PFE1500FB-28-xxx-R

Evaluation Report

Table of Contents

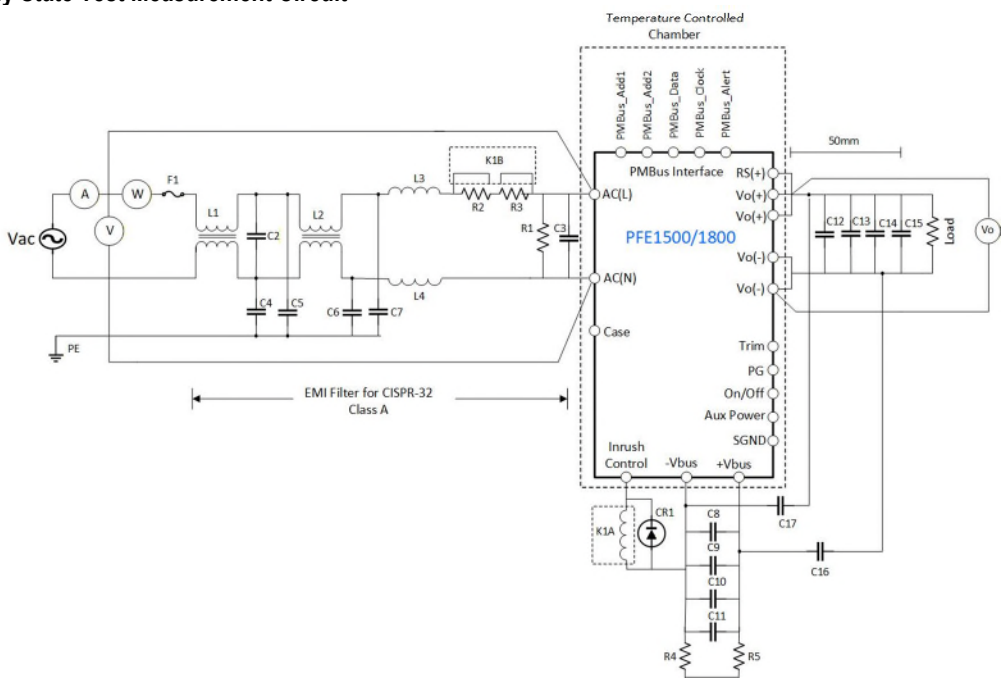
1. EVALUATION METHOD

1.1. Test / Measurement Circuits

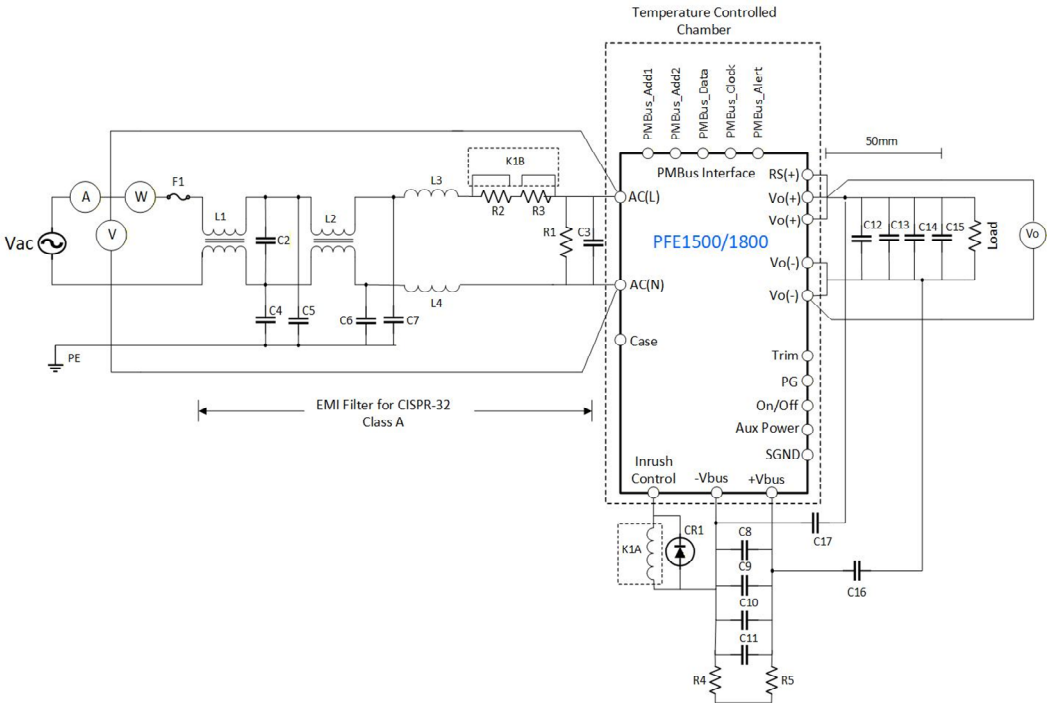
1.1.1. Components

Reference Designator	Description	Reference Designator	Description
C2	0.47 µF Film Capacitor	C3	2 x 2.2 µF Film Capacitor
C4, C5, C6, C7	4700 pF Ceramic Capacitor	C15	0.1 µF Ceramic Capacitor
C16, C17	7500 pF Ceramic Capacitor	CR1	CRH01, 200 V, 1 A Diode
L1	1 mH	R2, R3	10 Ω 5 W
L2	1.3 mH	C12, C13	560 µF Electrolytic Capacitor
L3, L4	27 µH	C14	8 x 4.7 µF Ceramic Capacitor
R1, R4, R5	470 kΩ, 2 W	C8, C9, C10, C11	470 µF Electrolytic Capacitor
K1	1 Form A Relay Contact Rating: 16 A, 277 VAC Coil Rating: 12 VDC, 16.7 mA, 200 mW	F1	20 A, 280 V, Fast Blow

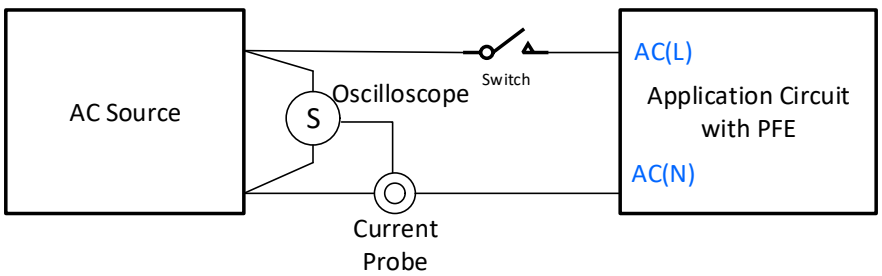
1.1.2. Steady State Test Measurement Circuit



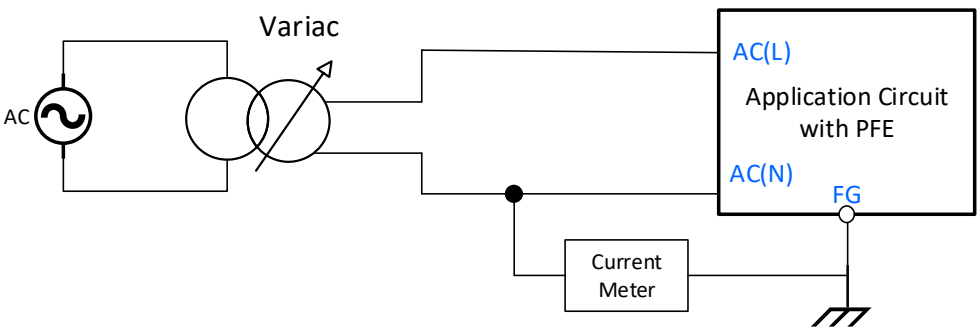
1.1.3. Dynamic, Protection, Output Ripple, and Noise Measurement Circuit



1.1.4. Inrush Current Measurement Circuit



1.1.5. Leakage Current Measurement Circuit

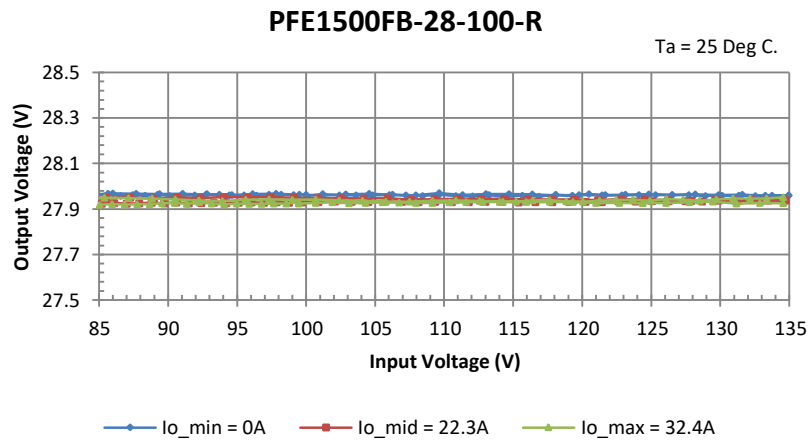


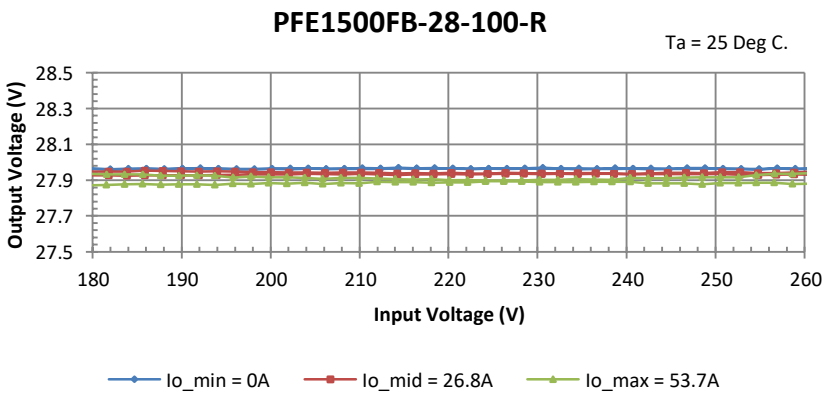
2. CHARACTERISTICS

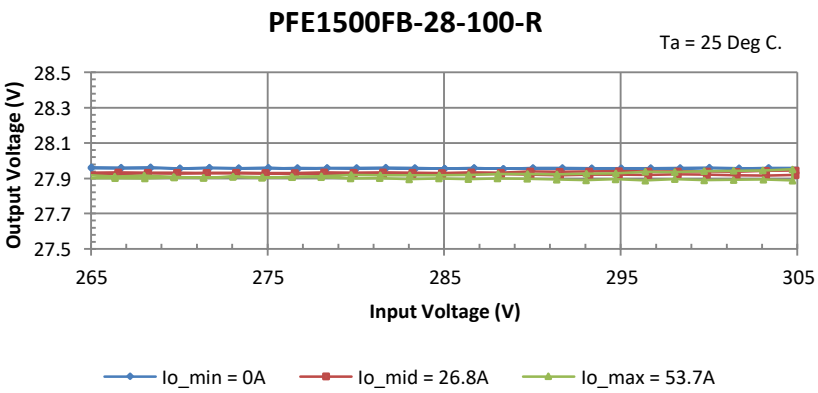
2.1. Steady State Data

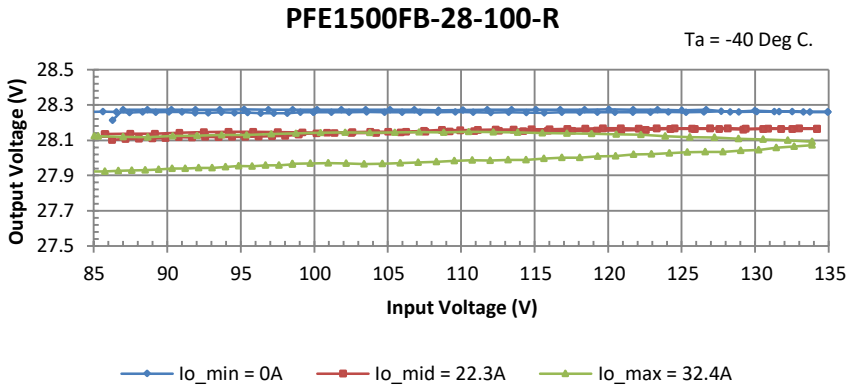
2.1.1. Regulation – Line, Load (60 Hz)

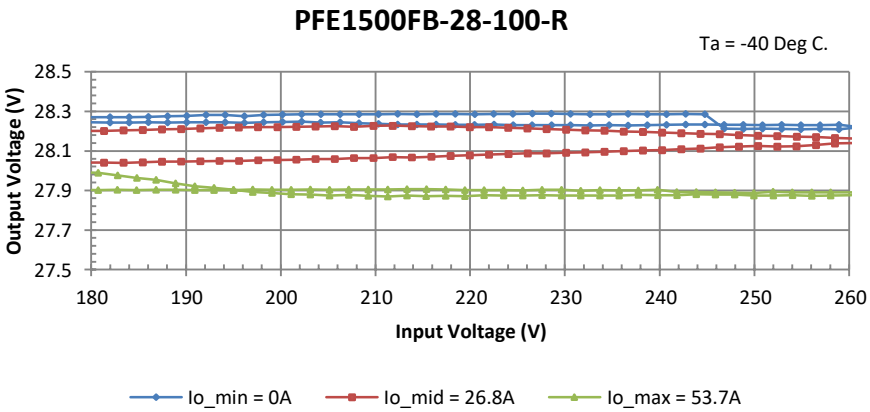
2.1.1.1. Line Regulation

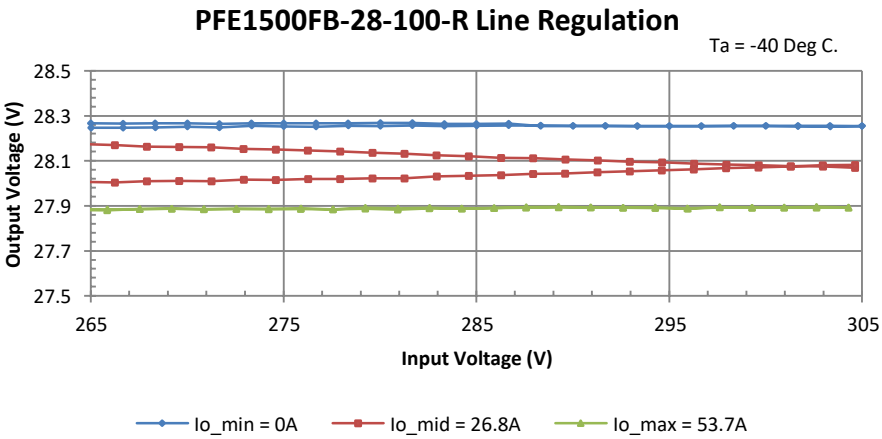


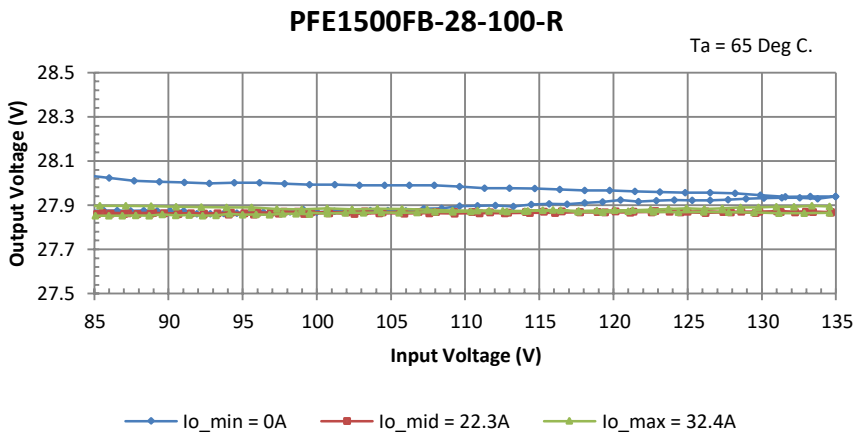


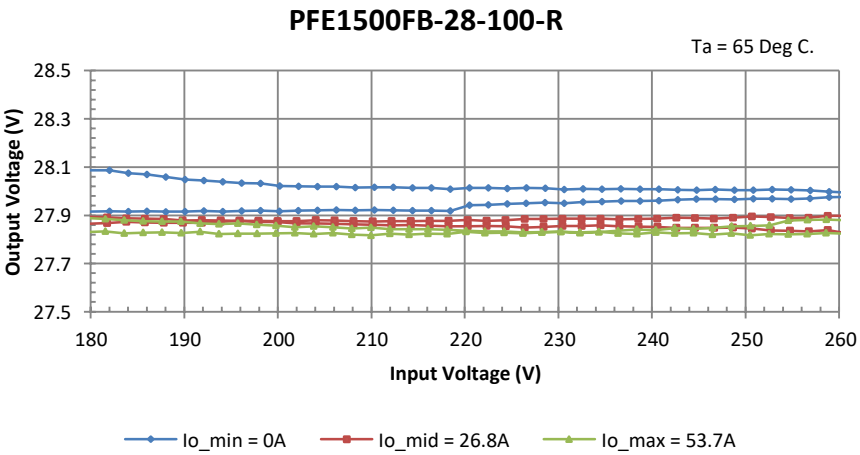


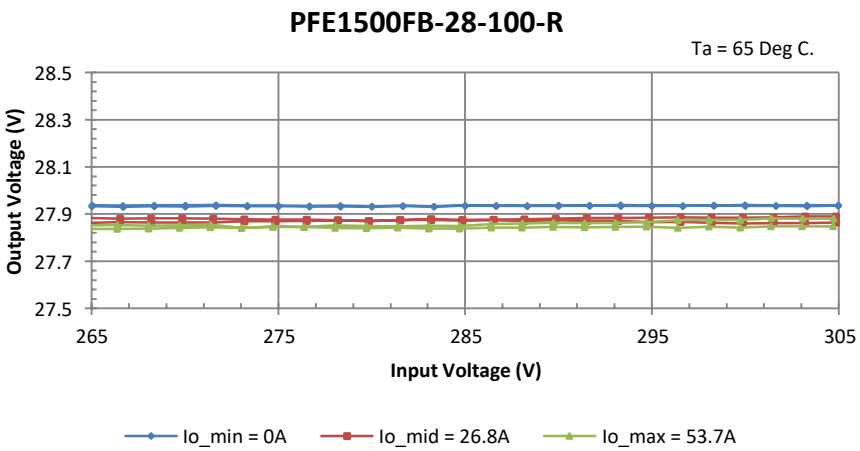

PFE1500FB-28-100-R
Ta = -40 Deg C.
Output Voltage (V)
28.5
28.3
28.1
27.9
27.7
27.5
85
90
95
100
105
110
115
120
125
130
135
Input Voltage (V)
Io_min = 0A
Io_mid = 22.3A
Io_max = 32.4A


