PFH500F-48-xxx-R

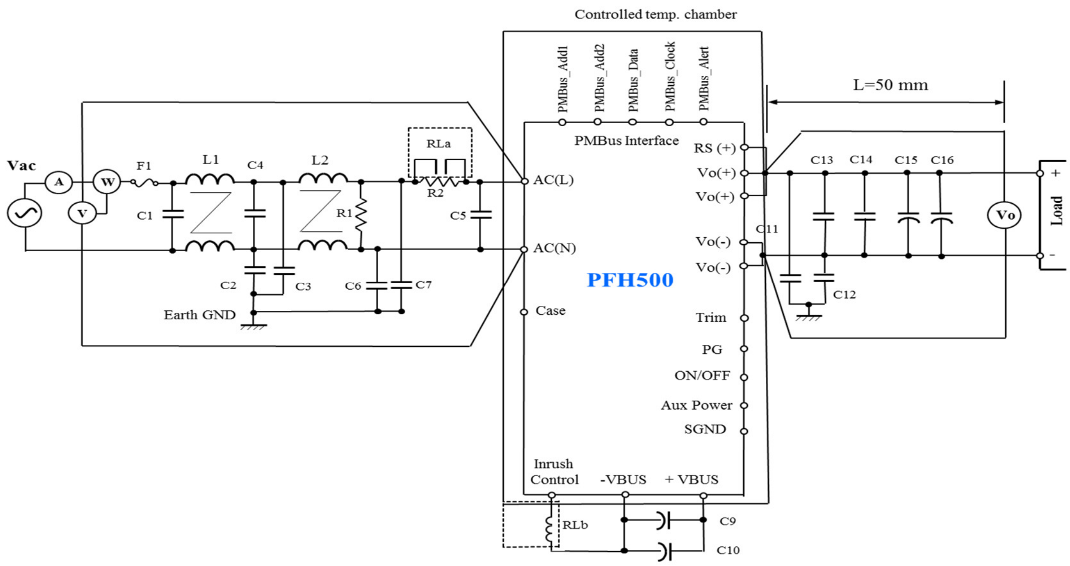
Evaluation Report

Contents

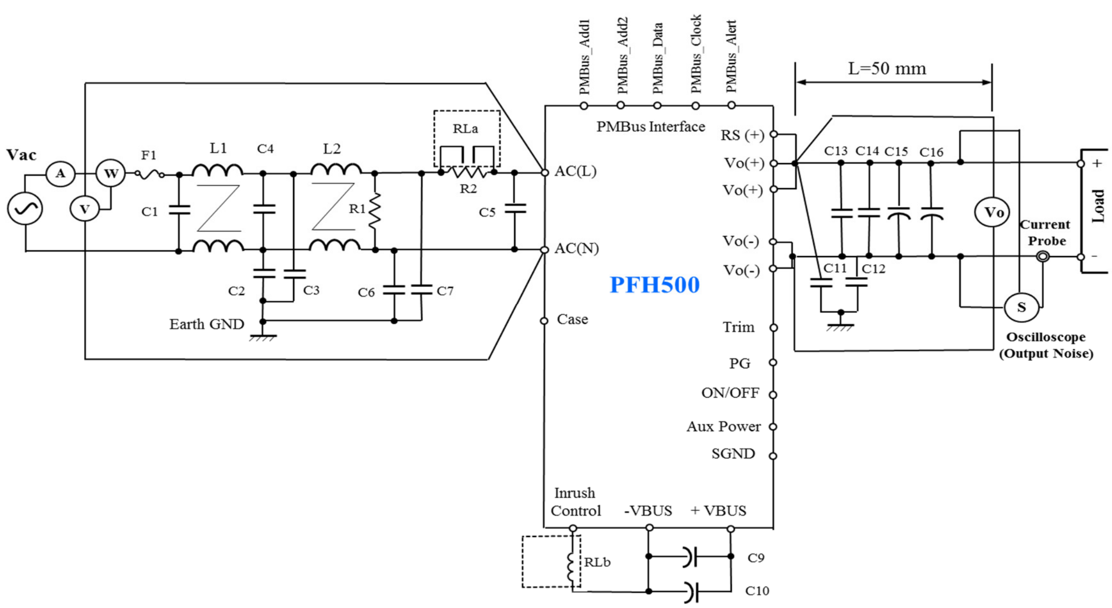
1. EVALUATION METHOD

1.1 Test / Measurement Circuits

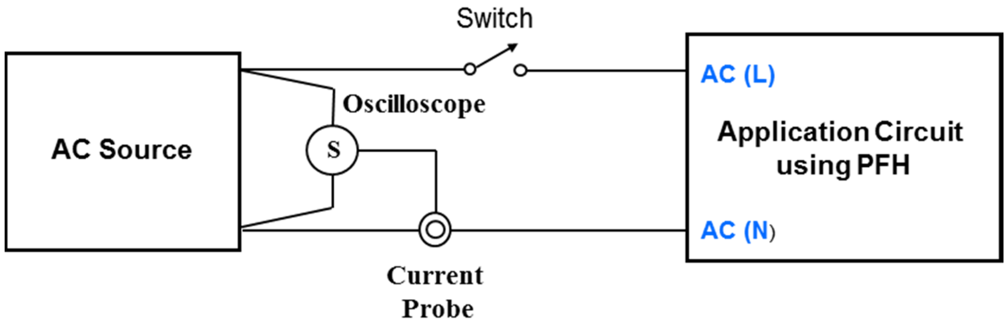
1.1.1 Steady State Test Measurement Circuit



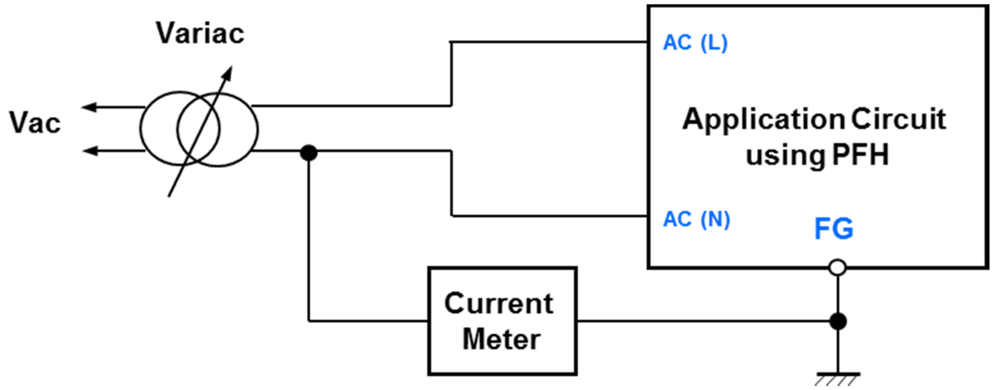
1.1.2 Dynamic, Protection and Output Ripple and Noise Measurement Circuit



