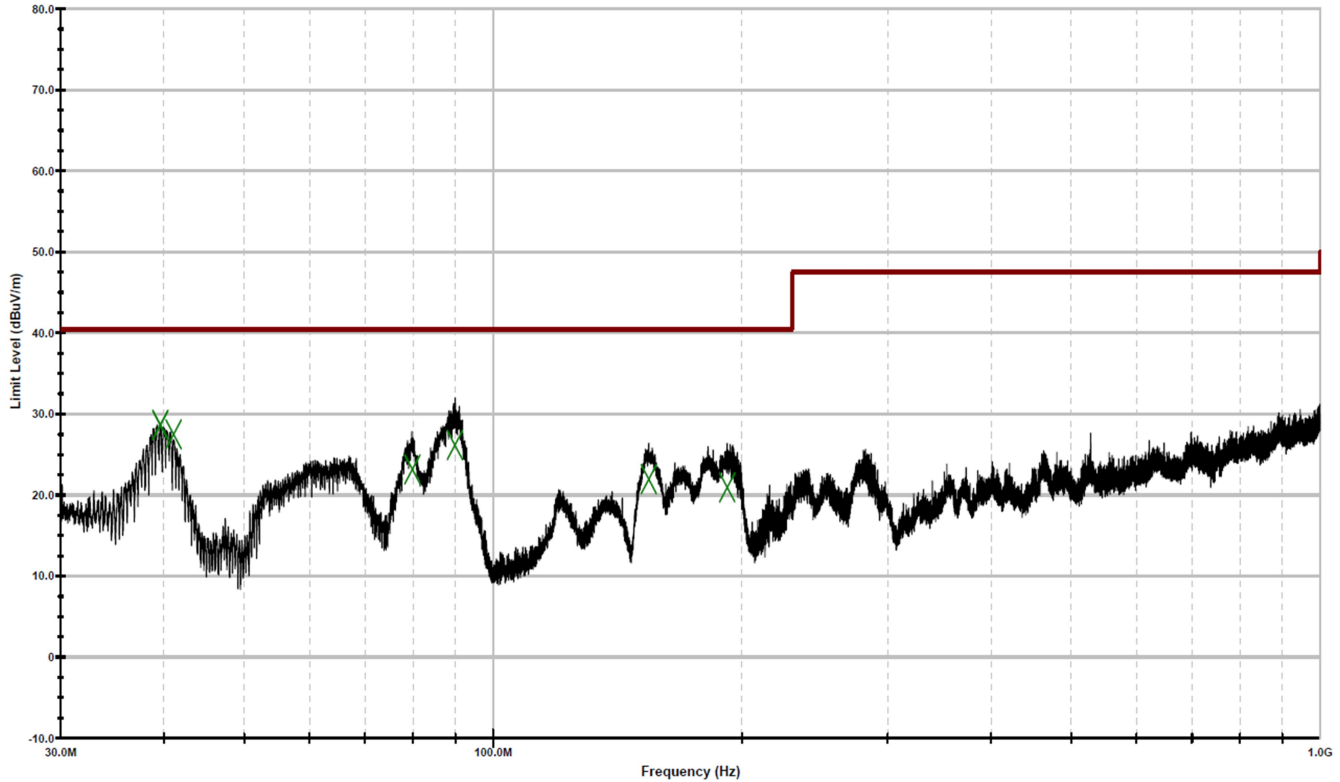
Vertical

CISPR32 RE 30-1000MHz

Class B 3 meter

230VAC/50Hz

Fully Functional



Frequency MHz	1 Limit dBuV/m	2 QP dBuV/m	3 QP Margin dB	4 Tower cm	5 Turntable Degrees
39.61 MHz	40.457	28.624	-11.833	100.100	304.200
41.08 MHz	40.457	27.467	-12.990	108.200	40.200
79.89 MHz	40.457	23.126	-17.331	99.800	1.000
89.91 MHz	40.457	26.130	-14.327	99.800	1.000
154.25 MHz	40.457	21.913	-18.544	99.900	1.000
191.95 MHz	40.457	20.894	-19.563	99.800	1.000
CISPR32 RE 30-1000MHz					
Class B 3 meter					
230VAC/50Hz					
Fully Functional					

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