PFE1500FB-28-100-R
Ta = -40 Deg C.
Output Voltage (V)
28.5
28.3
28.1
27.9
27.7
27.5
180
190
200
210
220
230
240
250
260
Input Voltage (V)
Io_min = 0A
Io_mid = 26.8A
Io_max = 53.7A

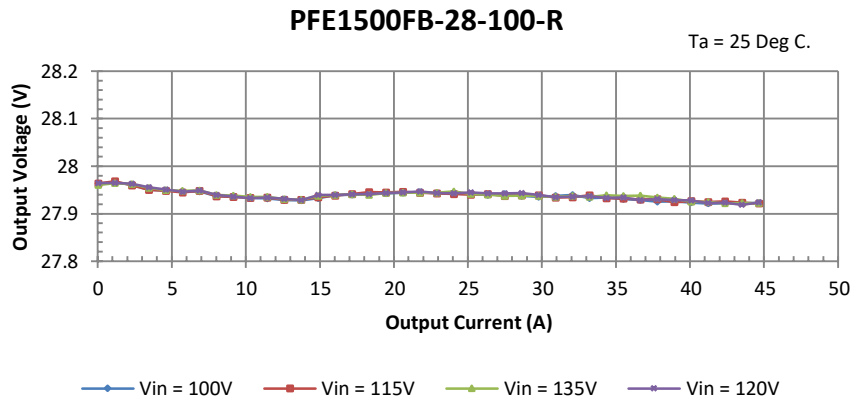

PFE1500FB-28-100-R Line Regulation
Ta = -40 Deg C.
Output Voltage (V)
28.5
28.3
28.1
27.9
27.7
27.5
265
275
285
295
305
Input Voltage (V)
Io_min = 0A
Io_mid = 26.8A
Io_max = 53.7A

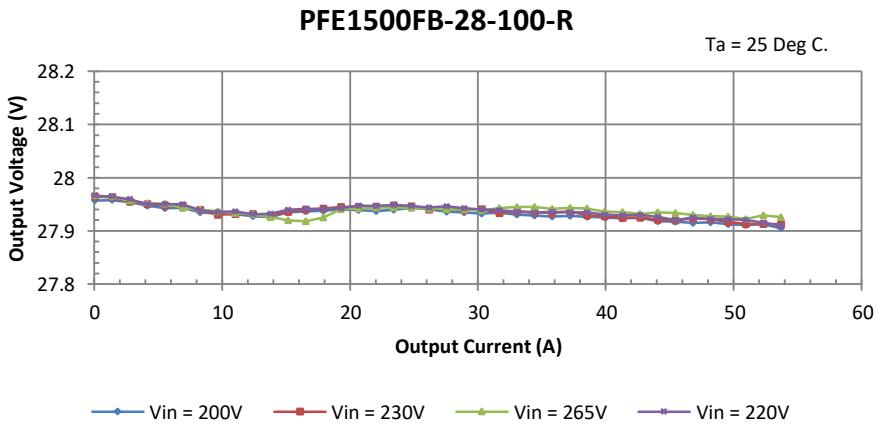

PFE1500FB-28-100-R
Ta = 65 Deg C.
Output Voltage (V)
28.5
28.3
28.1
27.9
27.7
27.5
85
90
95
100
105
110
115
120
125
130
135
Input Voltage (V)
Io_min = 0A
Io_mid = 22.3A
Io_max = 32.4A

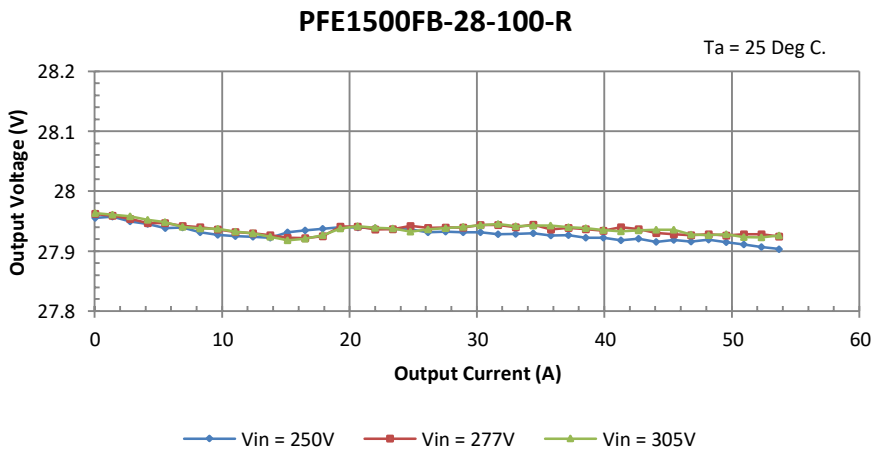

PFE1500FB-28-100-R
Ta = 65 Deg C.
Output Voltage (V)
28.5
28.3
28.1
27.9
27.7
27.5
180
190
200
210
220
230
240
250
260
Input Voltage (V)
Io_min = 0A
Io_mid = 26.8A
Io_max = 53.7A

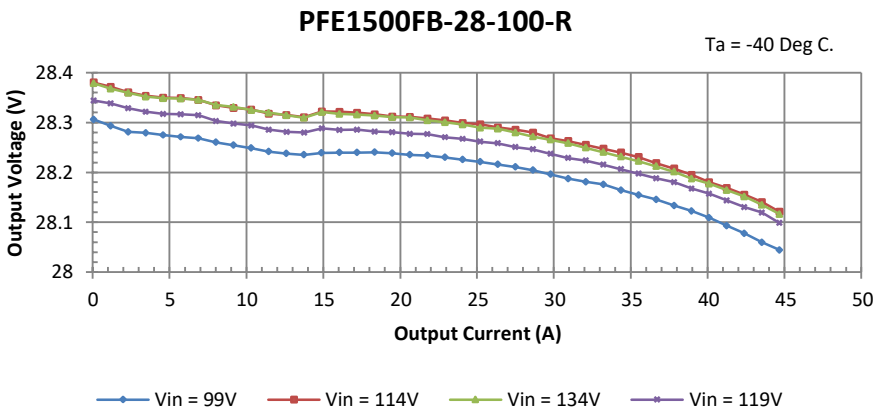

PFE1500FB-28-100-R
Ta = 65 Deg C.
Output Voltage (V)
28.5
28.3
28.1
27.9
27.7
27.5
265
275
285
295
305
Input Voltage (V)
Io_min = 0A
Io_mid = 26.8A
Io_max = 53.7A

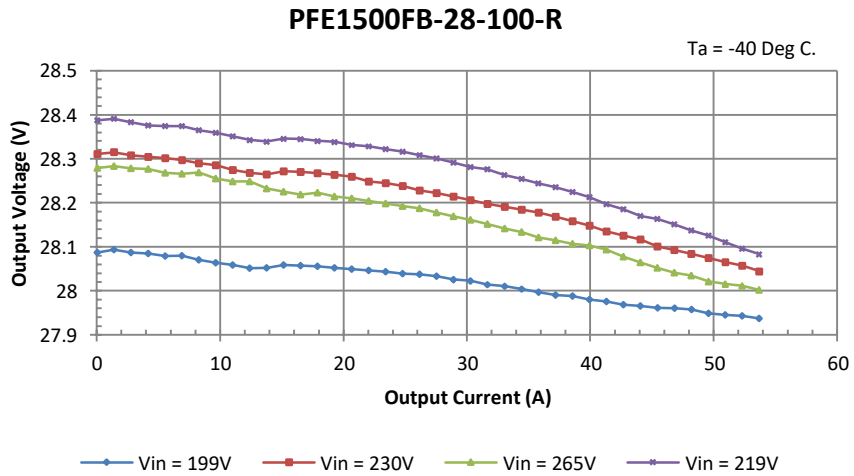
2.1.1.2. Load Regulation

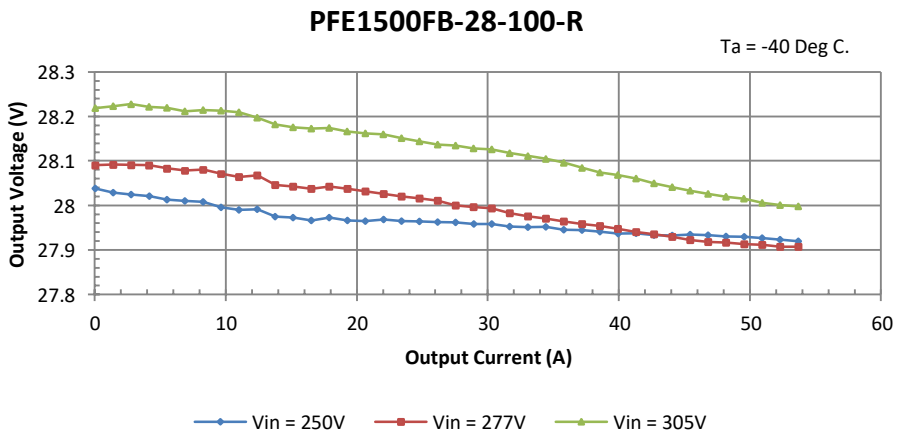


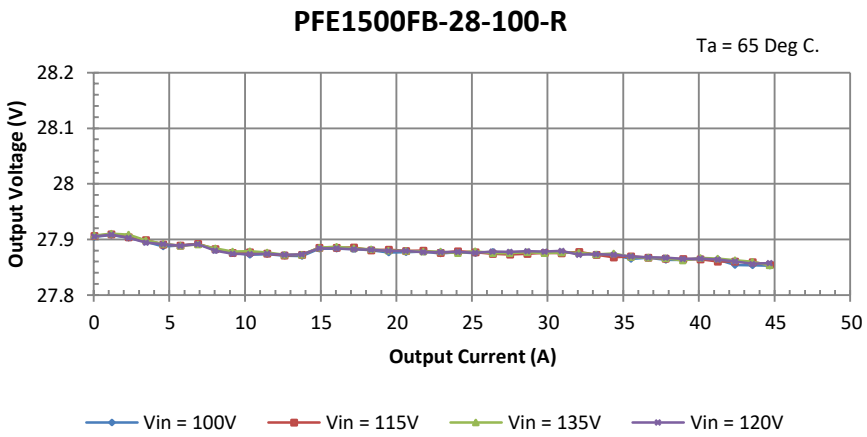


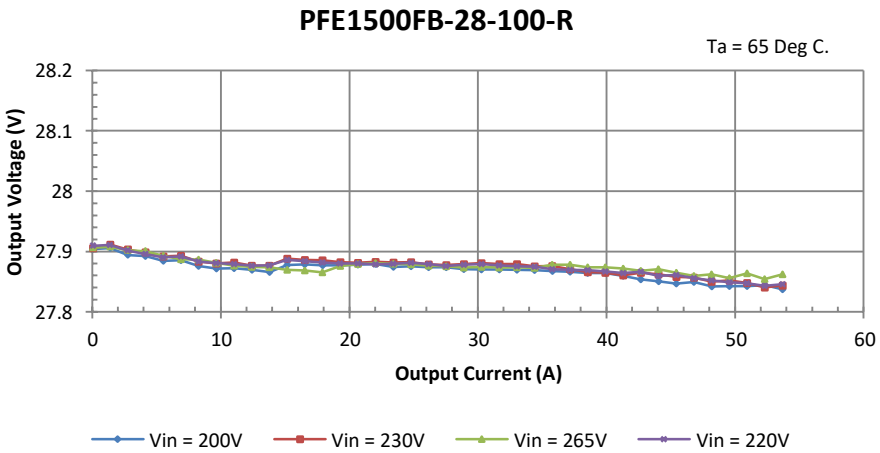


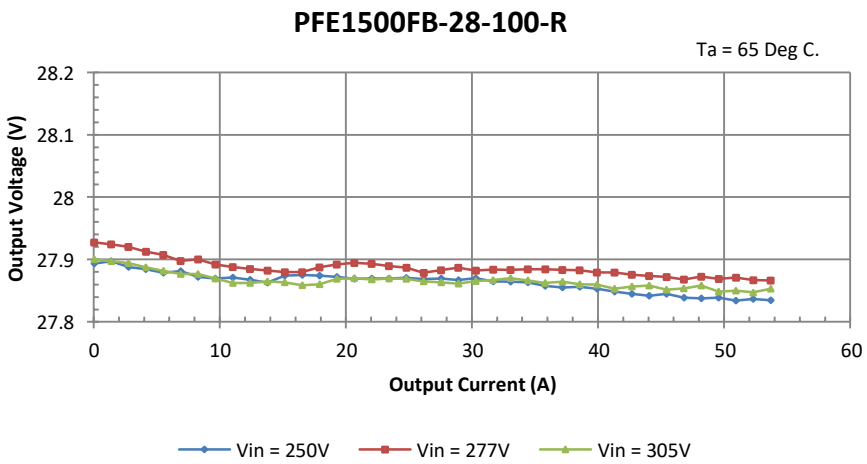

PFE1500FB-28-100-R
Ta = -40 Deg C.
Output Voltage (V)
28.4
28.3
28.2
28.1
28
0
5
10
15
20
25
30
35
40
45
50
Output Current (A)
Vin = 99V
Vin = 114V
Vin = 134V
Vin = 119V


PFE1500FB-28-100-R
Ta = -40 Deg C.
Output Voltage (V)
28.5
28.4
28.3
28.2
28.1
28
27.9
0
10
20
30
40
50
60
Output Current (A)
Vin = 199V
Vin = 230V
Vin = 265V
Vin = 219V

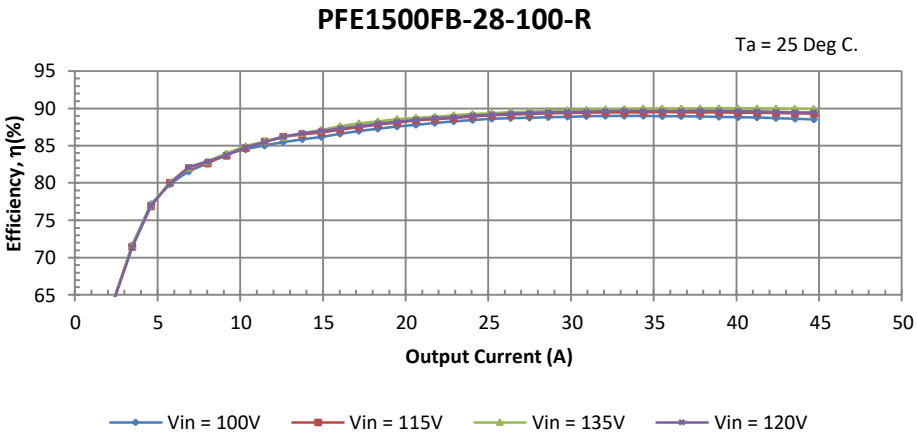

PFE1500FB-28-100-R
Ta = -40 Deg C.
Output Voltage (V)
28.3
28.2
28.1
28
27.9
27.8
0
10
20
30
40
50
60
Output Current (A)
Vin = 250V
Vin = 277V
Vin = 305V

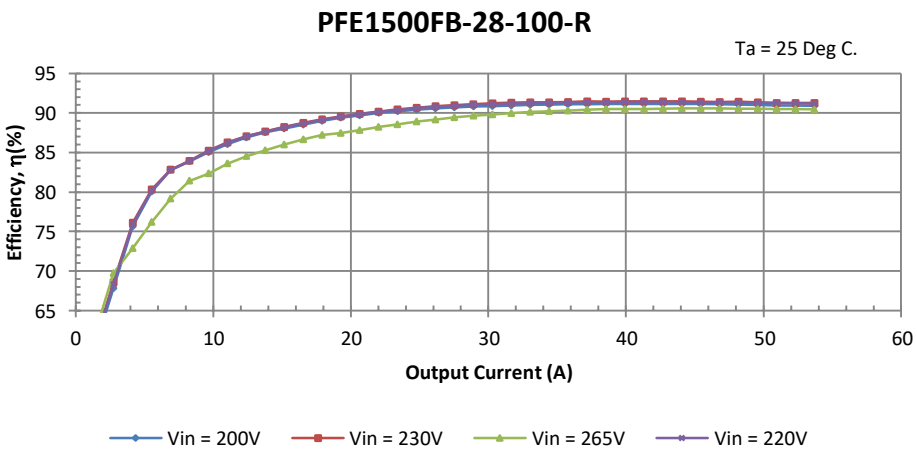

PFE1500FB-28-100-R
Ta = 65 Deg C.
Output Voltage (V)
28.2
28.1
28
27.9
27.8
0
5
10
15
20
25
30
35
40
45
50
Output Current (A)
Vin = 100V
Vin = 115V
Vin = 135V
Vin = 120V