1.1.3 Inrush Current Measurement Circuit

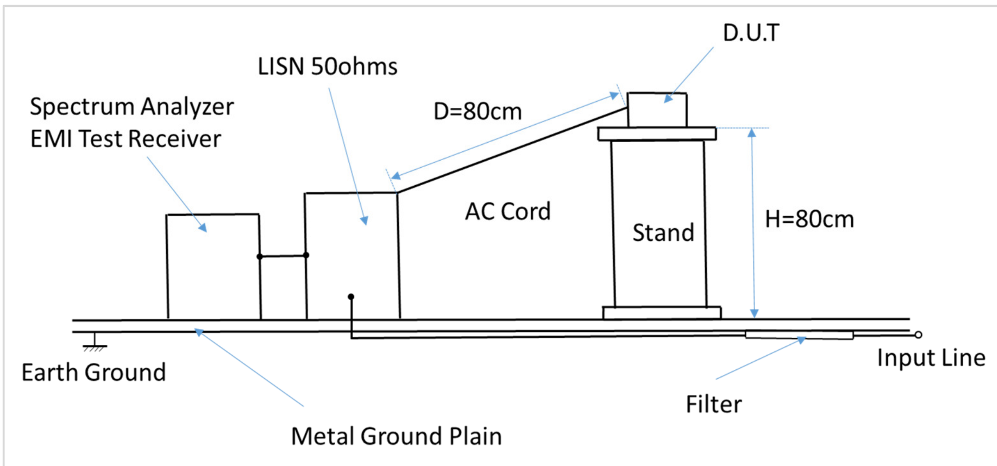


1.1.4 Leakage Current Measurement Circuit

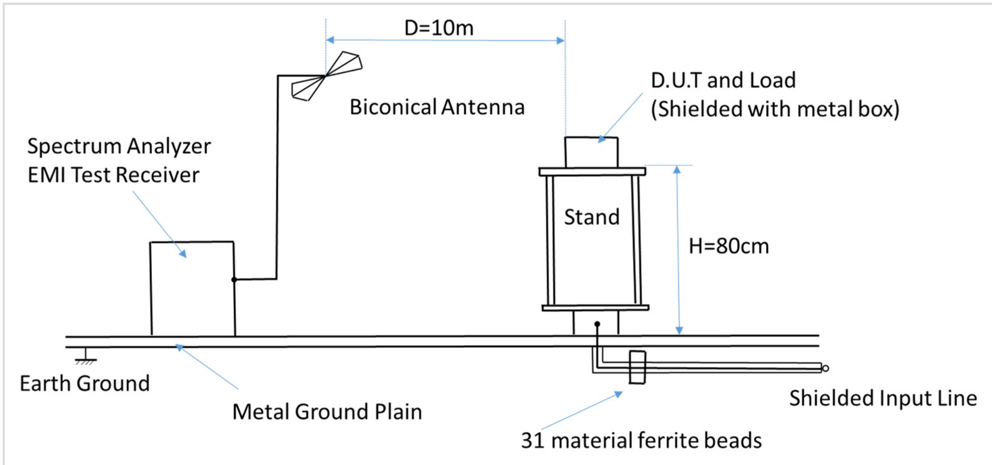


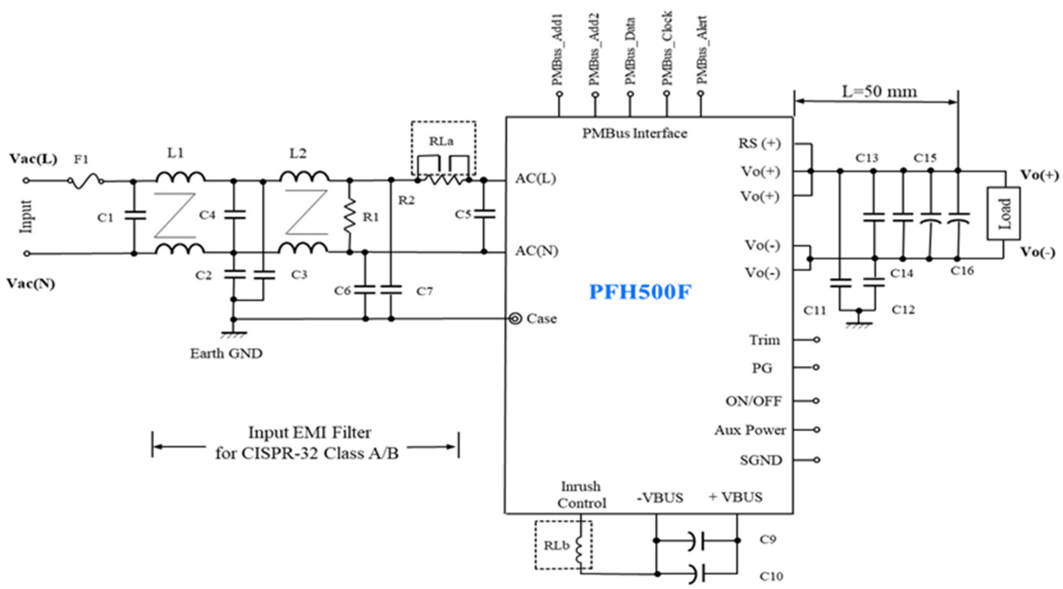
1.1.5 Electro-Magnetic Interference Test Set-Up

1.1.5.1 Conducted EMI



1.1.5.2 Radiated EMI





Circuit Code	Description	Circuit Code	Description
C1, C4	1.0µF Film Capacitor	C14	40uF Ceramic Capacitor
C2, C3	3300pF Ceramic Capacitor	C15, C16 (1)	470µF Electrolytic Capacitor
C5	2.2µF Film Capacitor	F1	10A, 250V, Fast Blow
C6, C7 (2)	800pF Ceramic Capacitor	L1, L2	6.3mH
C9, C10	470µF Electrolytic Capacitor	R1	470kOhms
C11, C12	2200pF Ceramic Capacitor	R2	22 Ohms
C13	0.1µF Ceramic Capacitor	RL	1 Form A relay with 10A, 277VAC, power rating: 12VDC, 16.7mA, 200mW, High Sensitivity

(1): Higher Capacitance Value (~2X total cap value recommended) for Ta ≤ -20 °C operation.
(2): 1pcs 470pF and 1 pc 330pF.

List of Equipment

	EQUIPMENT USED	MANUFACTURER	MODEL NO.
1	OSCILLOSCOPE	LECROY	WaveSurfer 454
2	OSCILLOSCOPE	LECROY	WaveRunner 6050
3	DIGITAL MULTIMETER	KEITHLEY	2110
4	DIGITAL MULTIMETER	KEITHLEY	2110
5	DIFFERENTIAL AMPLIFIER	LECROY	DA1855A
6	DIFFERENTIAL AMPLIFIER	LECROY	DA1855A
7	SHUNT RESISTER	EMPRO SHUNT	HA20-100
8	TEMP CHAMBER	TENNEY JUNIOR ENVIRONMENTAL	TJR
9	DIFFERENTIAL PROBE	LECROY	A101
10	DIFFERENTIAL PROBE	LECROY	DXG100A
11	DIGITAL POWER METER	YOKOGAWA	WT310
12	SURGE TESTER	THERMO SCIENTIFIC	EMCPRO PLUS
13	DC ELECTRONIC LOAD	CHROMA	63201
14	FREQUENCY ANALYZER	AP INSTRUMENT	300
15	AC POWER SOURCE	CHROMA	6530
16	INJECTION ISOLATOR	RIDLEY ENGINEERING	0.1Hz TO 30MHz
17	WAVEFORM GENERATOR	AGILENT	33120A
18	DC ELECTRONIC LOAD	CHROMA	6334
19	AC CONTROL	SORENSEN	DCS150-20
20	THERMOSTREAM	TEEMPTRONIC CORPORATION	ATS-810-M-4
21	CURRENT PROBE	LECROY	AP015
22	CURRENT PROBE	LECROY	CP150

2. CHARACTERISTIC

2.1 Steady State Data (Refer to Section 1.1.1 for Test Setup)

2.1.1 Regulation – Line, Load and Temperature

a. Low Line Regulation - Line and Load **Conditions:** T_a = 25 °C

IO \ VIN	100VAC	115VAC	120VAC	130VAC	Line Regulation	
10%	48.0447	48.0518	48.0515	48.0446	0.0072	0.02%
50%	48.0585	48.0688	48.0635	48.0564	0.0124	0.03%
100%	48.0822	48.0789	48.0836	48.0753	0.0083	0.02%
Load Regulation	0.0375	0.0271	0.0321	0.0307		
	0.08%	0.06%	0.07%	0.06%		

b. Low Line Regulation – No Load **Conditions:** Ta = 25 °C

IO \ VIN	100VAC	115VAC	120VAC	130VAC	Line Regulation	
0%	48.0562	48.0652	48.066	48.0574	0.0098	0.02%

c. Temperature Regulation **Conditions:** V_{IN} = 115 VAC, I_O = 100%

T_a	-40 °C	+25 °C	+55 °C	Temperature Stability	
V_O	47.9028	48.0789	48.1924	0.2896	0.60%

d. High Line Regulation - Line and Load **Conditions:** T_a = 25 °C

I_O \ V_{IN}	200VAC	220VAC	230VAC	265VAC	Line Regulation	
10%	48.0742	48.0456	48.0705	48.0755	0.0299	0.06%
50%	48.0759	48.0551	48.0663	48.0927	0.0376	0.08%
100%	48.078	48.0727	48.0791	48.0703	0.0088	0.02%
Load Regulation	0.0038	0.0271	0.0128	0.0224		
	0.01%	0.06%	0.03%	0.05%		

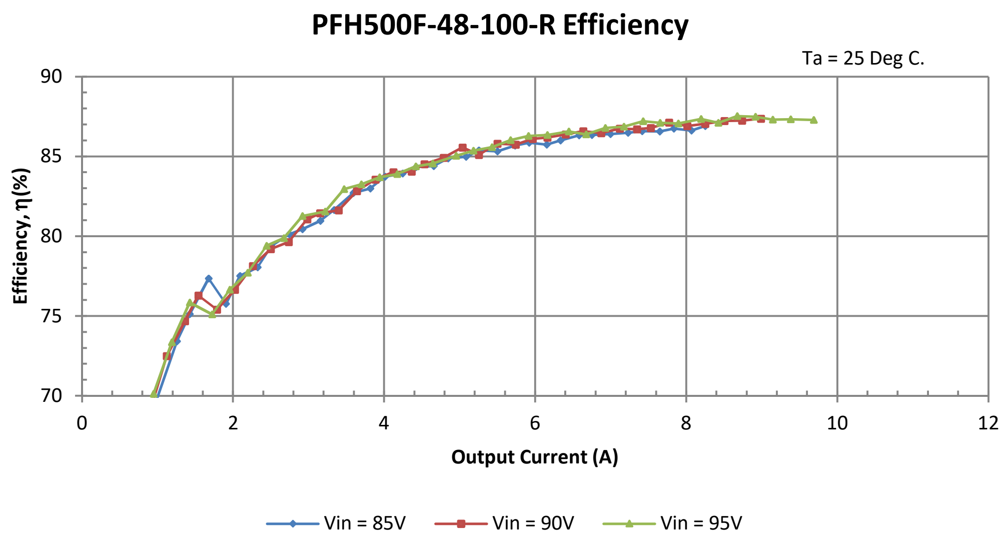
e. High Line Regulation – No Load **Conditions:** Ta = 25 °C

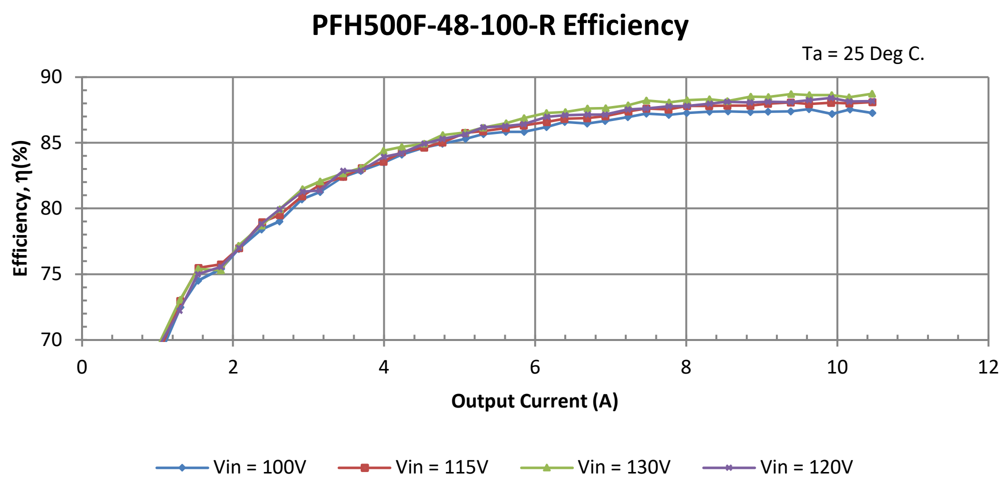
I_O \ V_{IN}	200VAC	220VAC	230VAC	265VAC	Line Regulation	
0%	48.2177	48.0562	48.0732	48.0502	0.1675	0.35%