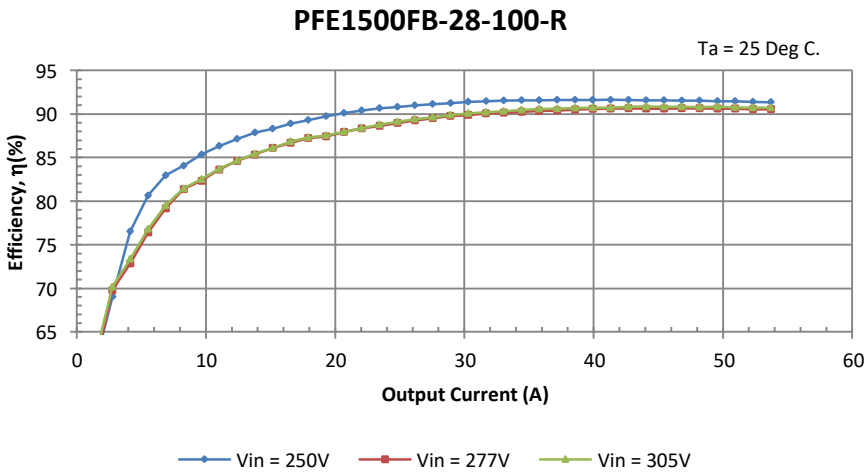

PFE1500FB-28-100-R
Ta = 65 Deg C.
Output Voltage (V)
28.2
28.1
28
27.9
27.8
0
10
20
30
40
50
60
Output Current (A)
Vin = 200V
Vin = 230V
Vin = 265V
Vin = 220V

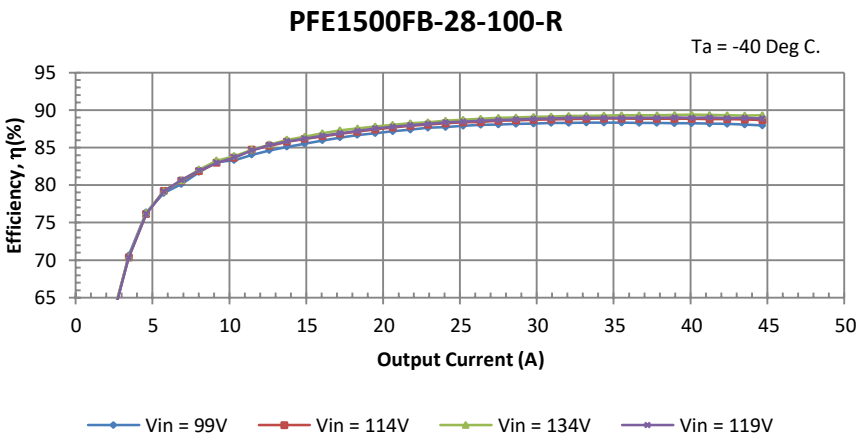

PFE1500FB-28-100-R
Ta = 65 Deg C.
Output Voltage (V)
28.2
28.1
28
27.9
27.8
0
10
20
30
40
50
60
Output Current (A)
Vin = 250V
Vin = 277V
Vin = 305V

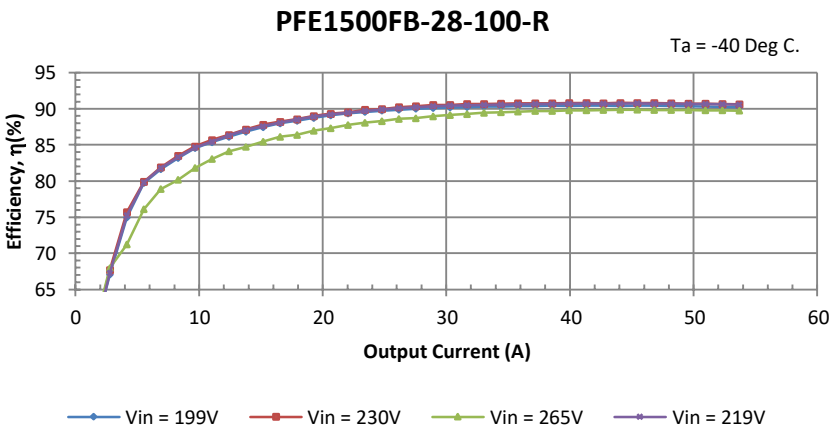
2.1.2. Efficiency vs. Output Current (60 Hz)

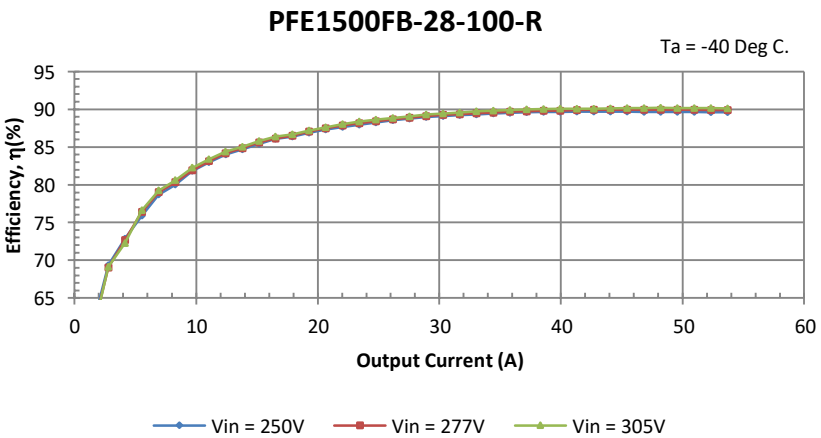


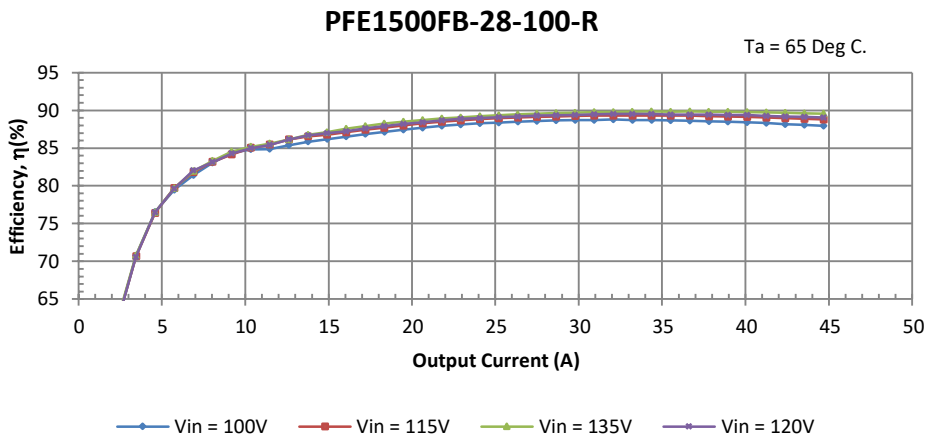


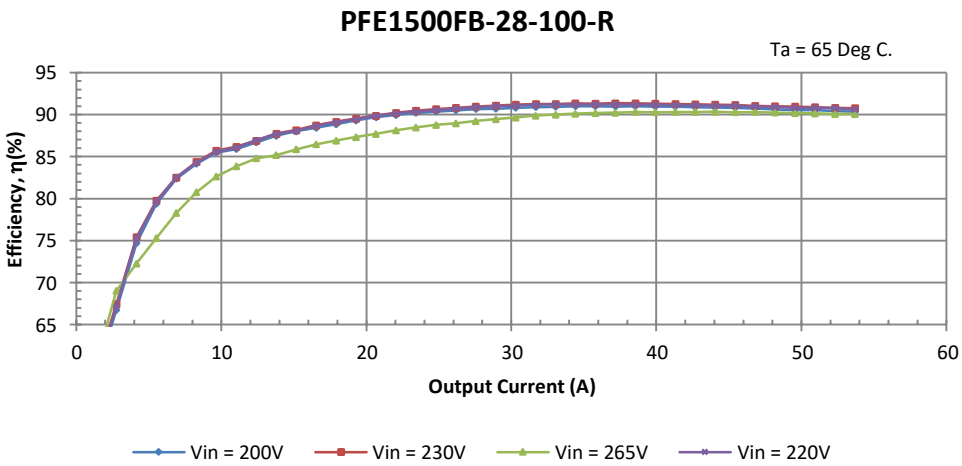


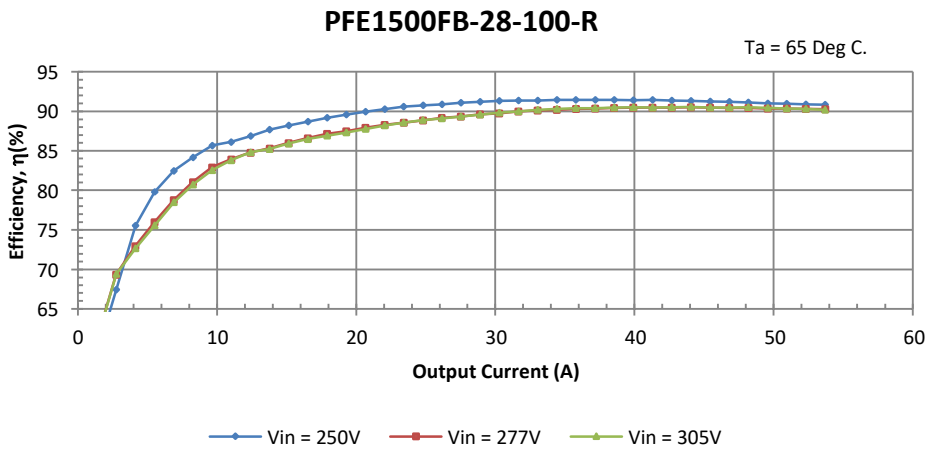

PFE1500FB-28-100-R
Ta = -40 Deg C.
Efficiency, η(%)
95
90
85
80
75
70
65
0
5
10
15
20
25
30
35
40
45
50
Output Current (A)
Vin = 99V
Vin = 114V
Vin = 134V
Vin = 119V


PFE1500FB-28-100-R
Ta = -40 Deg C.
Efficiency, η(%)
95
90
85
80
75
70
65
0
10
20
30
40
50
60
Output Current (A)
Vin = 199V
Vin = 230V
Vin = 265V
Vin = 219V

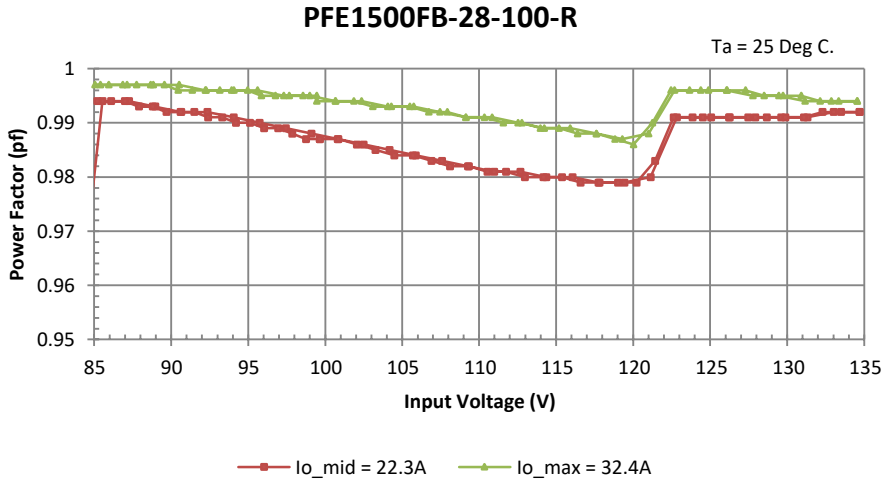

PFE1500FB-28-100-R
Ta = -40 Deg C.
Efficiency, η(%)
95
90
85
80
75
70
65
0
10
20
30
40
50
60
Output Current (A)
Vin = 250V
Vin = 277V
Vin = 305V

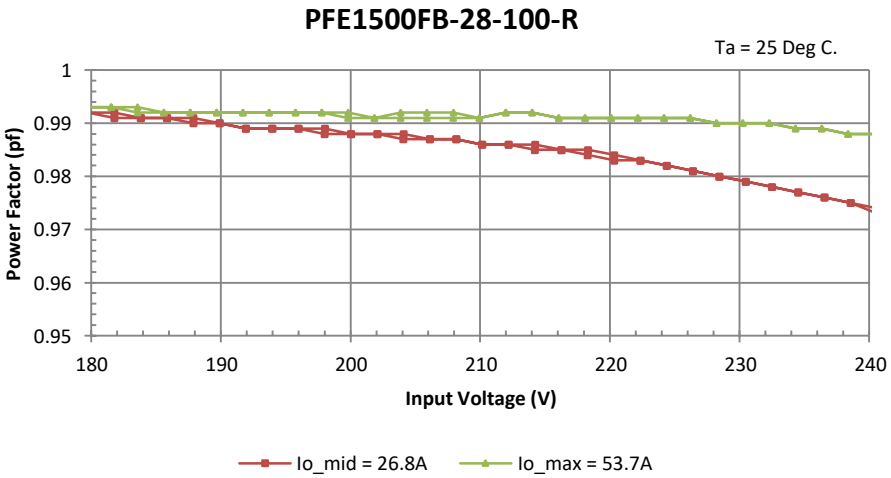

PFE1500FB-28-100-R
Ta = 65 Deg C.
Efficiency, η(%)
95
90
85
80
75
70
65
0
5
10
15
20
25
30
35
40
45
50
Output Current (A)
Vin = 100V
Vin = 115V
Vin = 135V
Vin = 120V

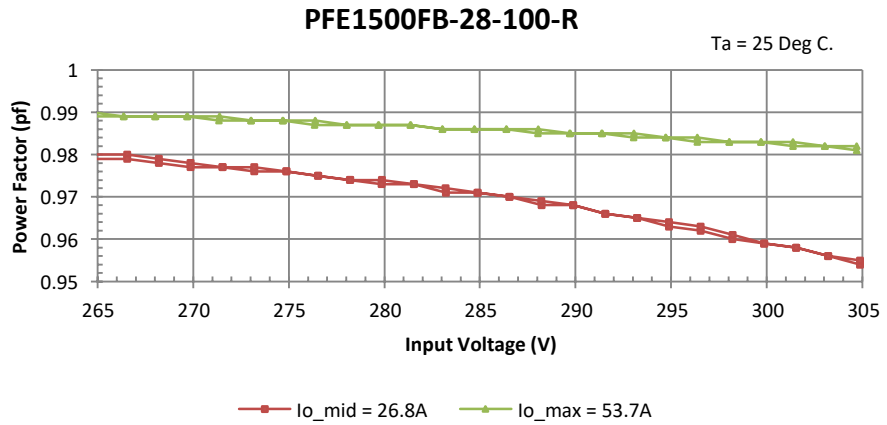

PFE1500FB-28-100-R
Ta = 65 Deg C.
Efficiency, η(%)
95
90
85
80
75
70
65
0
10
20
30
40
50
60
Output Current (A)
Vin = 200V
Vin = 230V
Vin = 265V
Vin = 220V

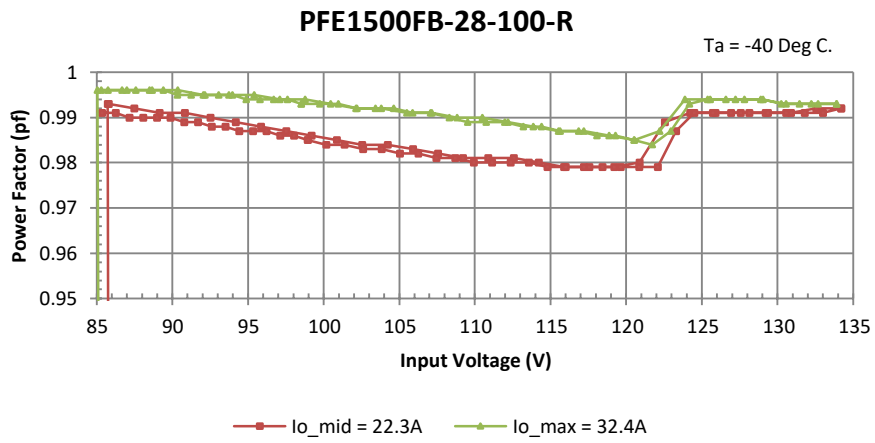

PFE1500FB-28-100-R
Ta = 65 Deg C.
Efficiency, η(%)
95
90
85
80
75
70
65
0
10
20
30
40
50
60
Output Current (A)
Vin = 250V
Vin = 277V
Vin = 305V

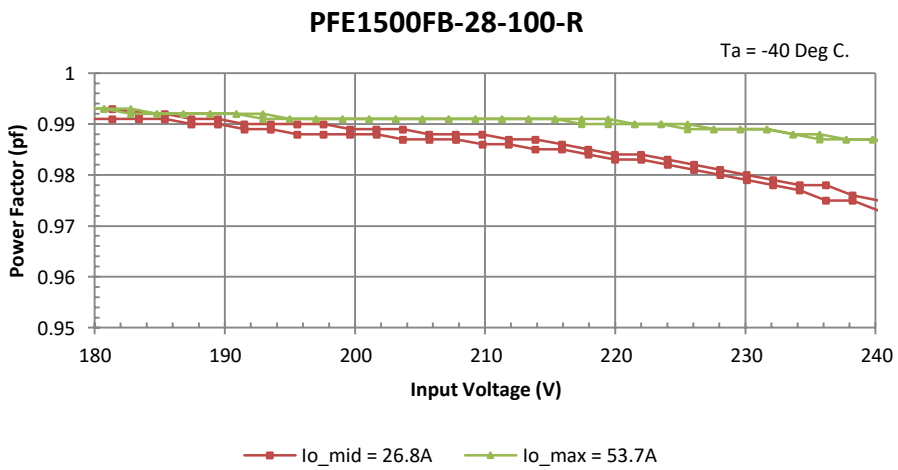
2.1.3. Power Factor (PF) vs. Input Voltage (60 Hz)

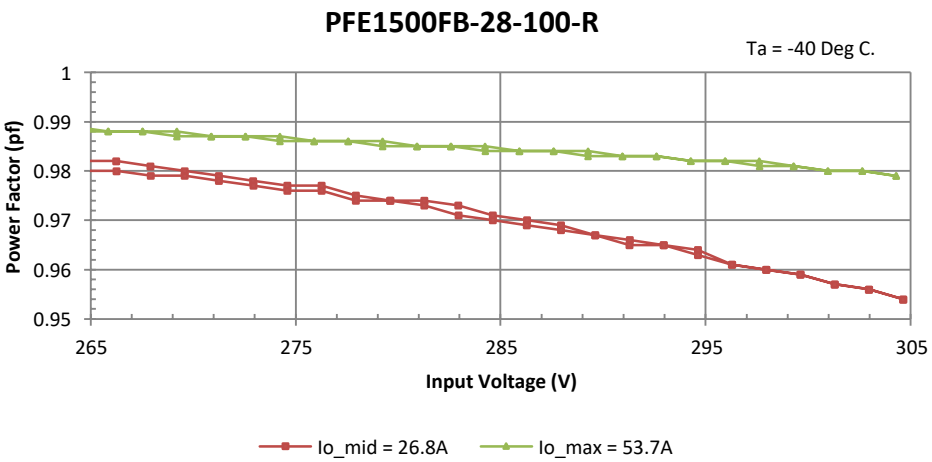


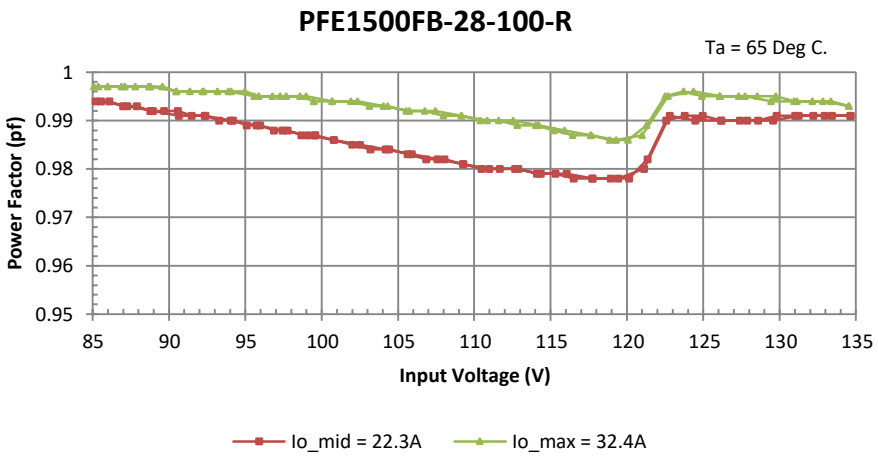


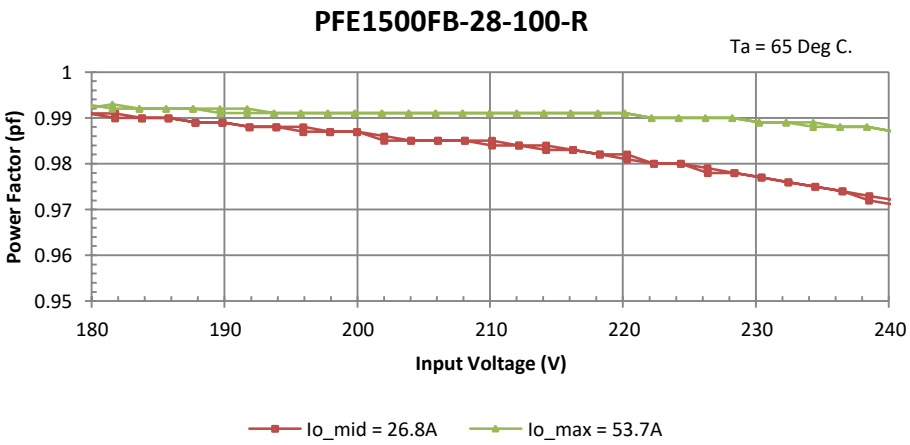


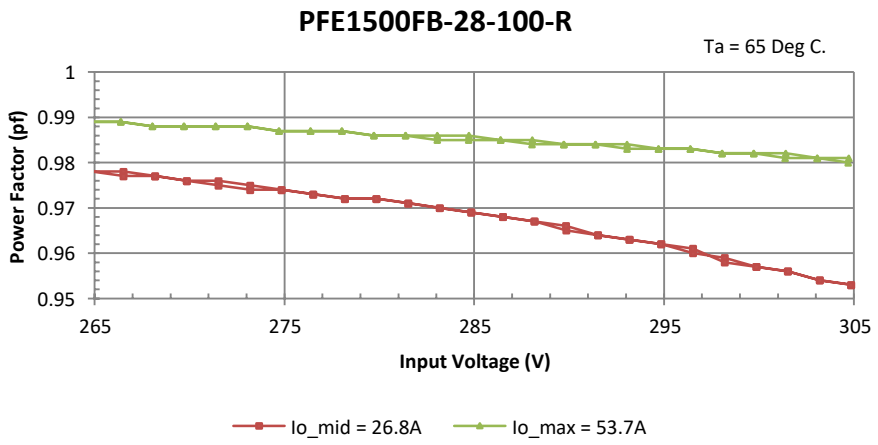

PFE1500FB-28-100-R
Ta = -40 Deg C.
Power Factor (pf)
1
0.99
0.98
0.97
0.96
0.95
85
90
95
100
105
110
115
120
125
130
135
Input Voltage (V)
Io_mid = 22.3A
Io_max = 32.4A


PFE1500FB-28-100-R
Ta = -40 Deg C.
Power Factor (pf)
1
0.99
0.98
0.97
0.96
0.95
180
190
200
210
220
230
240
Input Voltage (V)
Io_mid = 26.8A
Io_max = 53.7A

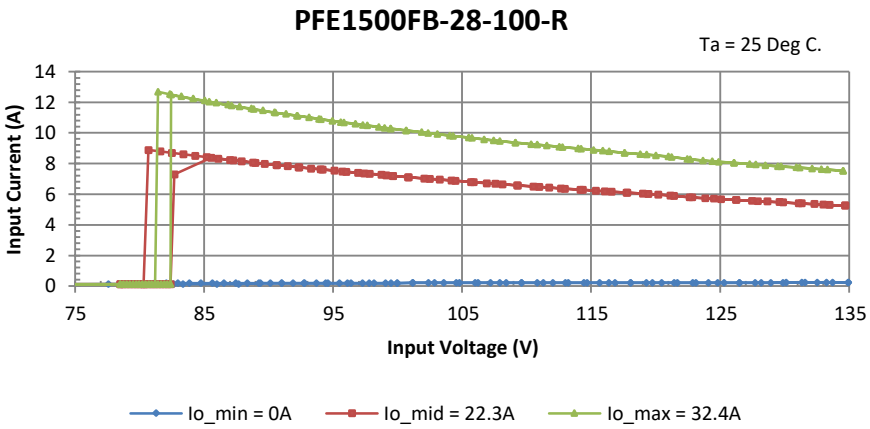

PFE1500FB-28-100-R
Ta = -40 Deg C.
Power Factor (pf)
1
0.99
0.98
0.97
0.96
0.95
265
275
285
295
305
Input Voltage (V)
Io_mid = 26.8A
Io_max = 53.7A

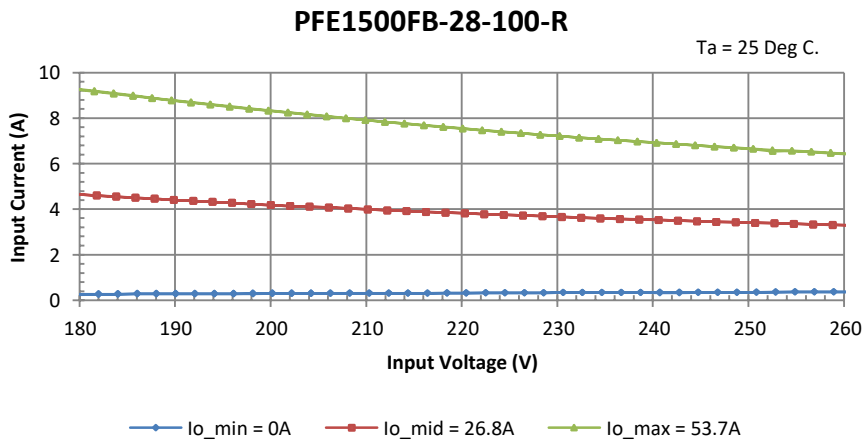

PFE1500FB-28-100-R
Ta = 65 Deg C.
Power Factor (pf)
1
0.99
0.98
0.97
0.96
0.95
85
90
95
100
105
110
115
120
125
130
135
Input Voltage (V)
Io_mid = 22.3A
Io_max = 32.4A

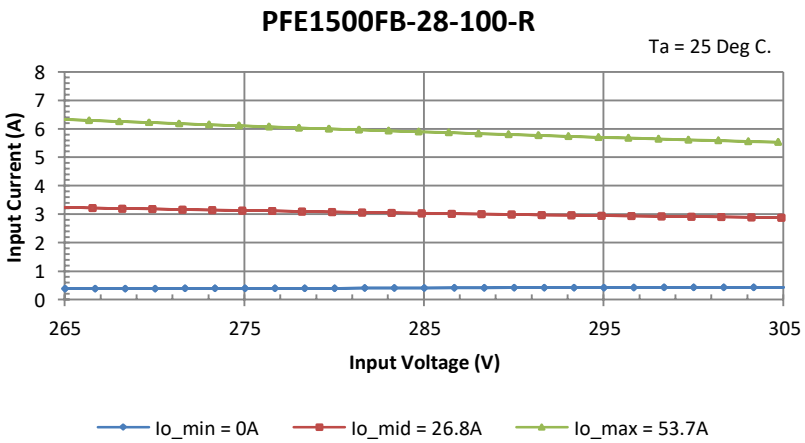

PFE1500FB-28-100-R
Ta = 65 Deg C.
Power Factor (pf)
1
0.99
0.98
0.97
0.96
0.95
180
190
200
210
220
230
240
Input Voltage (V)
Io_mid = 26.8A
Io_max = 53.7A


PFE1500FB-28-100-R
Ta = 65 Deg C.
Power Factor (pf)
1
0.99
0.98
0.97
0.96
0.95
265
275
285
295
305
Input Voltage (V)
Io_mid = 26.8A
Io_max = 53.7A

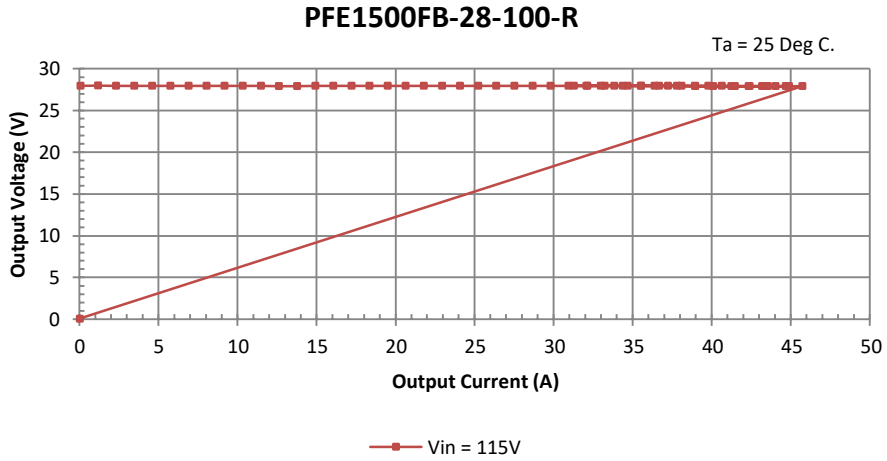
2.1.4. Input Line Current vs. Input Voltage (60 Hz)

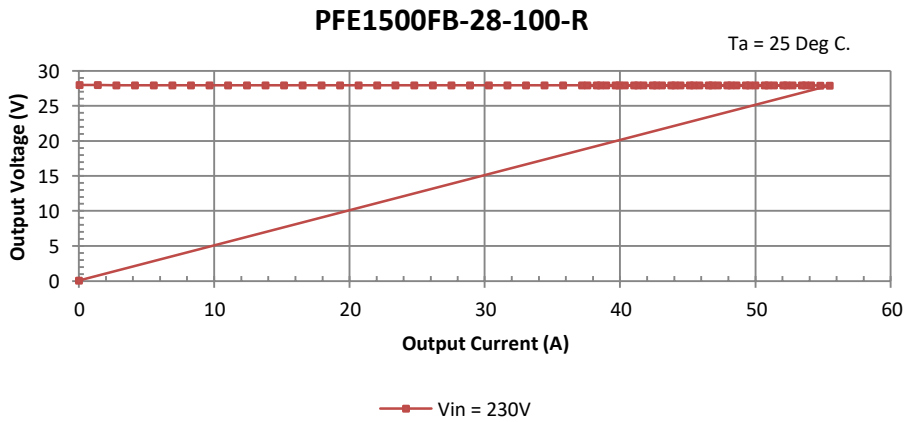


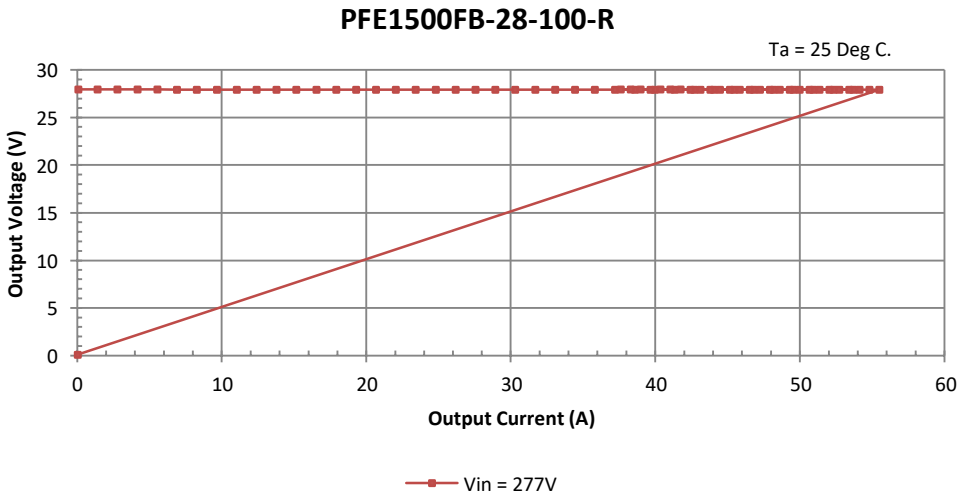


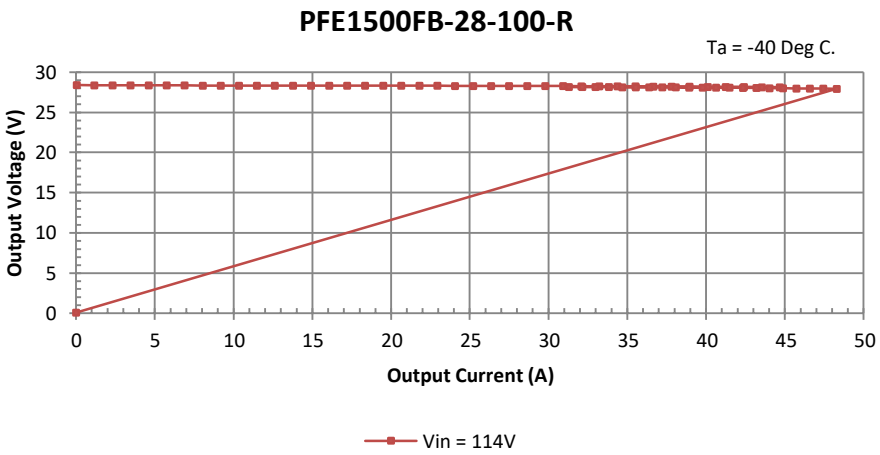


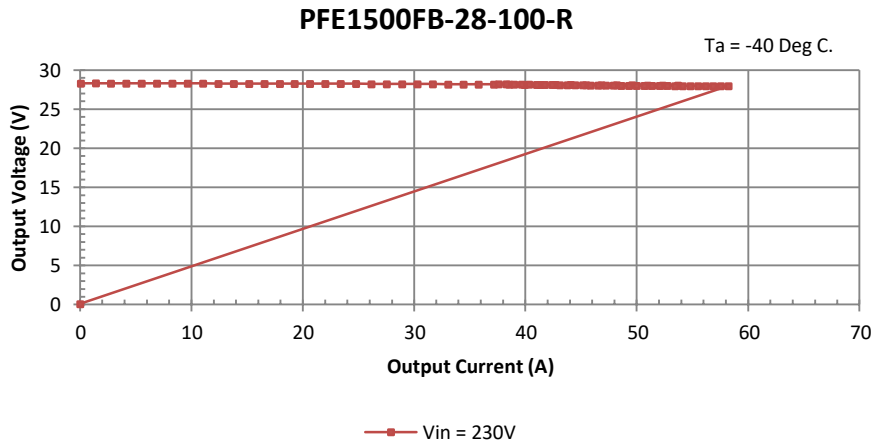
2.1.5. Over Current Protection (OCP) Characteristics (60 Hz)