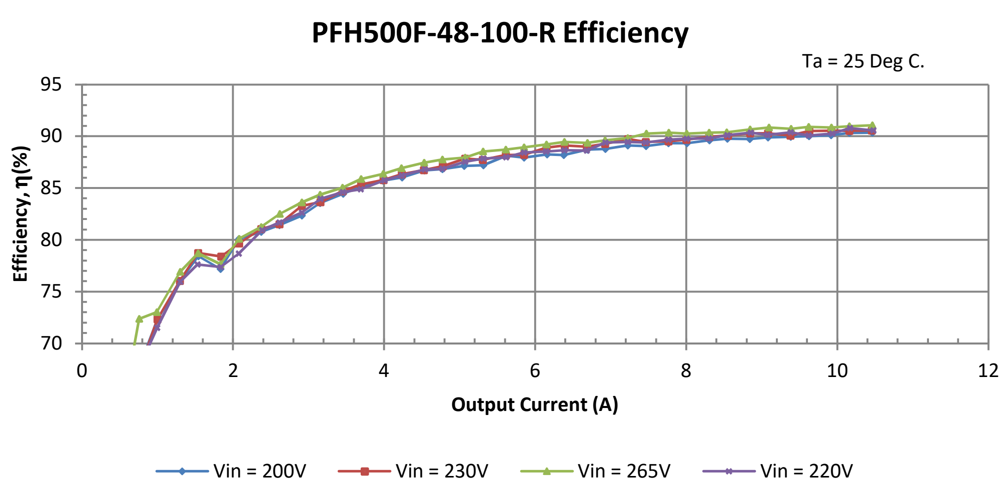
f. Temperature Regulation **Conditions:** V_{IN} = 230 VAC, I_O = 100%

T_a	-40 °C	+25 °C	+55 °C	Temperature Stability	
V_O	47.9183	48.0791	48.1832	0.2649	0.55%