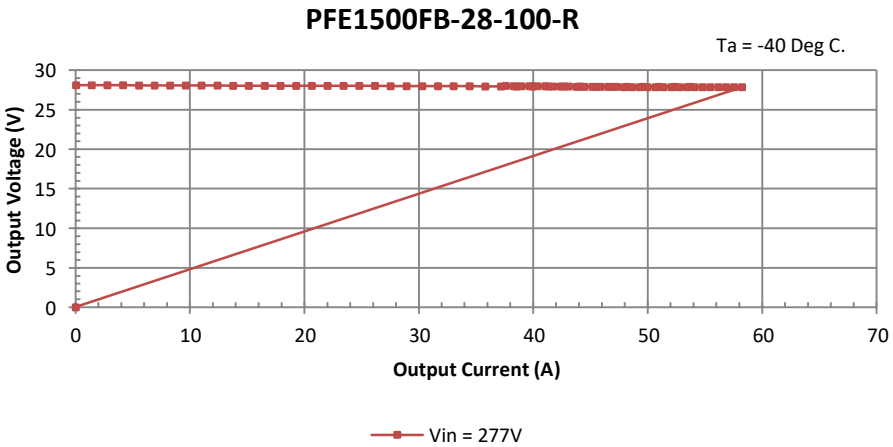


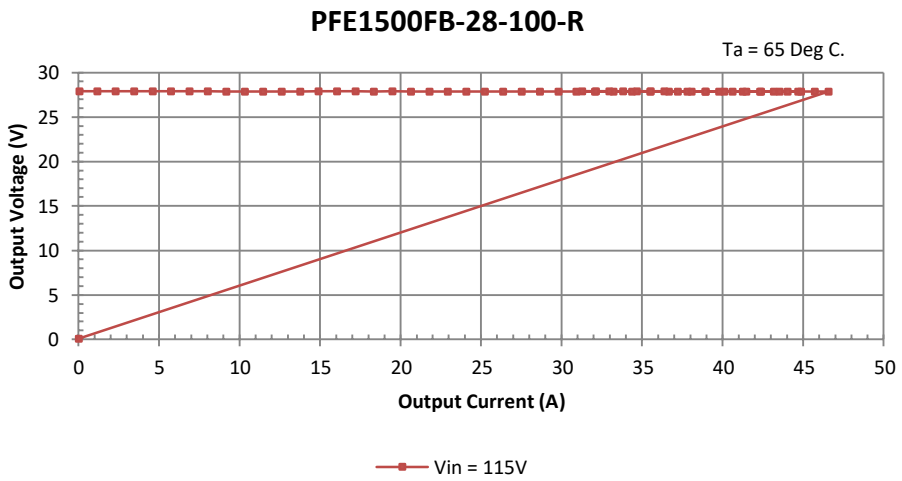


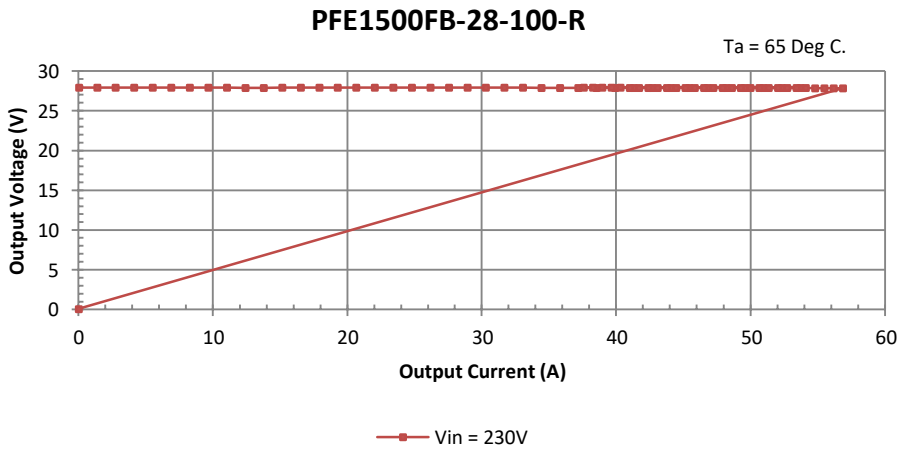


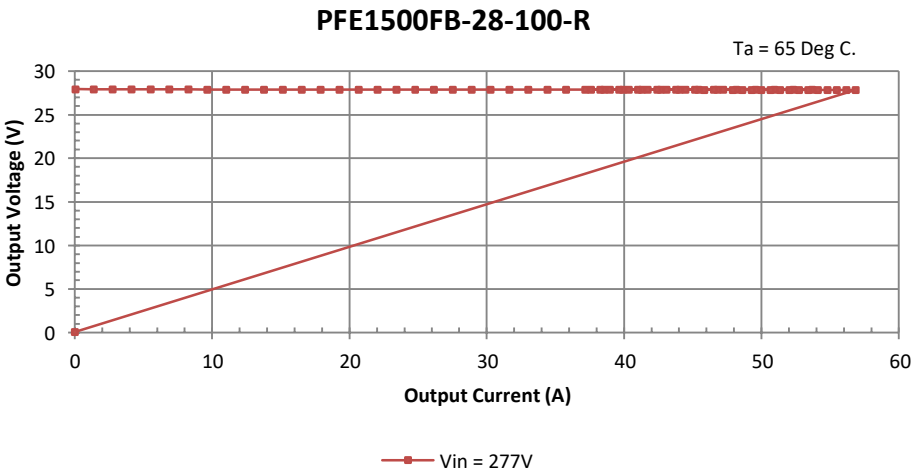

PFE1500FB-28-100-R
Ta = -40 Deg C.
Output Voltage (V)
Output Current (A)
Vin = 114V


PFE1500FB-28-100-R
Ta = -40 Deg C.
Output Voltage (V)
Output Current (A)
Vin = 230V


PFE1500FB-28-100-R
Ta = -40 Deg C.
Output Voltage (V)
Output Current (A)
Vin = 277V


PFE1500FB-28-100-R
Ta = 65 Deg C.
Output Voltage (V)
Output Current (A)
Vin = 115V

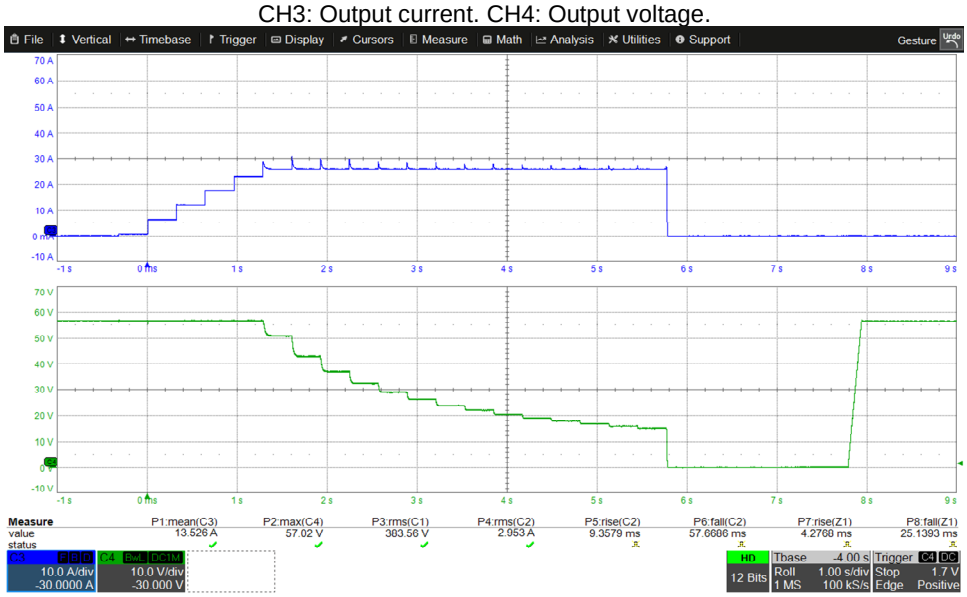

PFE1500FB-28-100-R
Ta = 65 Deg C.
Output Voltage (V)
Output Current (A)
Vin = 230V


PFE1500FB-28-100-R
Ta = 65 Deg C.
Output Voltage (V)
Output Current (A)
Vin = 277V

2.1.5.1. Voltage Foldback

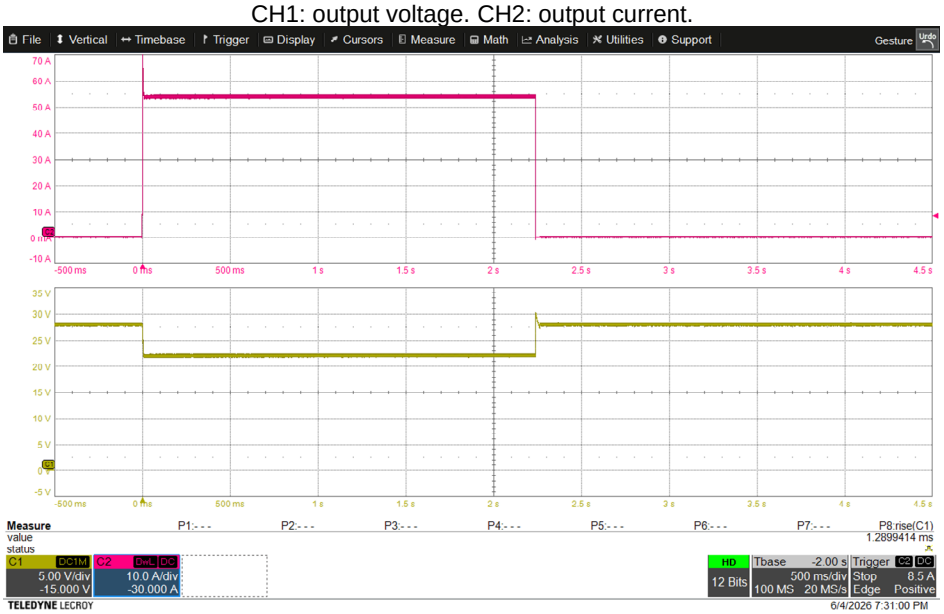
Using PFE1500FB-48-100-R as an example, Current Limit is 26 A. Resistive load value is decreased step by step every ~300 ms. Once the load current exceeds the 26 A limit, the output voltage folds back keeping the output current at about 26 A. This continues until the output voltage trips output Under Voltage Protection (UVP) hiccup. The resistive load is removed after UVP, and the output voltage recovers after 2 seconds.

CH3: Output current. CH4: Output voltage.



Current limit is 53.6 A. Resistive load is stepped from 1000 Ω to 0.4 Ω. Output voltage folds back to about 22 V limiting the output current to about 53.6 A. Then, the resistive load is stepped back to 1000 Ω and the output voltage returns to 28 V regulation.

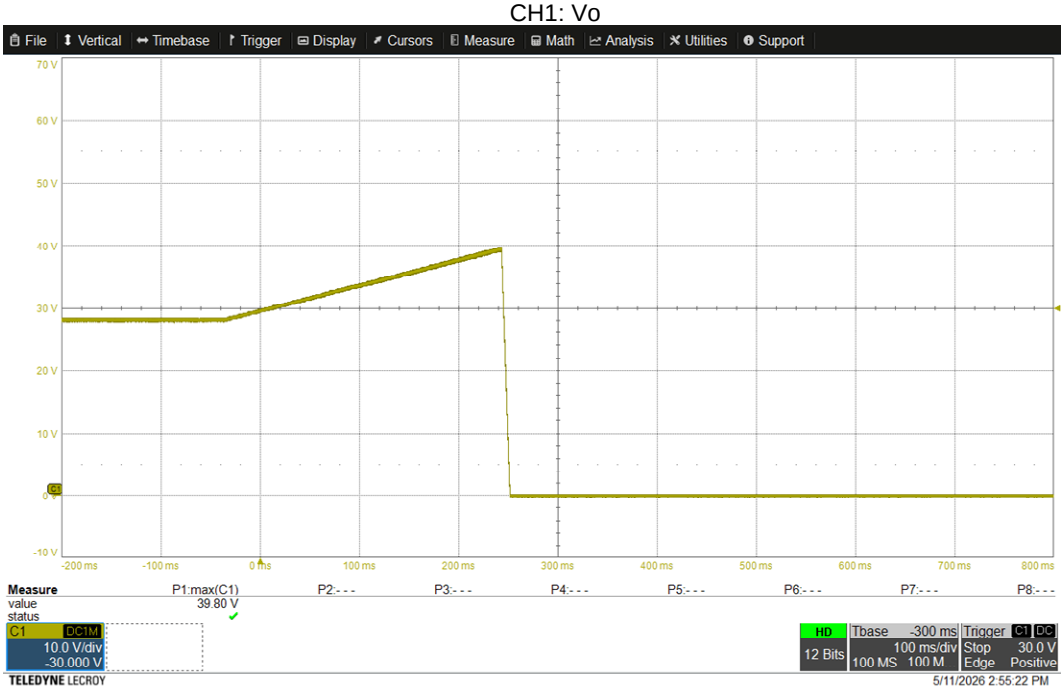
CH1: output voltage. CH2: output current.



2.2. Over Voltage Protection (OVP) Characteristics

Conditions: **OVP Setpoint = 39.59 V**	I_O = 5 A
	T_a = 25 °C
	V_{IN} = 115 VAC

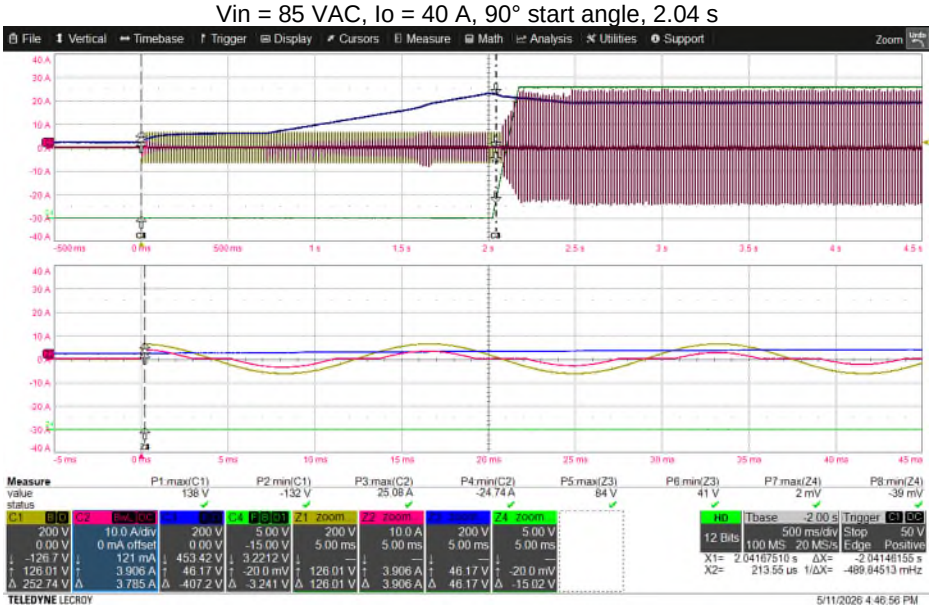
CH1: Vo



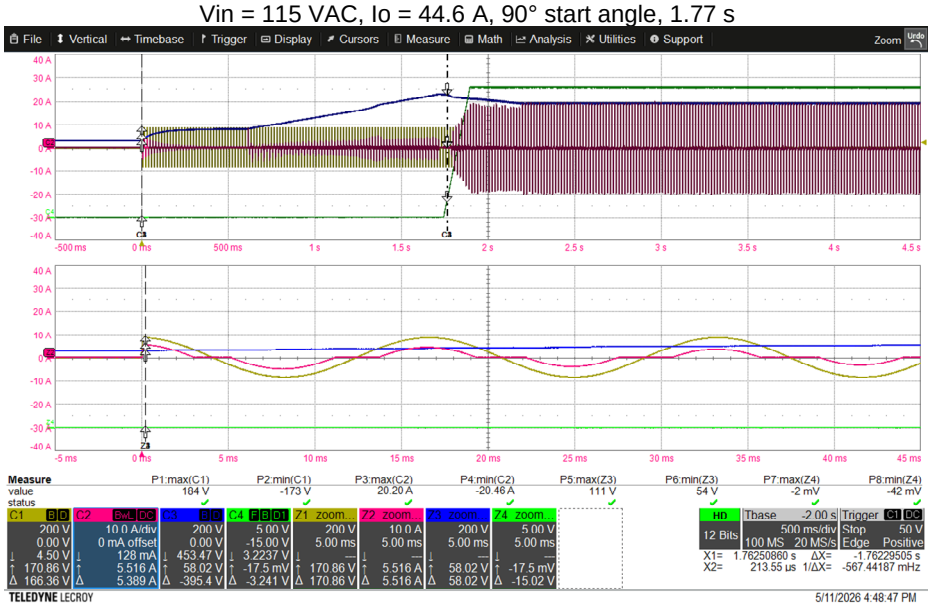
2.3. Turn-On Characteristics from AC Applied

CH1: Vin at fixture input, CH2: Iin at fixture input, CH3: Vbus, CH4: Vo
Top: full waveform. Bottom: zoom of AC applied

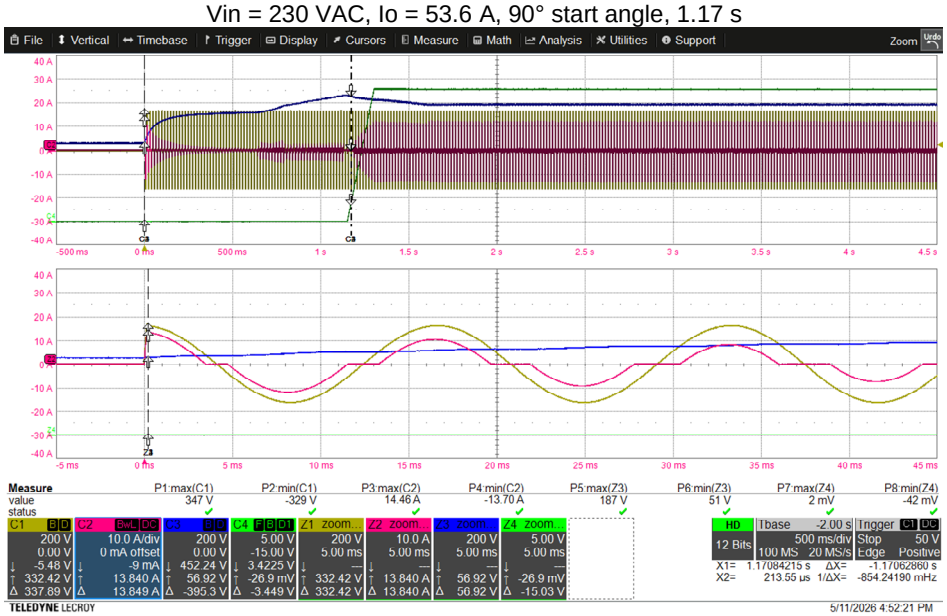
Vin = 85 VAC, Io = 40 A, 90° start angle, 2.04 s



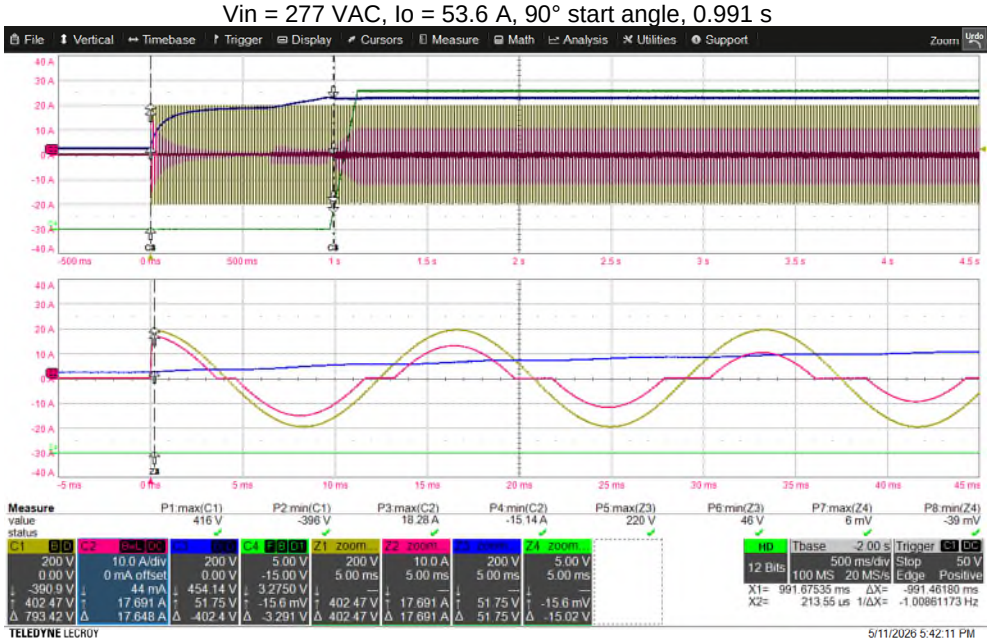
Vin = 115 VAC, Io = 44.6 A, 90° start angle, 1.77 s



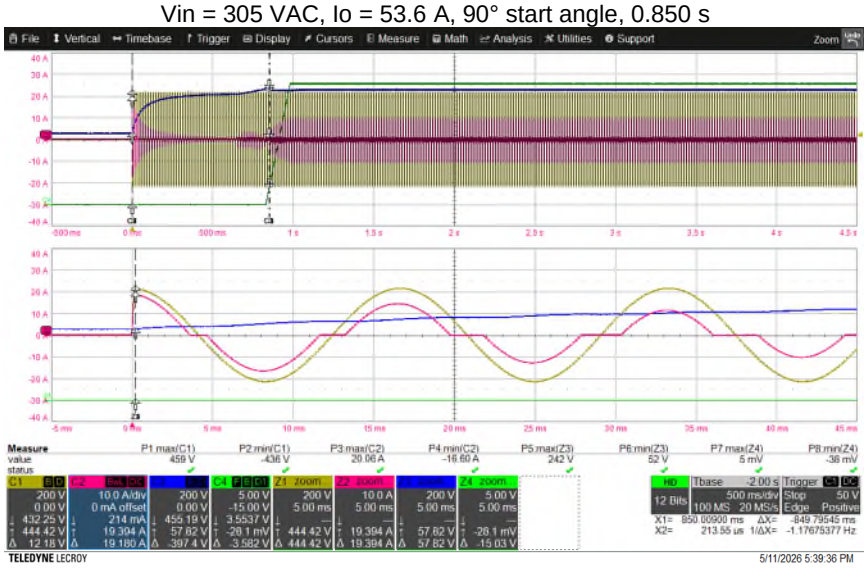
Vin = 230 VAC, Io = 53.6 A, 90° start angle, 1.17 s



Vin = 277 VAC, Io = 53.6 A, 90° start angle, 0.991 s

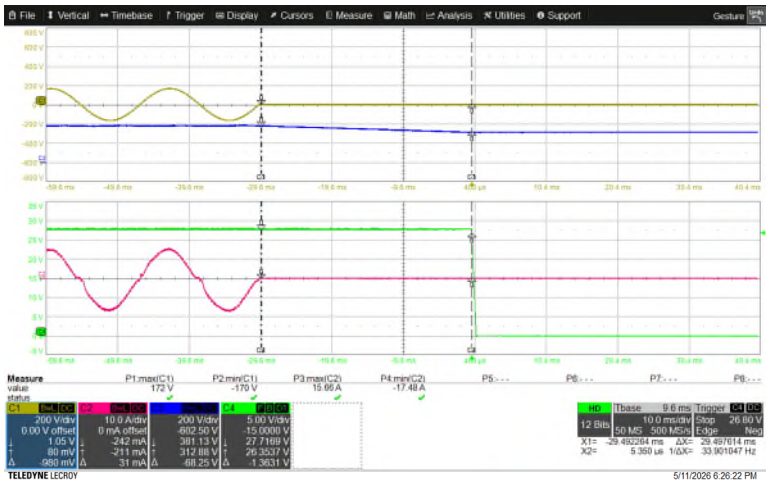


Vin = 305 VAC, Io = 53.6 A, 90° start angle, 0.850 s



2.4. Hold-Up Time Characteristic

Hold-up time is defined as the time from the loss of AC voltage to Vo violating its regulation accuracy specification at 100% load.

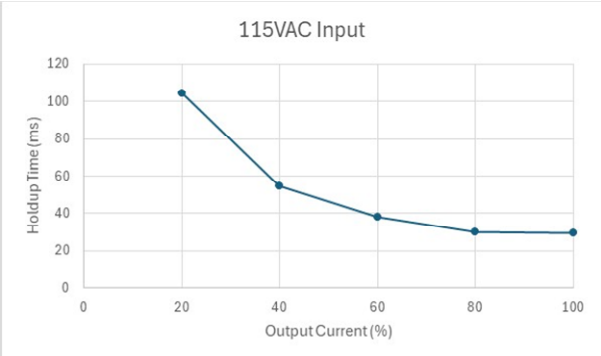


Vin = 115 VAC
Io = 44.6 A

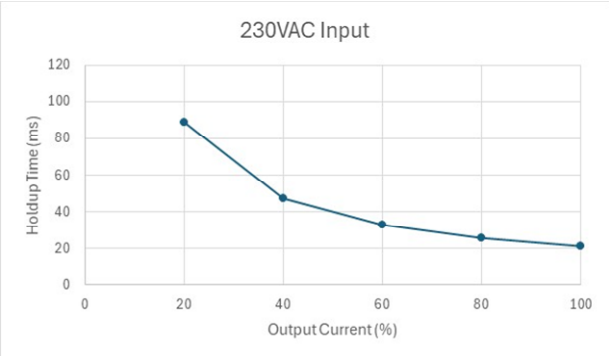
29.5 ms

Ch1: Vin (pre-filter)
Ch2: Iin (pre-filter)
Ch3: Vbus
Ch4: Vout

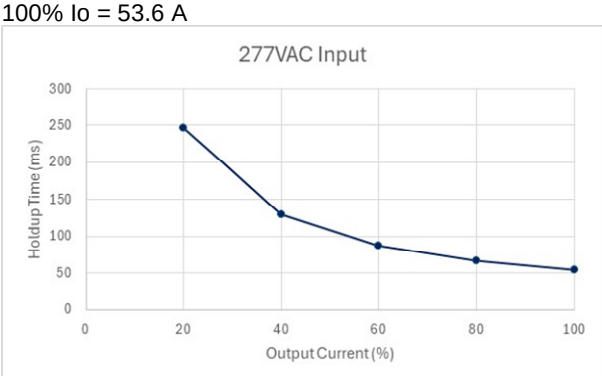
Vin = 115 VAC, Vo = 28 VDC
100% Io = 44.6 A



Vin = 230 VAC, Vo = 28 VDC
100% Io = 53.6 A



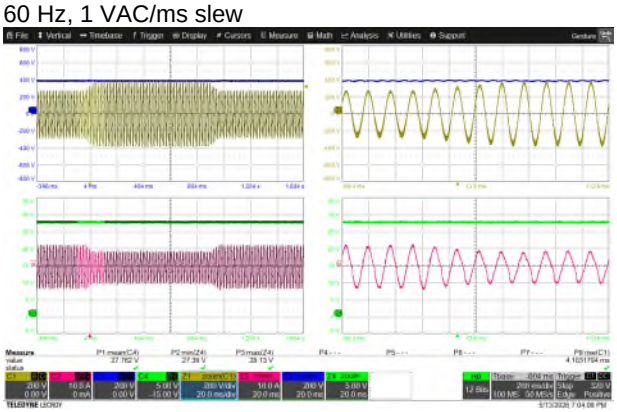
Vin = 277 VAC, Vo = 28 VDC
100% Io = 53.6 A



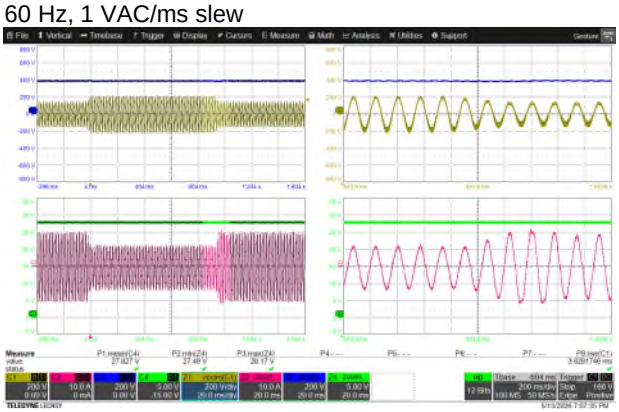
2.5. Dynamic Line Response (60 Hz)

CH1: AC line (pre-filter), CH2: AC input current, CH3: Vbus, CH4: Vout
Left: full waveform. Right: zoom of a transient.

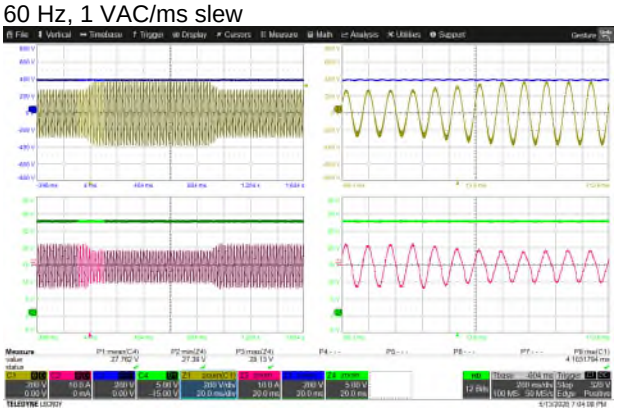
Vin = 92 VAC to 138 VAC, Io = 40 A
60 Hz, 1 VAC/ms slew



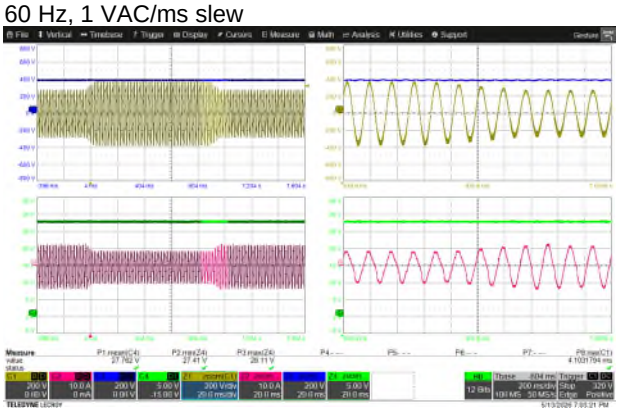
Vin = 92 VAC to 138 VAC, Io = 40 A
60 Hz, 1 VAC/ms slew



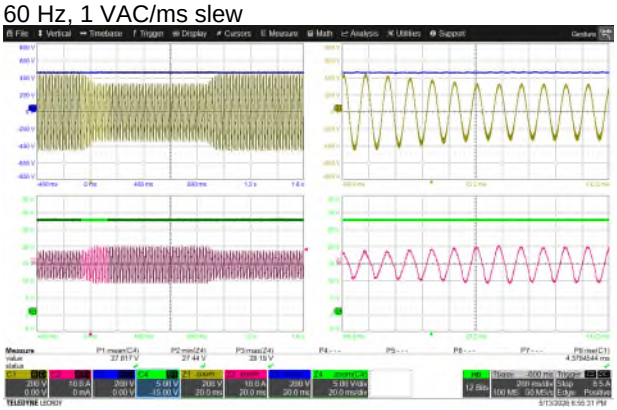
Vin = 184VAC to 253 VAC, Io = 53.6 A
60 Hz, 1 VAC/ms slew



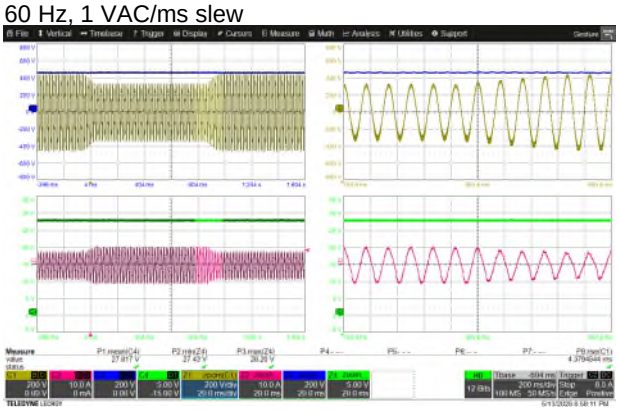
Vin = 184 VAC to 253 VAC, Io = 53.6 A
60 Hz, 1 VAC/ms slew



Vin = 305 VAC to 221 VAC, Io = 53.6 A
60 Hz, 1 VAC/ms slew



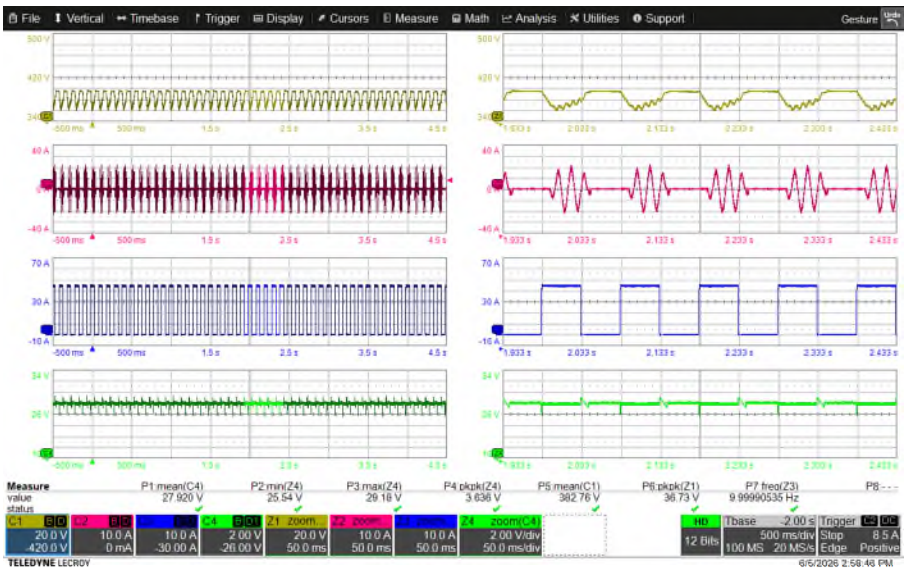
Vin = 305 VAC to 221 VAC, Io = 53.6 A
60 Hz, 1 VAC/ms slew