2.1.2 Efficiency vs. Output Current

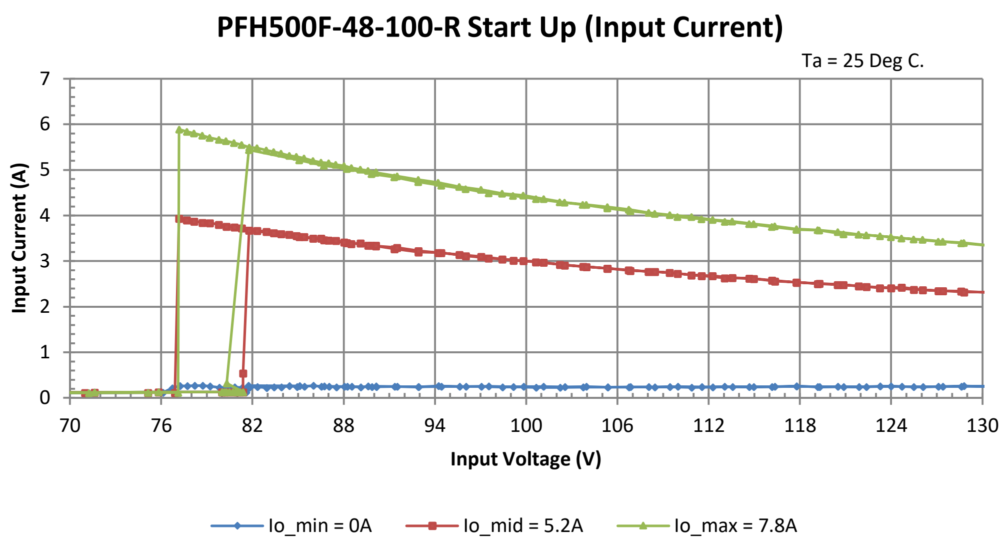




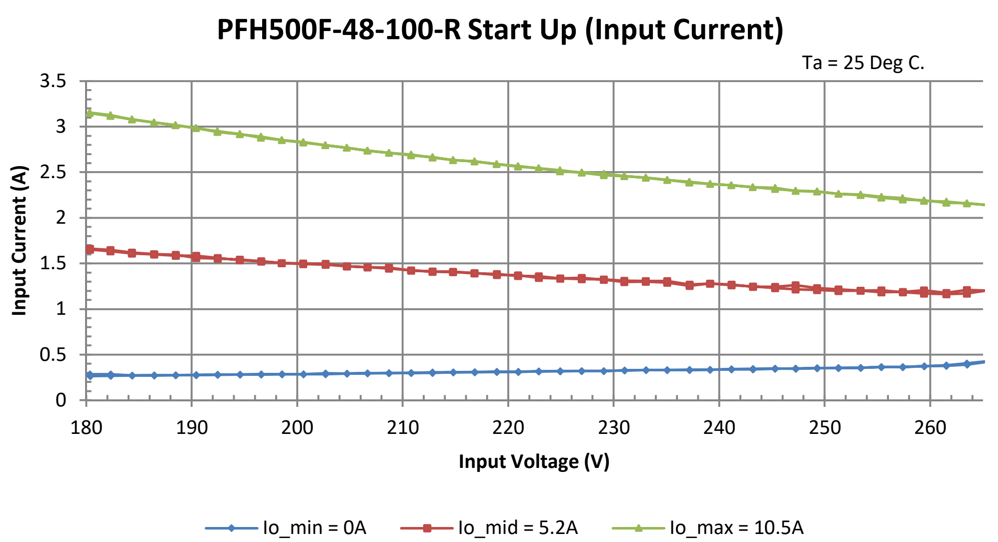


2.1.3 Input Current vs. Input Voltage

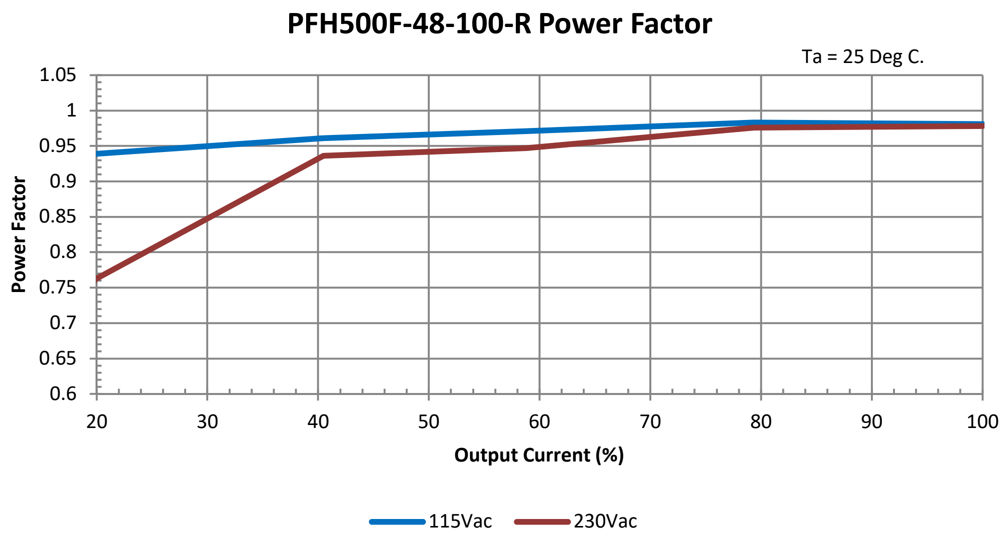
Low Line



High Line

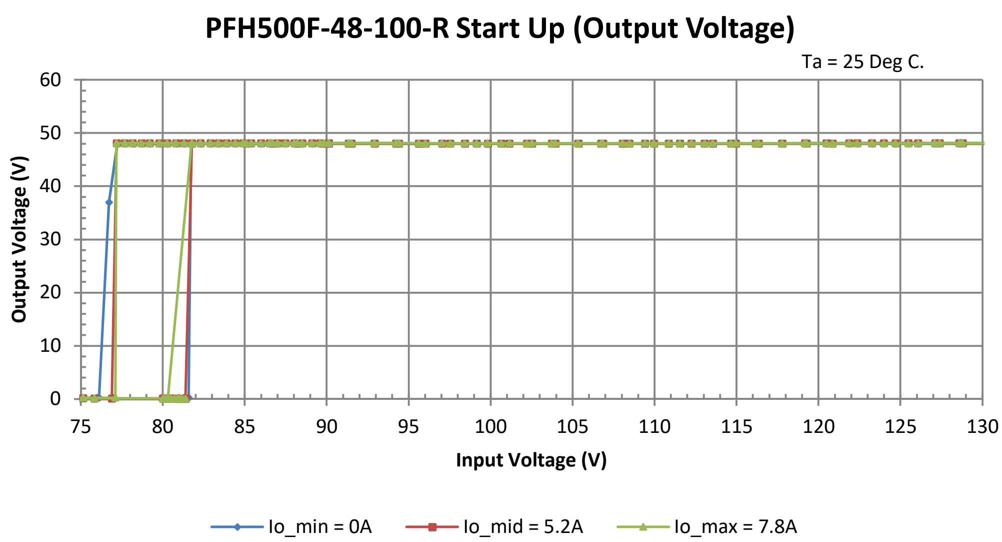


2.1.4 Power Factor (PF) vs. Output Current

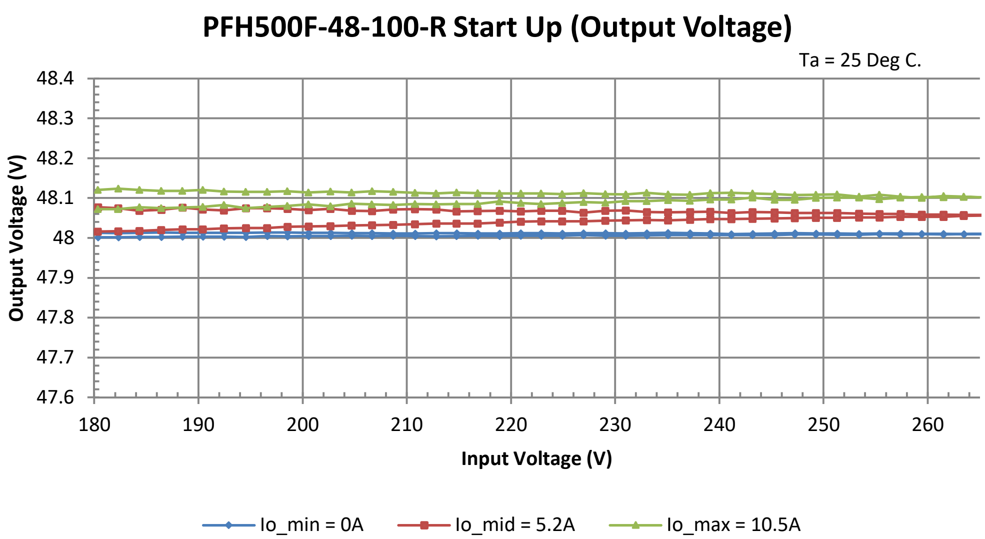


2.1.5 Output behavior with input line sweep

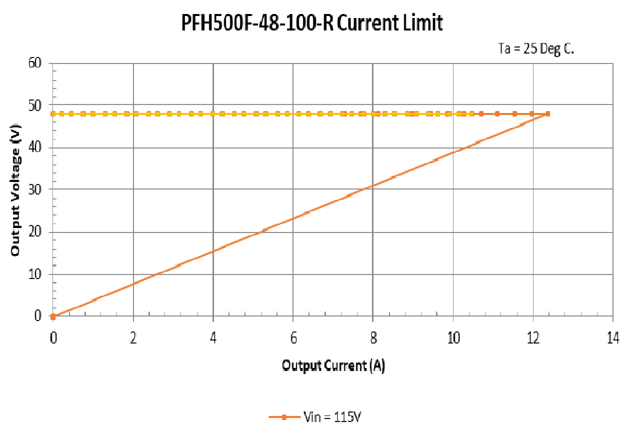
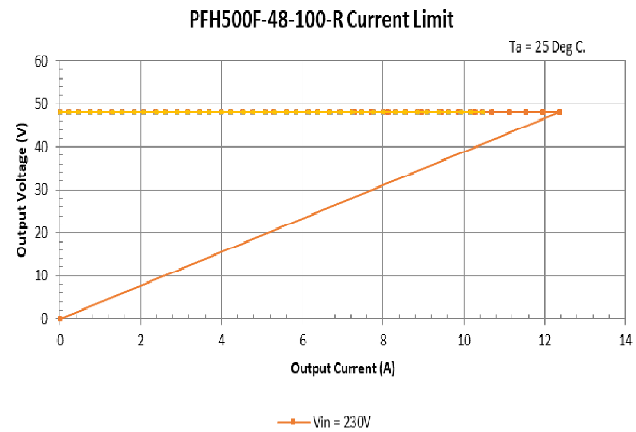
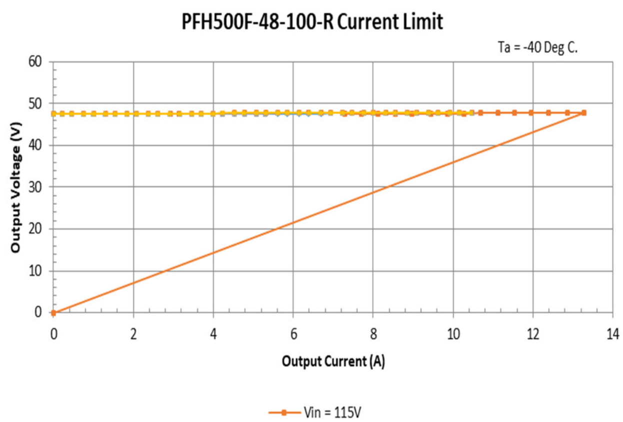
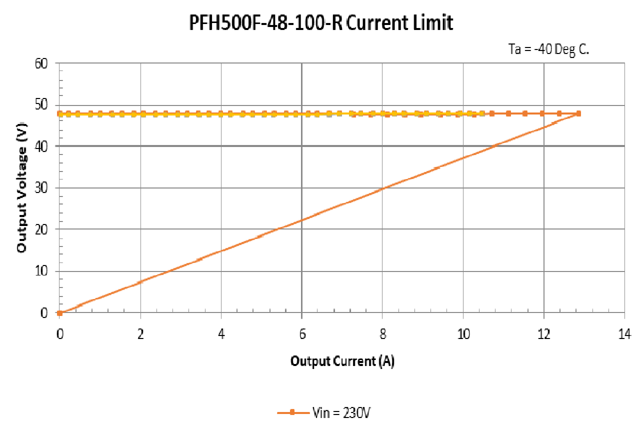
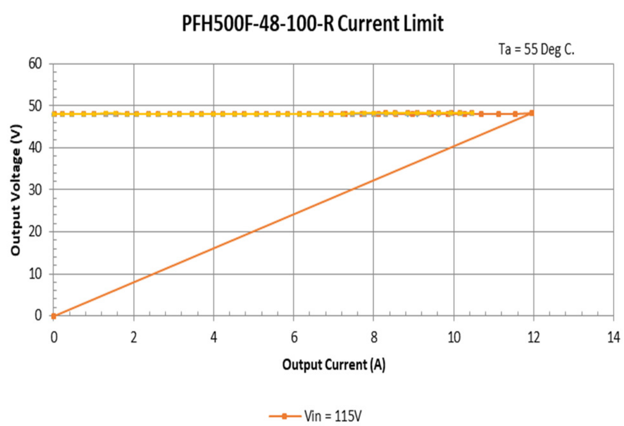
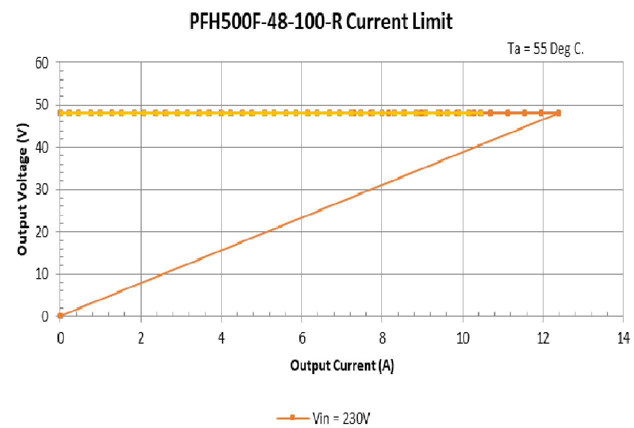
Low Line (Line Sweep from 0 → 135 →0 VAC)



High Line (Line Sweep from 180 → 265 → 180 VAC)



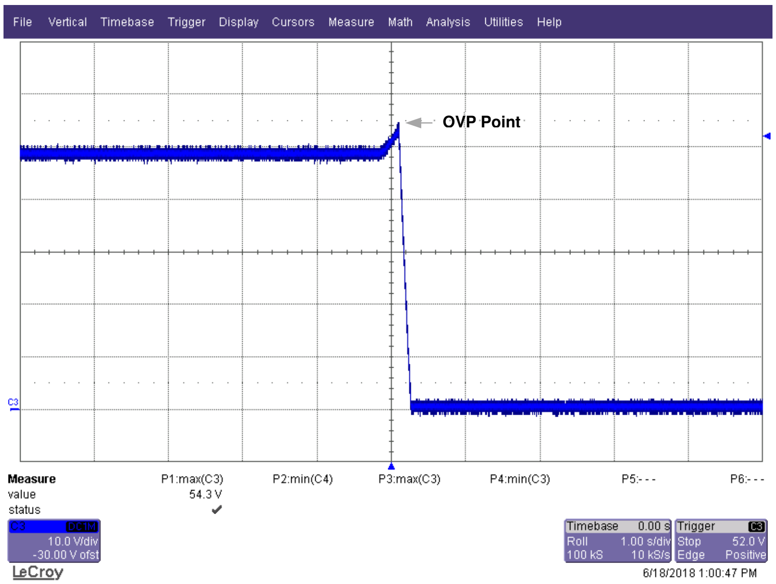
2.2 Over Current Protection (OCP) Characteristics (Refer to section 1.1.2 for Test Setup)

LOW LINE CONDITIONS	HIGH LINE CONDITIONS
	
	
	

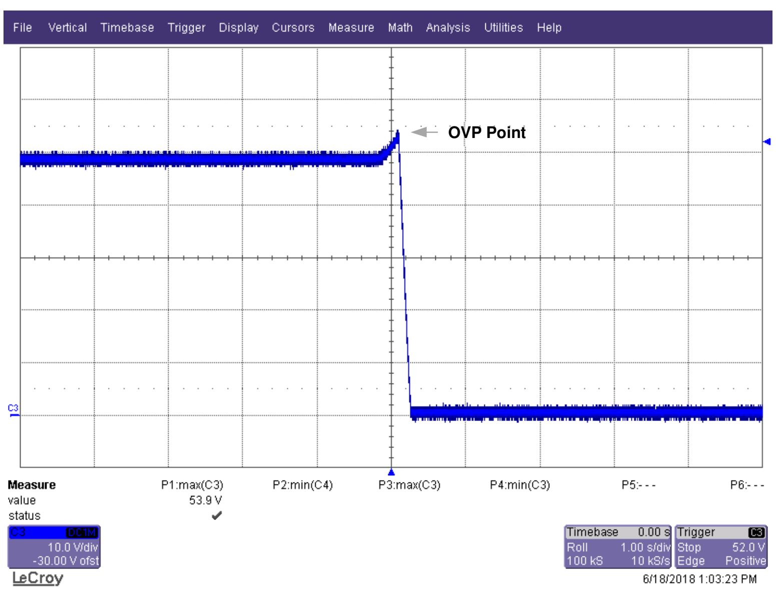
2.3 Over Voltage Protection (OVP) Characteristics (Refer to Section 1.1.2 for Test Setup)