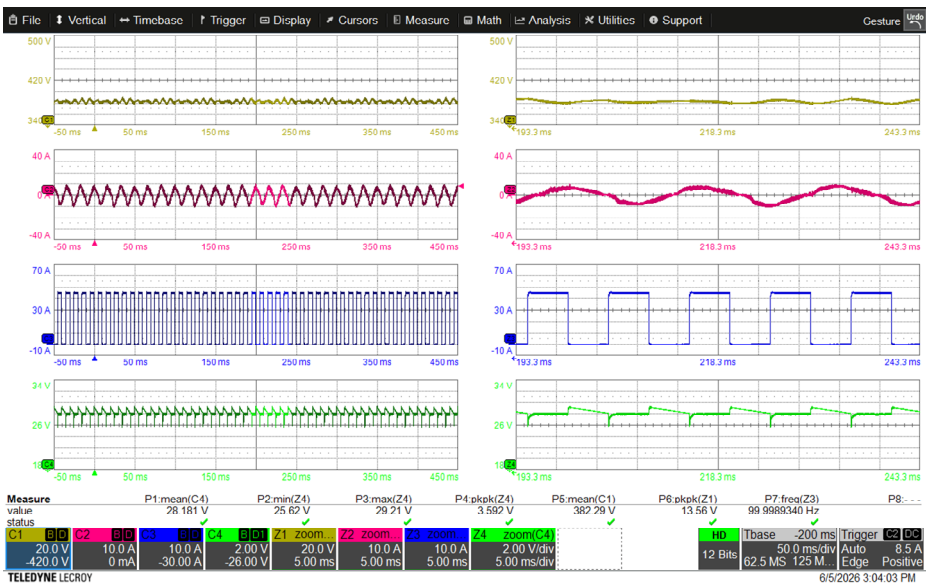
2.6. Dynamic Load Response

CH1: Vbus, CH2: Input current at module input, CH3: Io, CH4: Vo

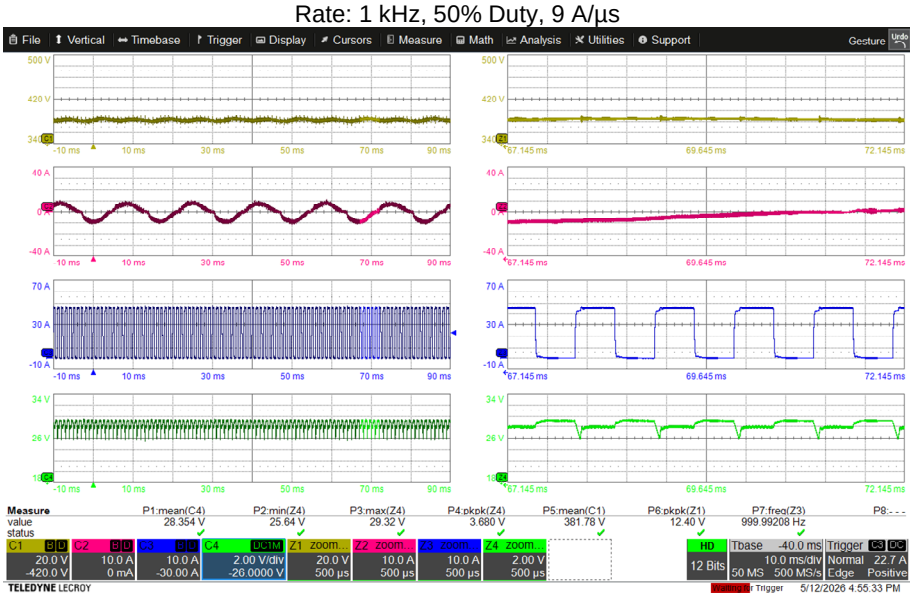
Vin = 115 VAC, Io = 0 A – 44.6 A, Vo = 28 V
Rate: 10 Hz, 50% Duty, 9 A/µs



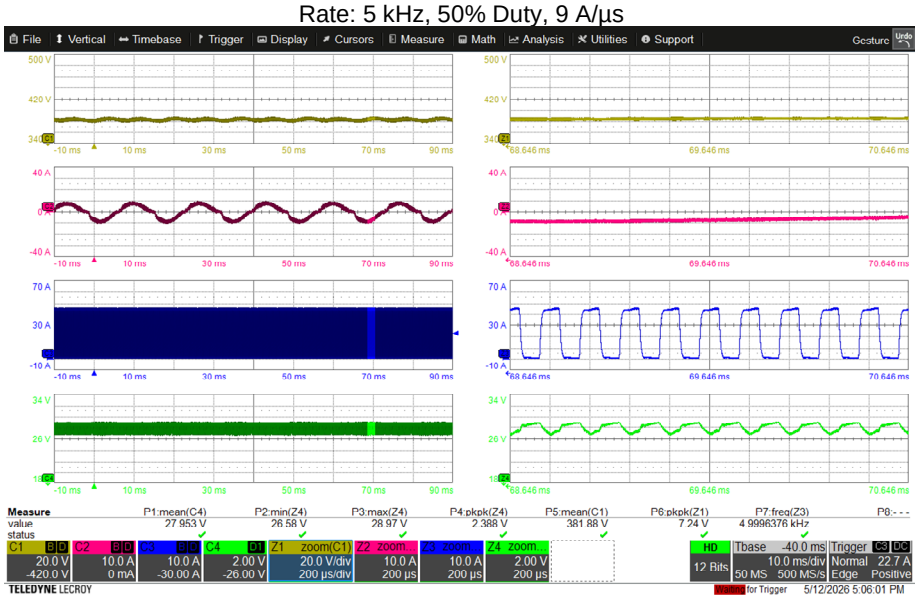
Vin = 115 VAC, Io = 0 A – 44.6 A, Vo = 28 V
Rate: 100 Hz, 50% Duty, 9 A/µs



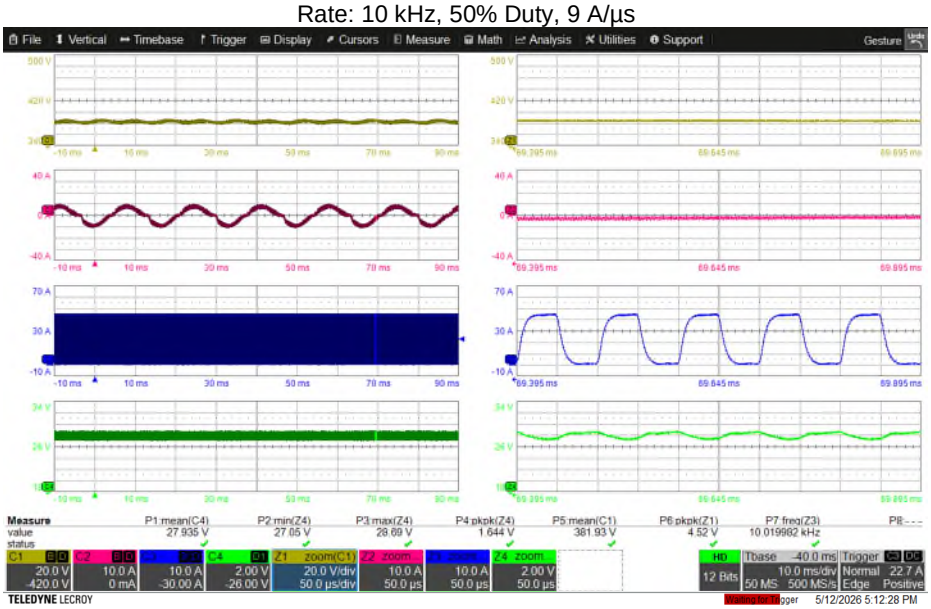
Vin = 115 VAC, Io = 0 A – 44.6 A, Vo = 28 V
Rate: 1 kHz, 50% Duty, 9 A/µs



Vin = 115 VAC, Io = 0 A – 44.6 A, Vo = 28 V
Rate: 5 kHz, 50% Duty, 9 A/µs

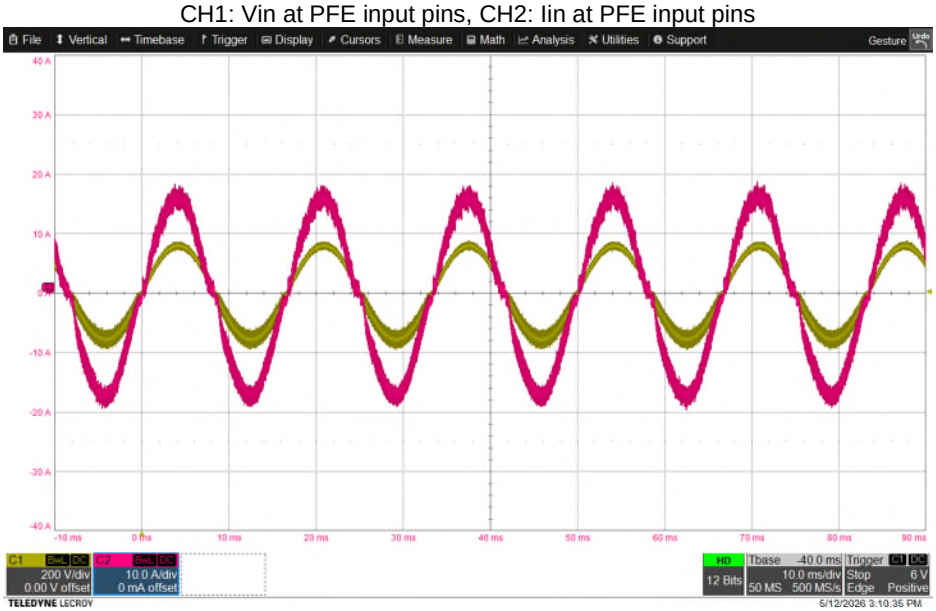


Vin = 115 VAC, Io = 0 A – 44.6 A, Vo = 28 V
Rate: 10 kHz, 50% Duty, 9 A/µs

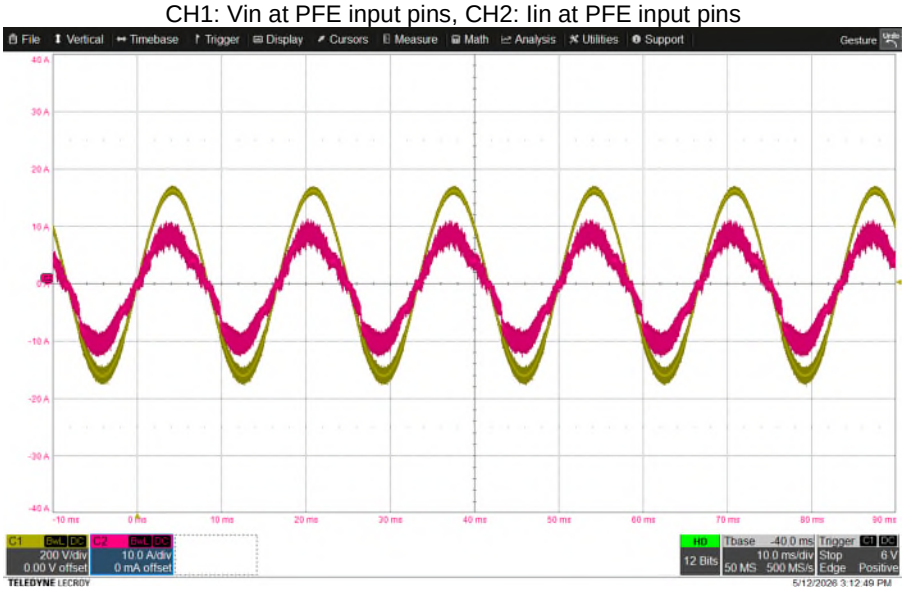


2.7. Input Current Waveform

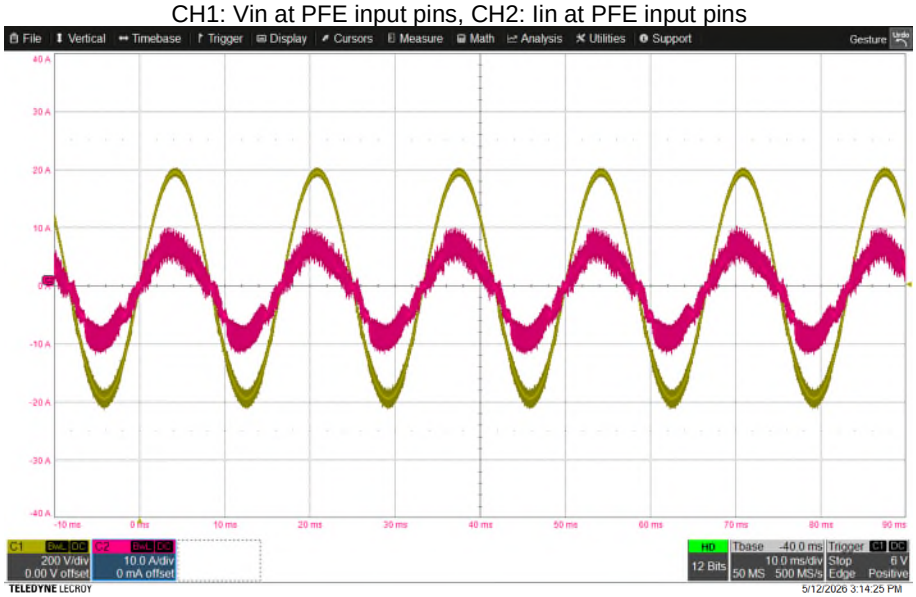
Vin = 115 VAC 60 Hz, Load = 44.6 A
CH1: Vin at PFE input pins, CH2: Iin at PFE input pins



Vin = 230 VAC 60 Hz, Load = 53.6 A
CH1: Vin at PFE input pins, CH2: Iin at PFE input pins

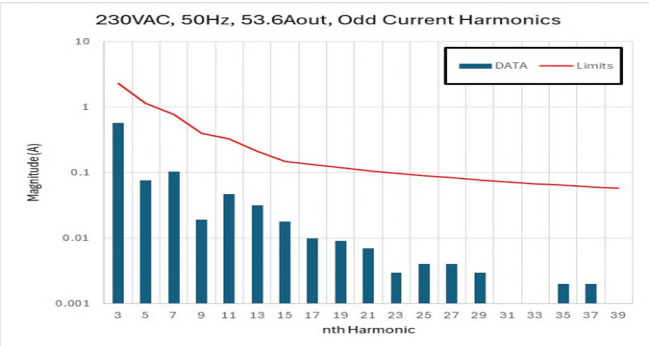


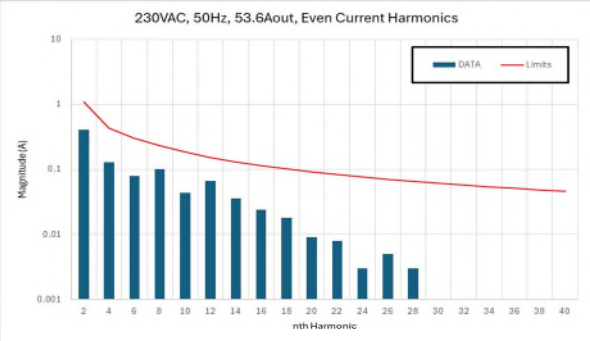
Vin = 277 VAC 60 Hz, Load = 53.6 A
CH1: Vin at PFE input pins, CH2: Iin at PFE input pins