Conditions:	I_O = 0.1A
	T_a = 25 °C

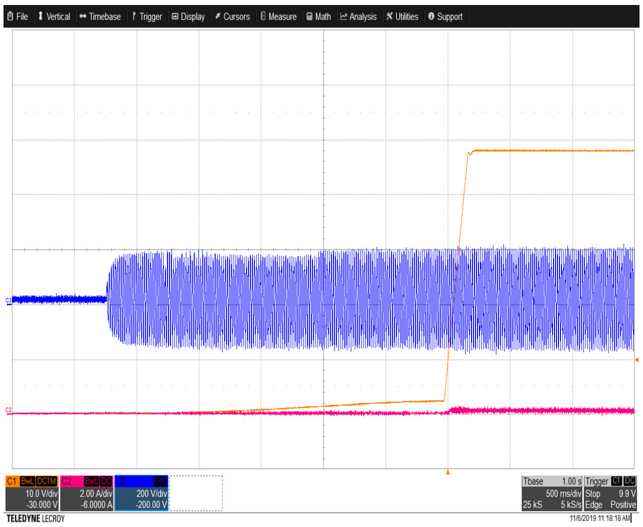
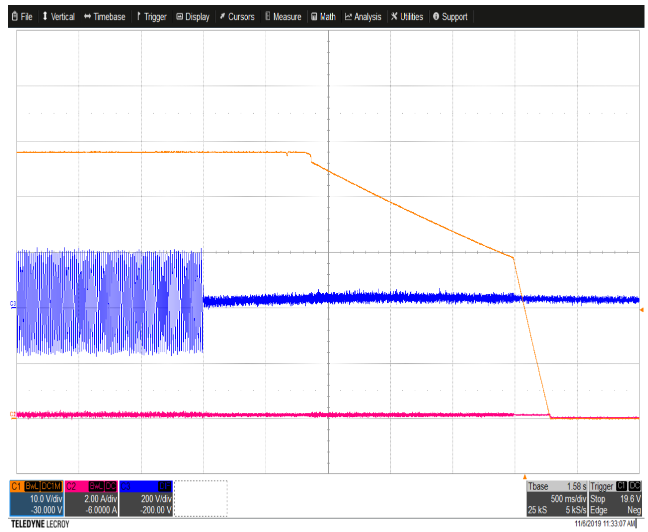
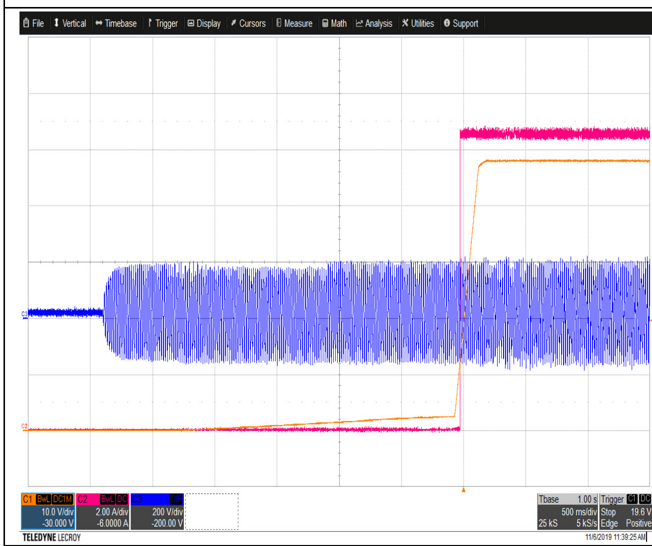
Vin = 115V



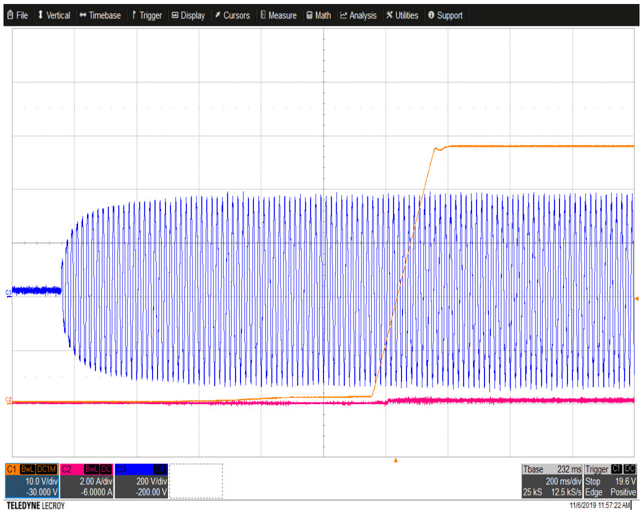
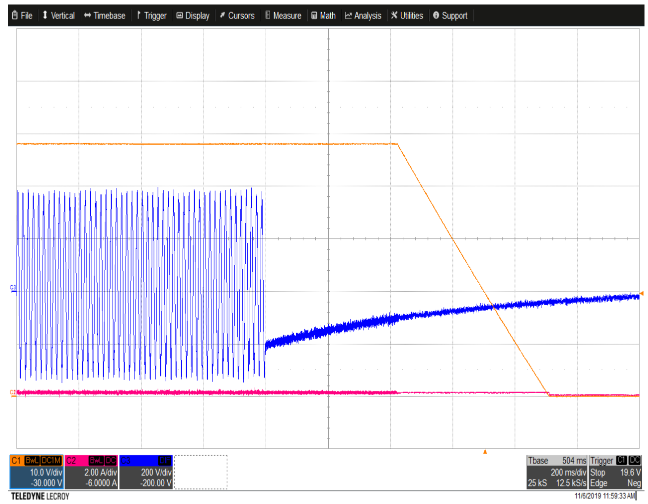
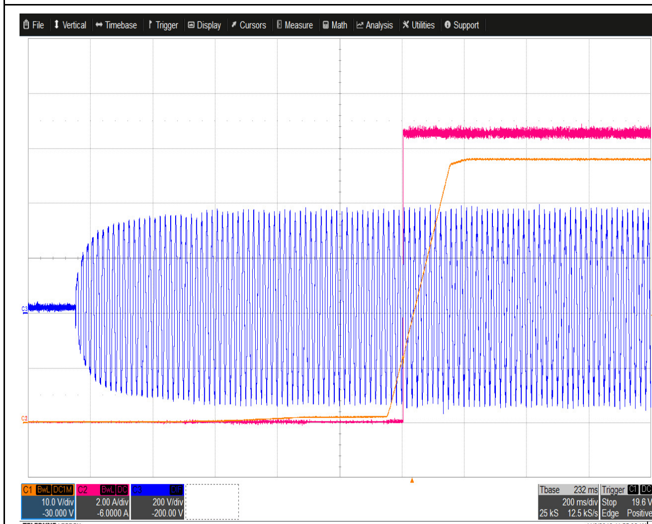
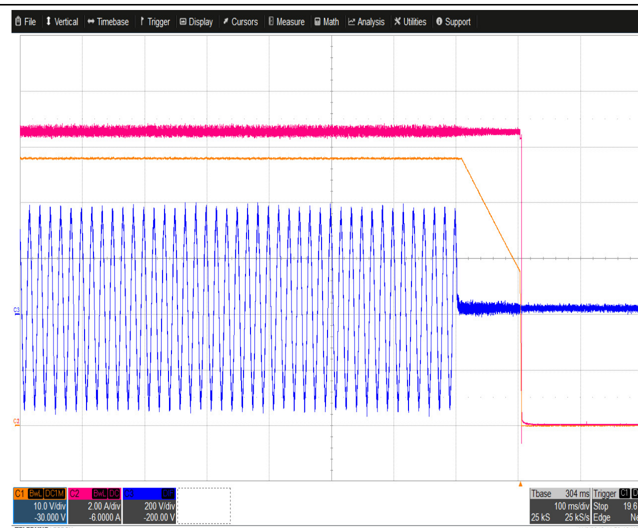
Vin = 230V



2.4 Output Rise and Fall Characteristic with AC Turn On / Turn-Off

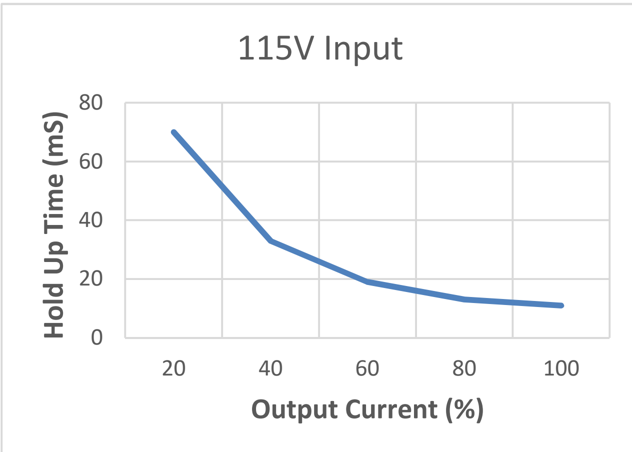
115 VAC No Load Start Up CH1: Vo; CH2: I_O; CH3: Vin	115 VAC No Load Shut Down CH1: Vo; CH2: I_O; CH3: Vin
	
115 VAC Full Load Start Up CH1: Vo; CH2: I_O; CH3: Vin	115 VAC Full Load Shut Down CH1: Vo; CH2: I_O; CH3: Vin
	

Output Rise and Fall Characteristic (continued)

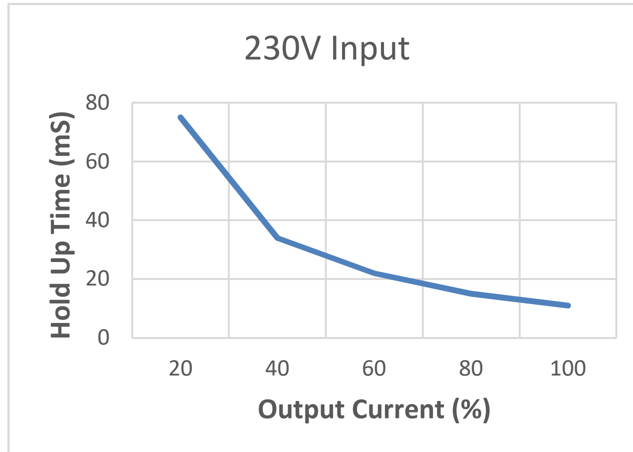
230 VAC No Load Start Up CH1: Vo; CH2: I_O; CH3: Vin	230 VAC No Load Shut Down CH1: Vo; CH2: I_O; CH3: Vin
	
230 VAC Full Load Start Up CH1: Vo; CH2: I_O; CH3: Vin	230 VAC Full Load Shut Down CH1: Vo; CH2: I_O; CH3: Vin
	

2.5 Hold Up Time Characteristic

V_{IN} = 115 VAC; V_O = 48 VDC
C9=C10=470uF/450V, C15=C16=470uF/100V

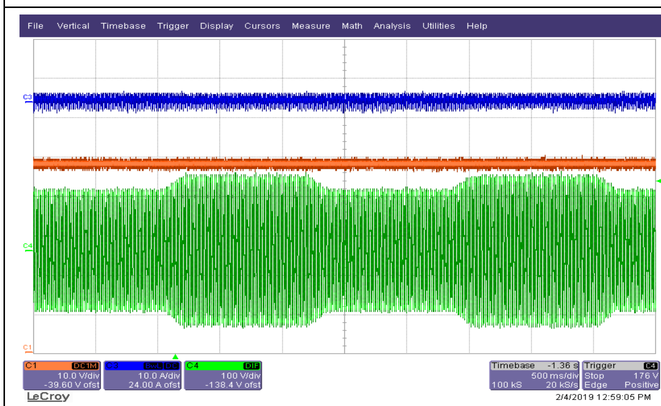


V_{IN} = 230 VAC; V_O = 48 VDC
C9=C10=470uF/450V, C15=C16=470uF/100V

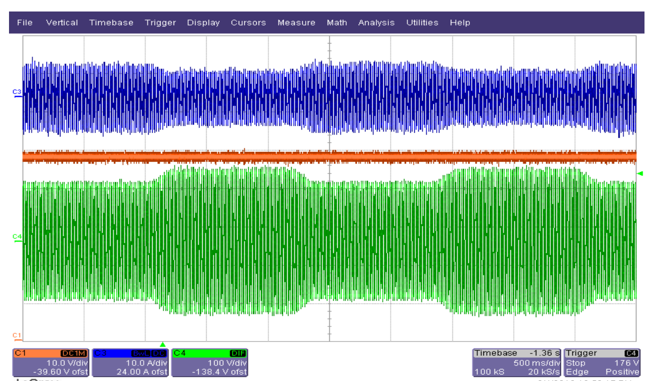


2.6 Dynamic Line Response

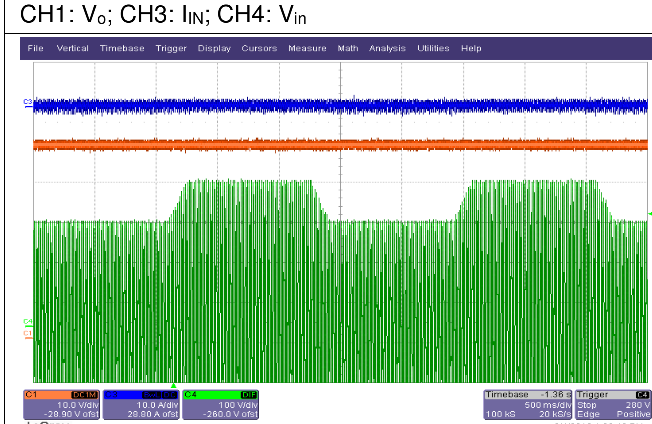
V_{IN} = 105 ↔ 130 VAC; I_O = 1 A
CH1: V_o; CH3: I_{IN}; CH4: V_{in}



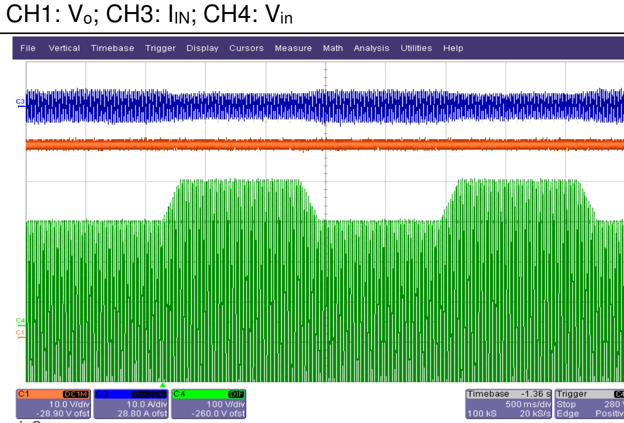
V_{IN} = 105 ↔ 130 VAC; I_O = 10.5 A
CH1: V_o; CH3: I_{IN}; CH4: V_{in}



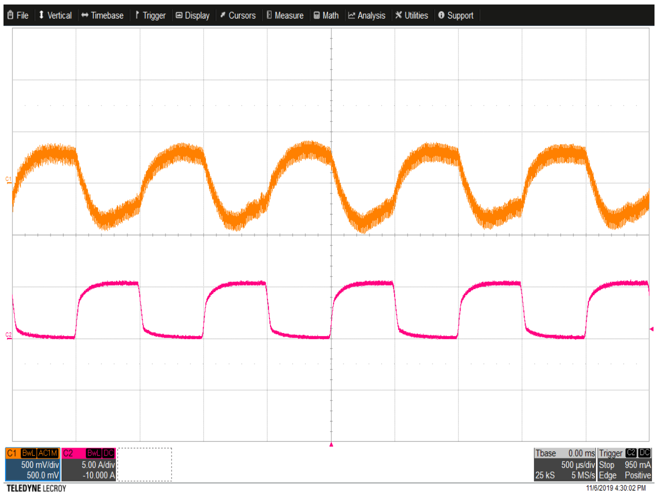
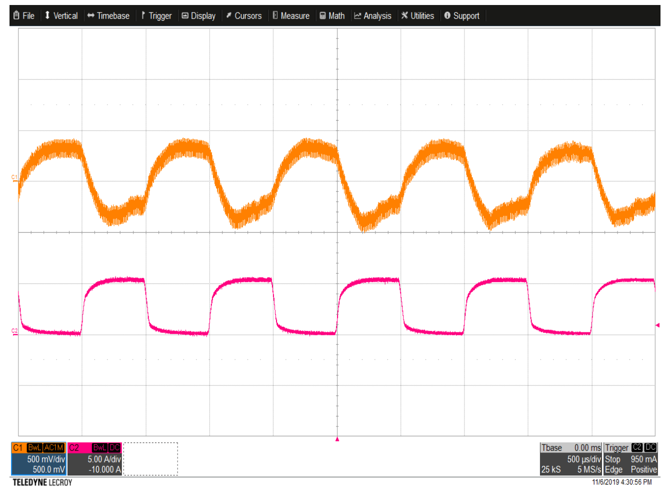
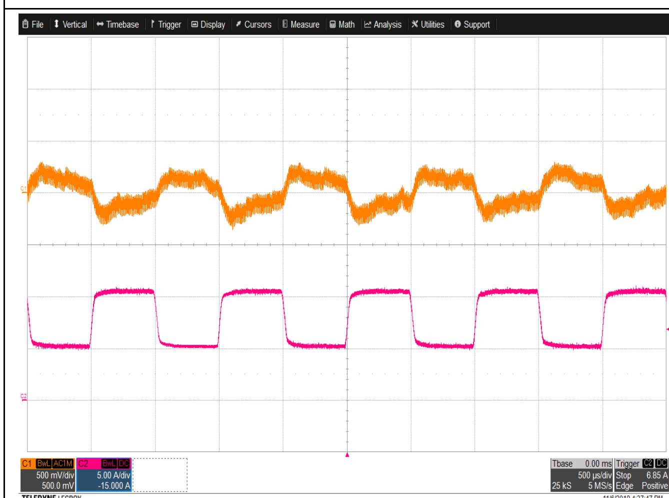
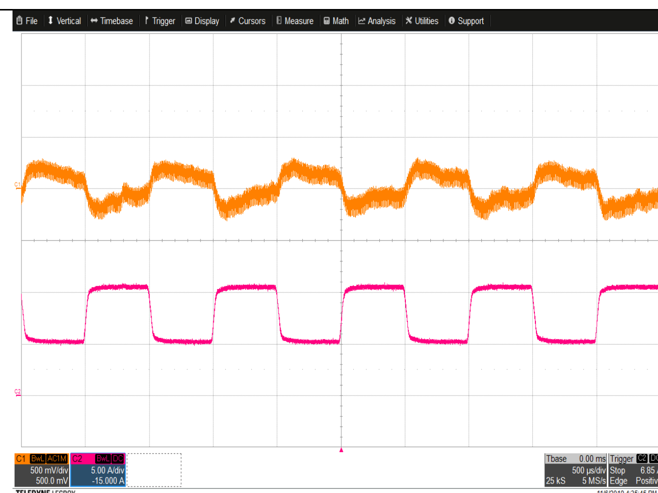
V_{IN} = 180 ↔ 250 VAC; I_O = 1 A
CH1: V_o; CH3: I_{IN}; CH4: V_{in}



V_{IN} = 180 ↔ 250 VAC; I_O = 10.5 A
CH1: V_o; CH3: I_{IN}; CH4: V_{in}

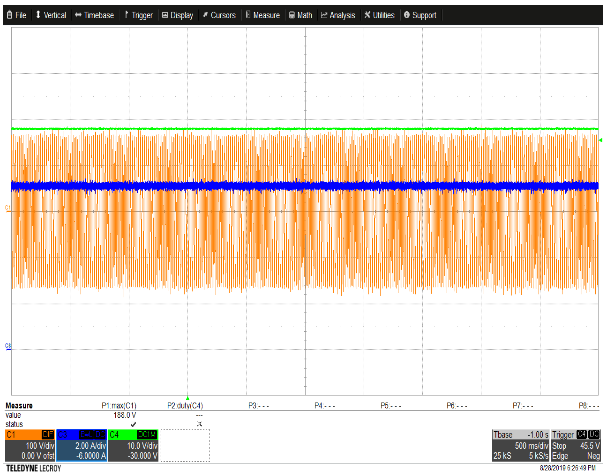
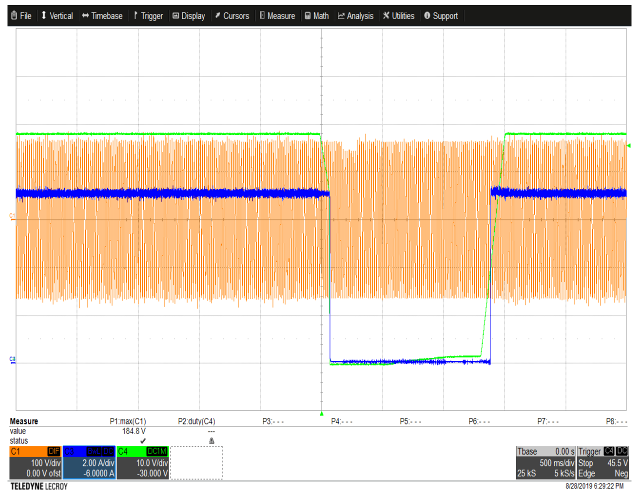
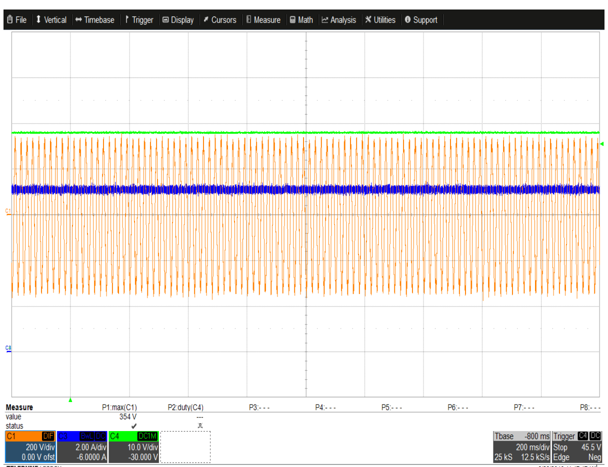
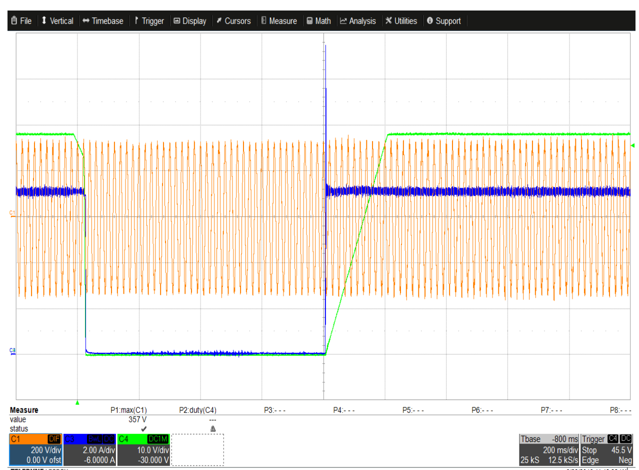