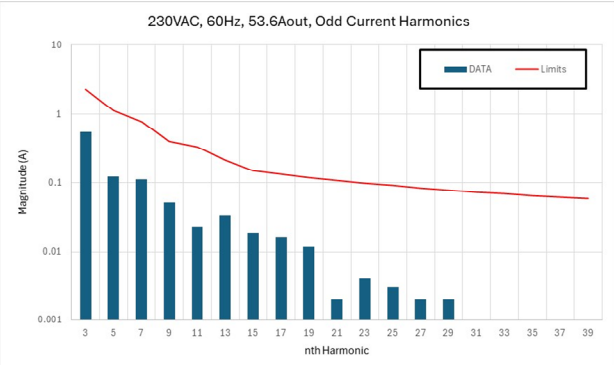
2.8. Input Current Harmonics

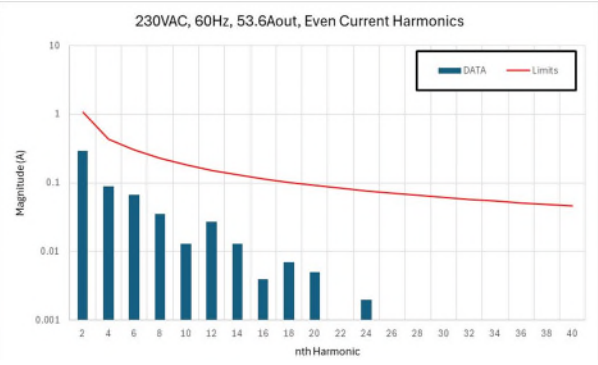
2.8.1. 230 VAC, 50 Hz, 53.6 A output





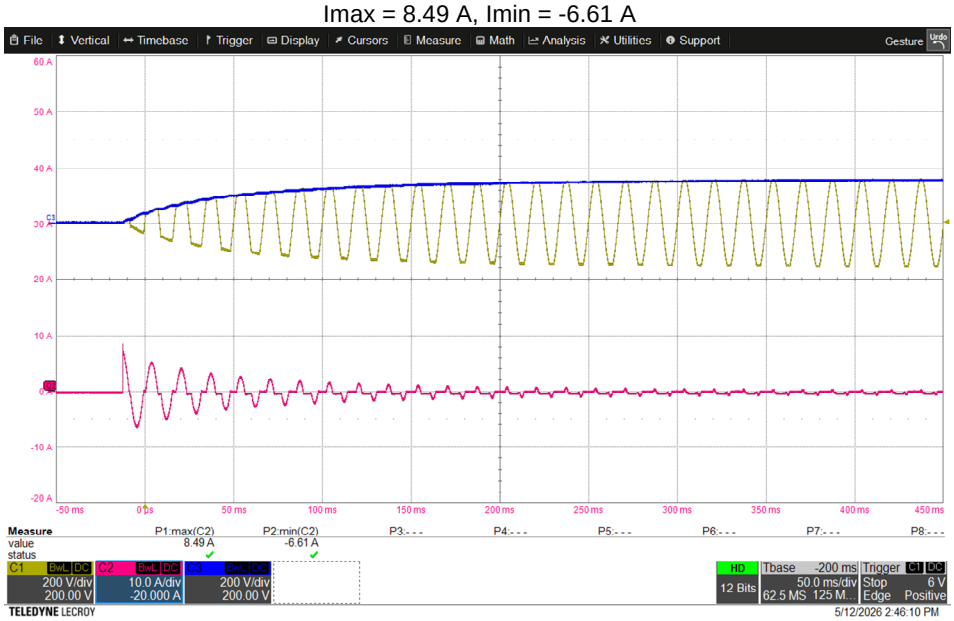
2.8.2. 230 VAC, 60 Hz, 53.6 A output



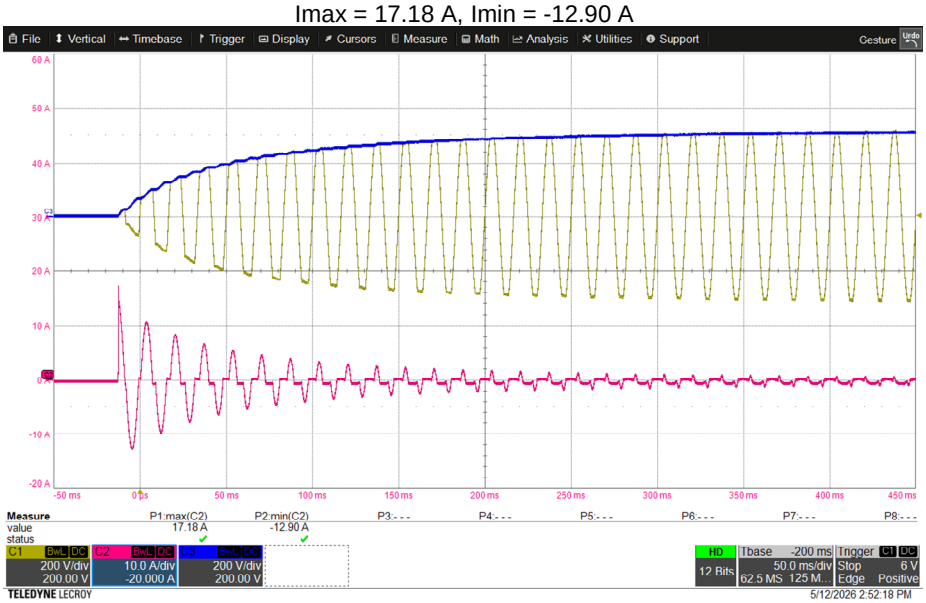


2.9. Input Inrush Current

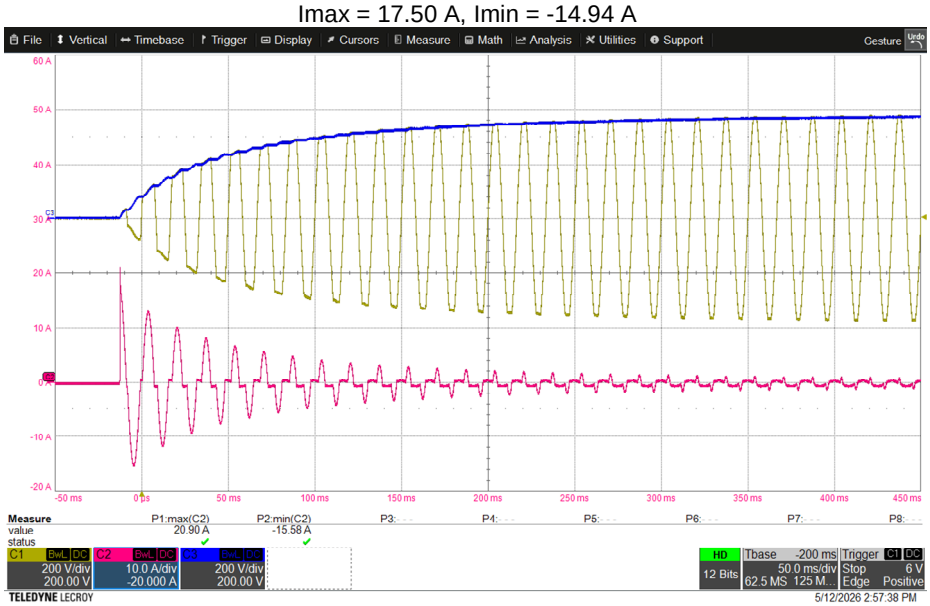
Vin = 115 VAC, Vo = 28 V
CH1: Vin, CH2: Iin, CH3: Vbus
Imax = 8.49 A, Imin = -6.61 A



Vin = 230 VAC, Vo = 28 V
CH1: Vin, CH2: Iin, CH3: Vbus
Imax = 17.18 A, Imin = -12.90 A



Vin = 277 VAC, Vo = 28 V
CH1: Vin, CH2: Iin, CH3: Vbus
Imax = 17.50 A, Imin = -14.94 A



2.10. Brownout Data

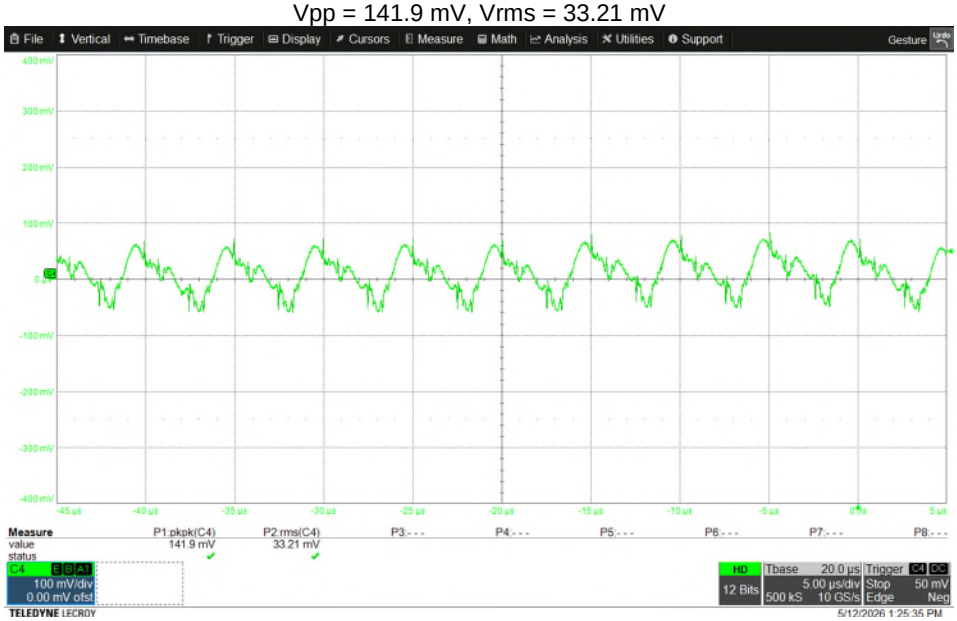
Vout = 48V model results
Hardware: Open-frame, Vbus 4*470µF (electrolytic cap), Output 5*220µF (electrolytic cap) 8*4.7µF ceramic cap.

Results table
A = criteria A - DUT operates within specification limits during and after test.
B = criteria B - DUT exhibits a change in performance when operating then self-recovered.
A/B = some are criteria A or criteria B based on start angle
A* = criteria A, but due to derate at low Vrms, either resistive load or foldback must be used. Otherwise, criteria B.

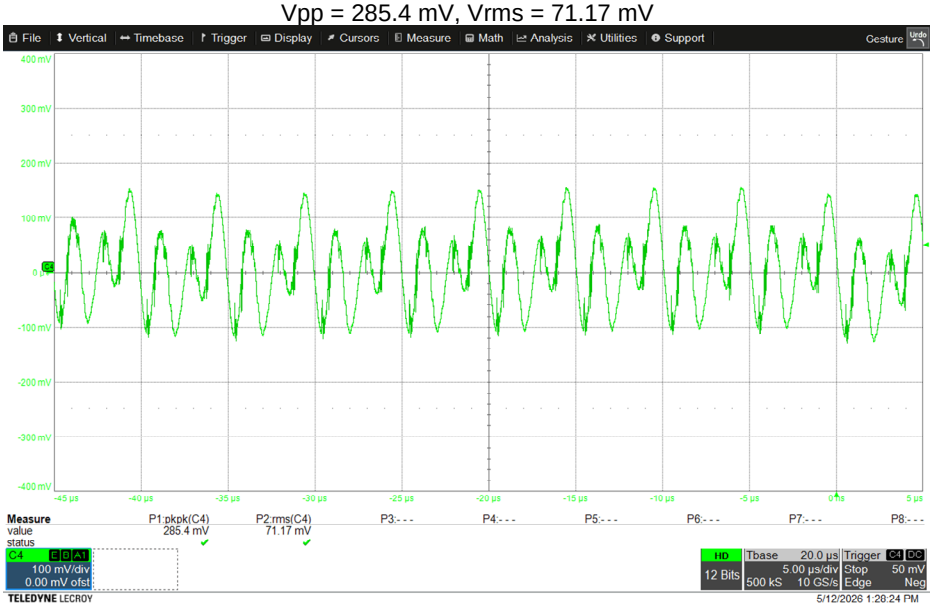
	50 Hz			60 Hz		
	115Vac	230Vac	277Vac	115Vac	230Vac	277Vac
70% VAC, 0.5 cycle	A	A	A	A	A	A
40% VAC, 25 cycle	B	B	B	B	B	B
0% VAC, 250/300 cycles	B	B	B	B	B	B
0% VAC, 0.5 cycle	A	A/B	A	A	A	A
0% VAC, 1 cycle	B	B	A/B	B	B	A
40% VAC, 10 cycles	B	B	B	B	B	B
70% VAC, 25 cycles	B	A	A	B	A	A
80% VAC, 250 cycles	A*	A	A	A*	A	A
0% VAC, 250 cycles	B	B	B	B	B	B

2.11. Output Ripple and Noise

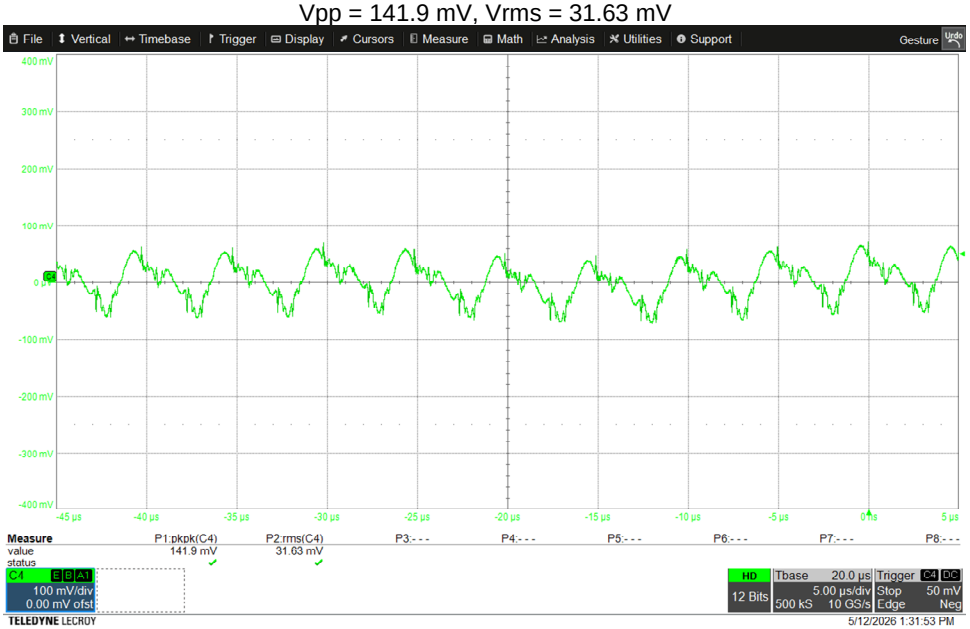
Vin = 115 VAC 60 Hz, Io = 5 A, Vo = 28 VDC, 20 MHz BW
Vpp = 141.9 mV, Vrms = 33.21 mV



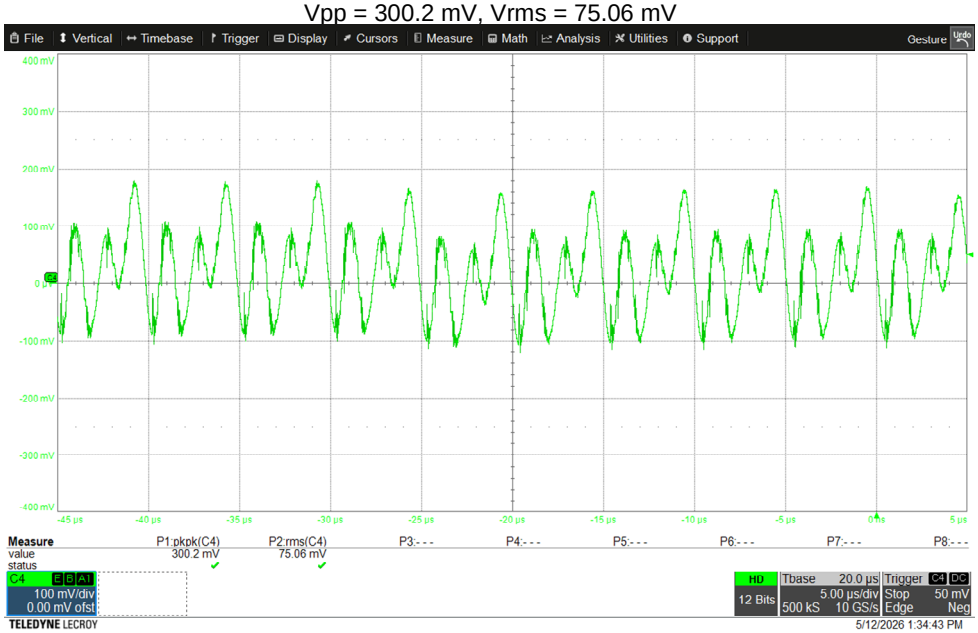
Vin = 115 VAC 60 Hz, Io = 44.6 A, Vo = 28 VDC, 20 MHz BW
Vpp = 285.4 mV, Vrms = 71.17 mV



Vin = 230 VAC 60 Hz, Io = 5 A, Vo = 28 VDC, 20 MHz BW
Vpp = 141.9 mV, Vrms = 31.63 mV



Vin = 230 VAC 60 Hz, Io = 53.6 A; Vo = 28 VDC, 20 MHz BW
Vpp = 300.2 mV, Vrms = 75.06 mV



TDK·Lambda

TDK-Lambda France SAS
Tel: +33 1 60 12 71 65
tlf.fr-powersolutions@tdk.com
www.emea.lambda.tdk.com/fr

TDK-Lambda Americas
Tel: +1 800-LAMBDA-4 or 1-800-526-2324
tla.powersolutions@tdk.com
www.us.lambda.tdk.com

Italy Sales Office
Tel: +39 02 61 29 38 63
tlf.it-powersolutions@tdk.com
www.emea.lambda.tdk.com/it

TDK Electronics do Brasil Ltda
Tel: +55 11 3289-9599
sales.br@tdk-electronics.tdk.com
www.tdk-electronics.tdk.com/en

Netherlands
tlf.nl-powersolutions@tdk.com
www.emea.lambda.tdk.com/nl

TDK-Lambda Corporation
Tel: +81-3-6778-1113
www.jp.lambda.tdk.com

TDK-Lambda Europe GmbH
Tel: +49 7841 666 0
tlg.powersolutions@tdk.com
www.emea.lambda.tdk.com/de

TDK-Lambda (China) Electronics Co. Ltd.
Tel: +86 21 6485-0777
tlc.powersolutions@tdk.com
www.lambda.tdk.com.cn

Austria Sales Office
Tel: +43 2256 655 84
tlg.at-powersolutions@tdk.com
www.emea.lambda.tdk.com/at

TDK-Lambda Singapore Pte Ltd.
Tel: +65 6251 7211
tls.marketing@tdk.com
www.sg.lambda.tdk.com

Switzerland Sales Office
Tel: +41 44 850 53 53
tlg.ch-powersolutions@tdk.com
www.emea.lambda.tdk.com/ch

TDK India Private Limited, Power Supply Division
Tel: +91 80 4039-0660
mathew.philip@tdk.com
www.sg.lambda.tdk.com

TDK-Lambda Europe GmbH
Tel: +45 3222 8086
tlg.dk-powersolutions@tdk.com
www.emea.lambda.tdk.com/dk

TDK-Lambda UK Ltd.
Tel: +44 (0) 12 71 85 66 66
tlu.powersolutions@tdk.com
www.emea.lambda.tdk.com/uk

TDK-Lambda Israel Ltd.
Tel: +972 3 902 4333
tli.powersolutions@tdk.com
www.emea.lambda.tdk.com/il-en

For additional information, please visit
https://product.tdk.com/en/power/