2.7 Dynamic Load Response

V_{IN} = 115 VAC; Load Step: 0% (0A) ↔ 50% (5.25A), 1KHz CH4: V_O (AC Couple); CH2: I_O; Slew rate: 0.1A/us	V_{IN} = 230 VAC; Load Step: 0% (0A) ↔ 50% (5.25A), 1KHz CH4: V_O (AC Couple); CH2: I_O; Slew rate: 0.1A/us
	
V_{IN} = 115 VAC; Load Step: 50% (5.25A) ↔ 100% (10.5A), 1KHz CH4: V_O (AC Couple); CH2: I_O; Slew rate: 0.1A/us	V_{IN} = 230 VAC; Load Step: 50% (5.25A) ↔ 100% (10.5A), 1KHz CH4: V_O (AC Couple); CH2: I_O; Slew rate: 0.1A/us
	

2.8 Brownout

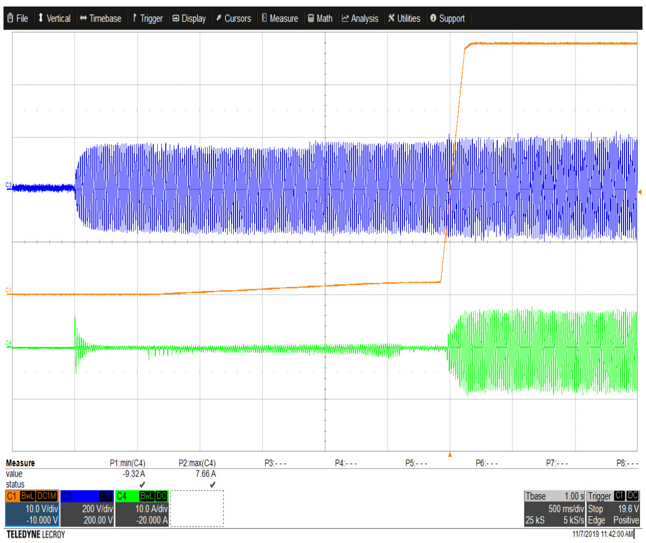
T_a = 25 °C

V_{IN} = 115 VAC / 60Hz; I_O = 7 A; Brownout Time = 1mS CH1: V_{IN}; CH3: I_{out}; CH4: Vo	V_{IN} = 115 VAC / 60Hz; I_O = 7 A; Brownout Time = 1.6mS CH1: V_{IN}; CH3: I_{out}; CH4: Vo
	
V_{IN} = 230 VAC / 50Hz; I_O = 7 A; Brownout Time = 0.6mS CH1: V_{IN}; CH3: I_{out}; CH4: Vo	V_{IN} = 230 VAC / 50Hz; I_O = 7 A; Brownout Time = 1mS CH1: V_{IN}; CH3: I_{out}; CH4: Vo
	

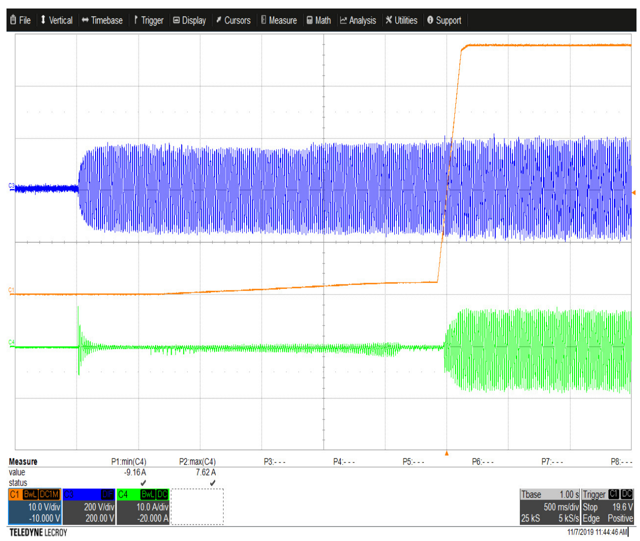
2.9 Inrush Current (Refer to Section 1.1.3 for Test Setup)

Condition:	I_O = 100%
	T_a = 25 °C
	C9=C10=470uF/450V

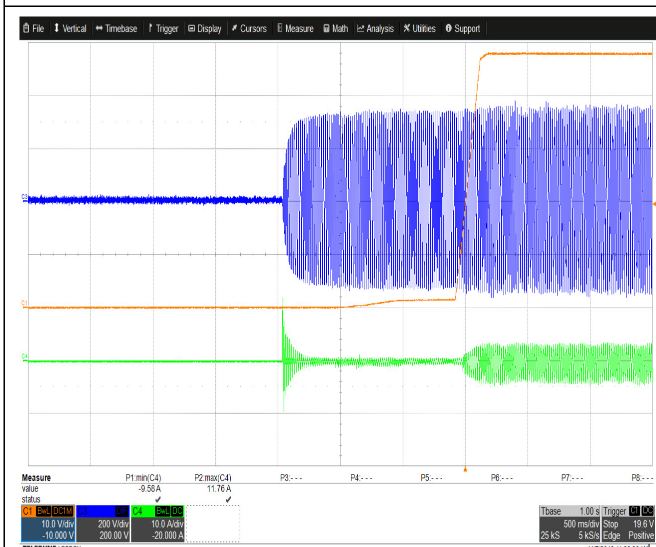
V_{IN} = 115 VAC; Ø = 0° (Switch On Phase Angle)
CH1: V_o; CH3:V_{IN}; CH4: I_{IN}



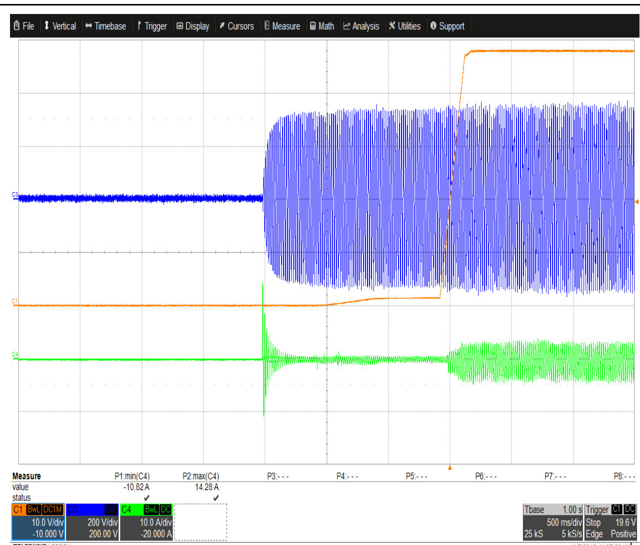
V_{IN} = 115 VAC; Ø = 90° (Switch On Phase Angle)
CH1: V_o; CH3:V_{IN}; CH4: I_{IN}



V_{IN} = 230 VAC; Ø = 0° (Switch On Phase Angle)
CH1: V_o; CH3:V_{IN}; CH4: I_{IN}

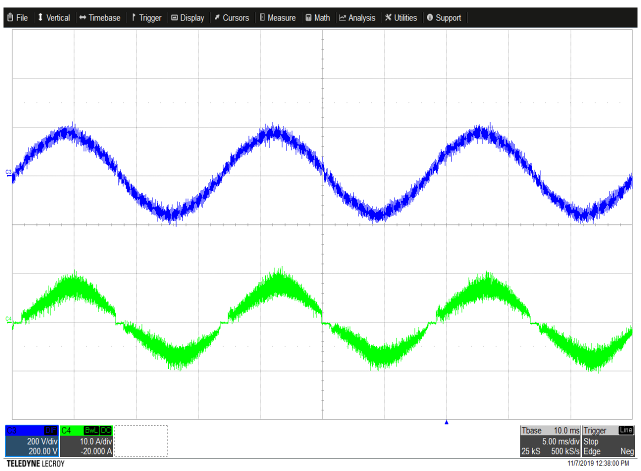
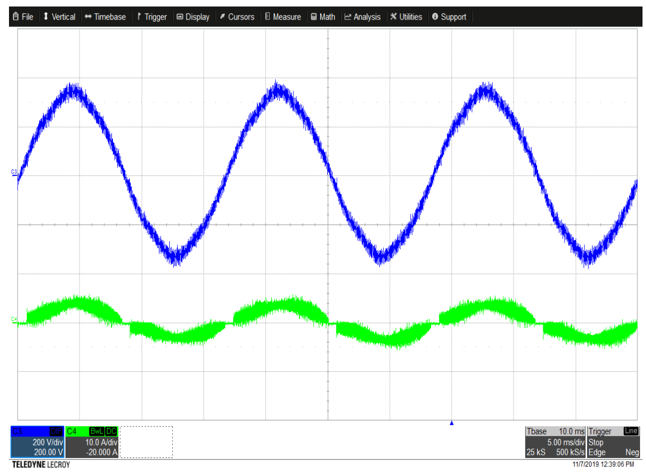


V_{IN} = 230 VAC; Ø = 90° (Switch On Phase Angle)
CH1: V_o; CH3:V_{IN}; CH4: I_{IN}



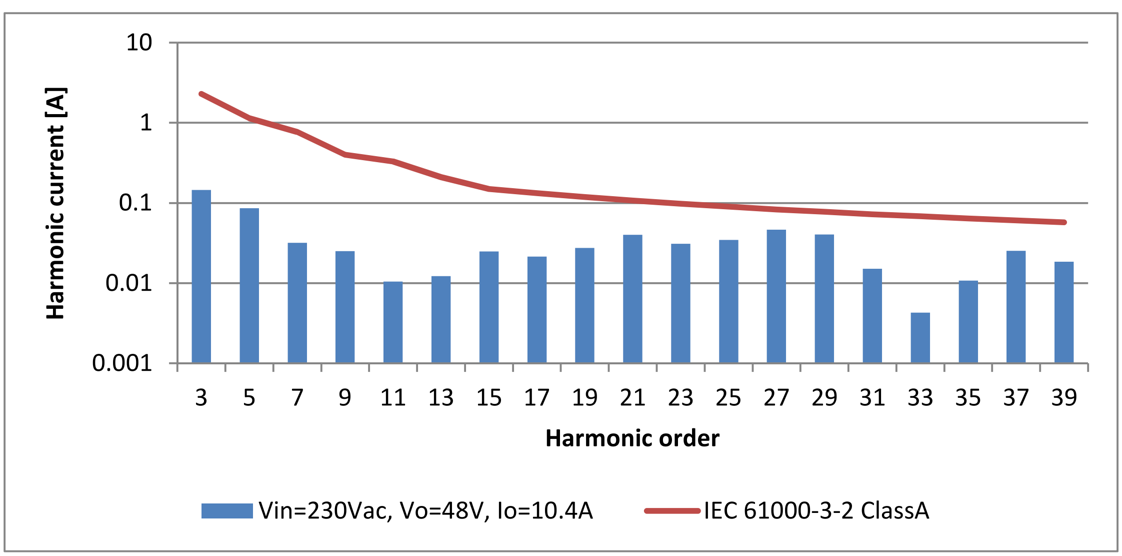
2.10 Input Current Waveform

Condition:	I_O = 100%
	T_a = 25 °C

V_{IN} = 115 VAC; I_O = 10.5A CH3: V_{IN}; CH4: I_{IN};	V_{IN} = 230 VAC; I_O = 10.5A CH3: V_{IN}; CH4: I_{IN};
	

2.11 Input Current Harmonics

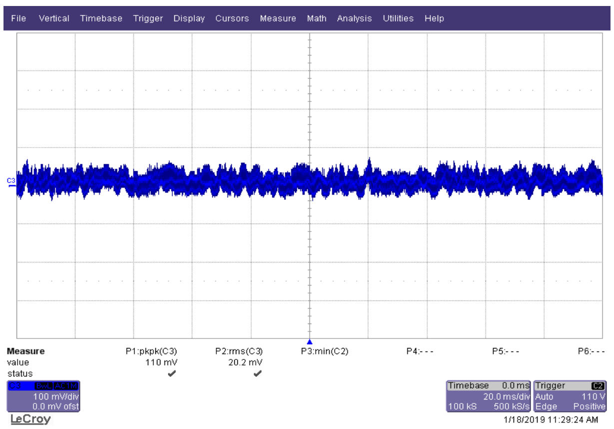
Condition:	V_{IN} = 230 Vac
	I_O = 10.5%
	T_a = 25°C
	IEC 61000-3-2 Class A



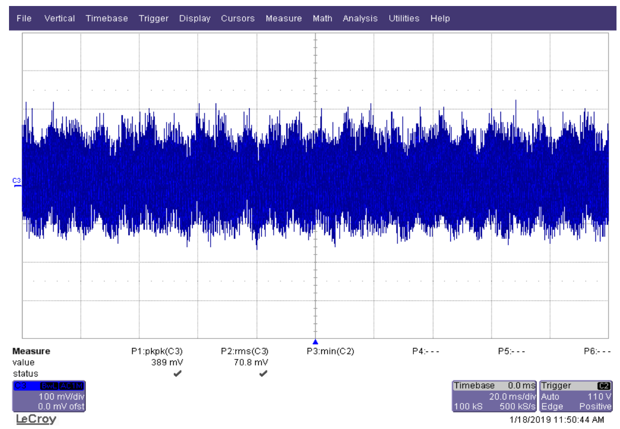
2.12 Output Ripple and Noise

T_a = 25 °C

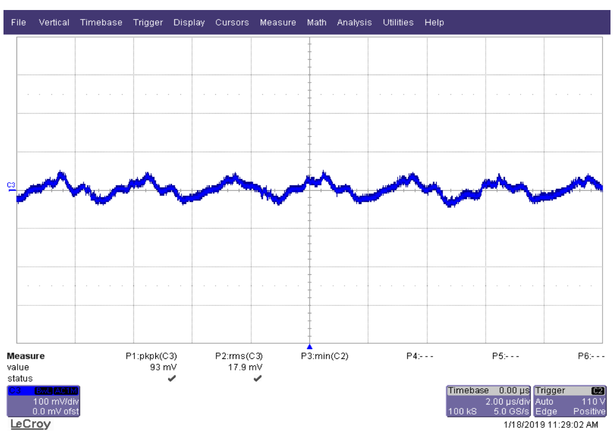
V_{IN} = 115 VAC; I_O = 1 A; V_O = 48 VDC
CH1: V_O / 20.0mS/div



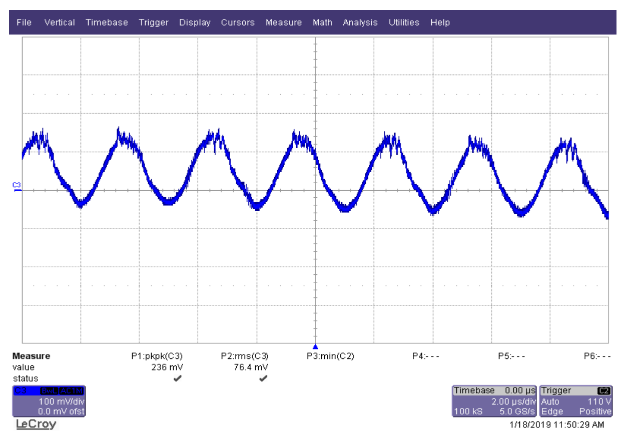
V_{IN} = 115 VAC; I_O = 10.5 A; V_O = 48 VDC
CH1: V_O / 20.0mS/div



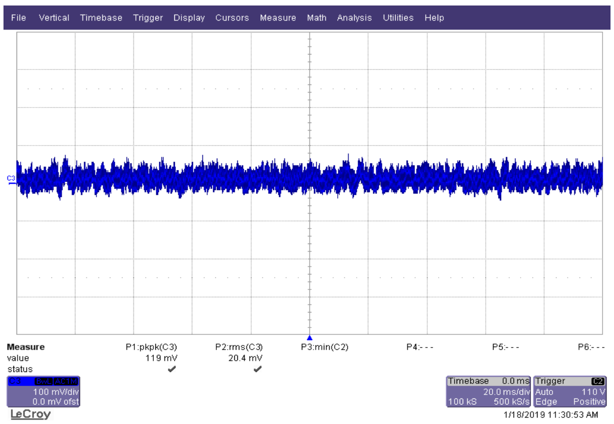
V_{IN} = 115 VAC; I_O = 1 A; V_O = 48 VDC
CH1: V_O / 2.0uS/div



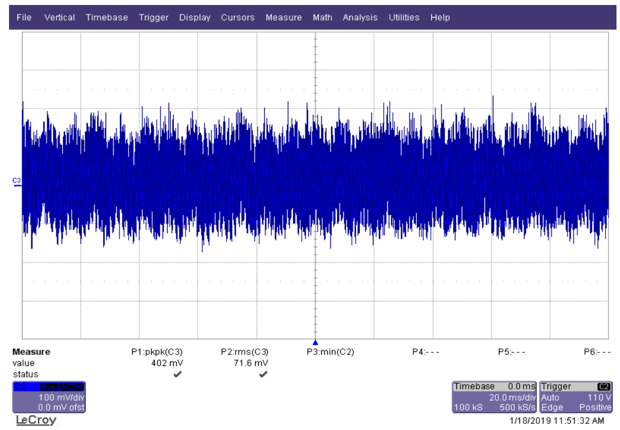
V_{IN} = 115 VAC; I_O = 10.5 A; V_O = 48 VDC
CH1: V_O / 2.0uS/div



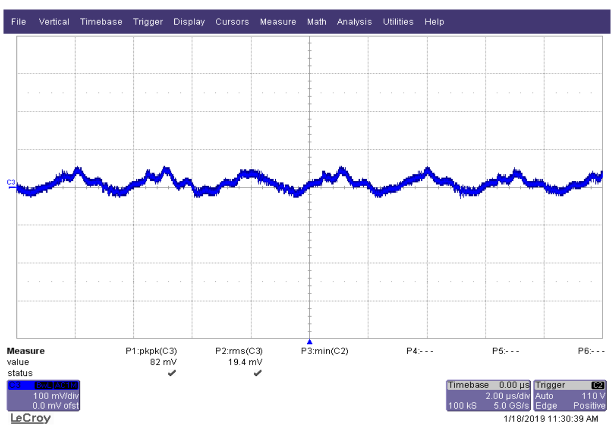
V_{IN} = 230 VAC; I_O = 1 A; V_O = 48 VDC
CH1: V_O / 20.0mS/div



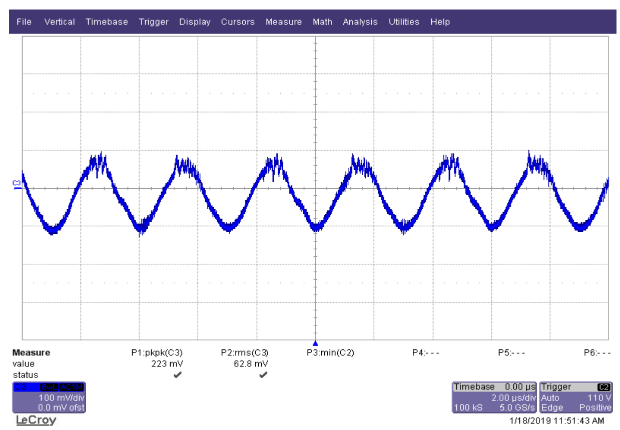
V_{IN} = 230 VAC; I_O = 10.5 A; V_O = 48 VDC
CH1: V_O / 20.0mS/div



V_{IN} = 230 VAC; I_O = 1 A; V_O = 48 VDC
CH1: V_O / 2.0uS/div



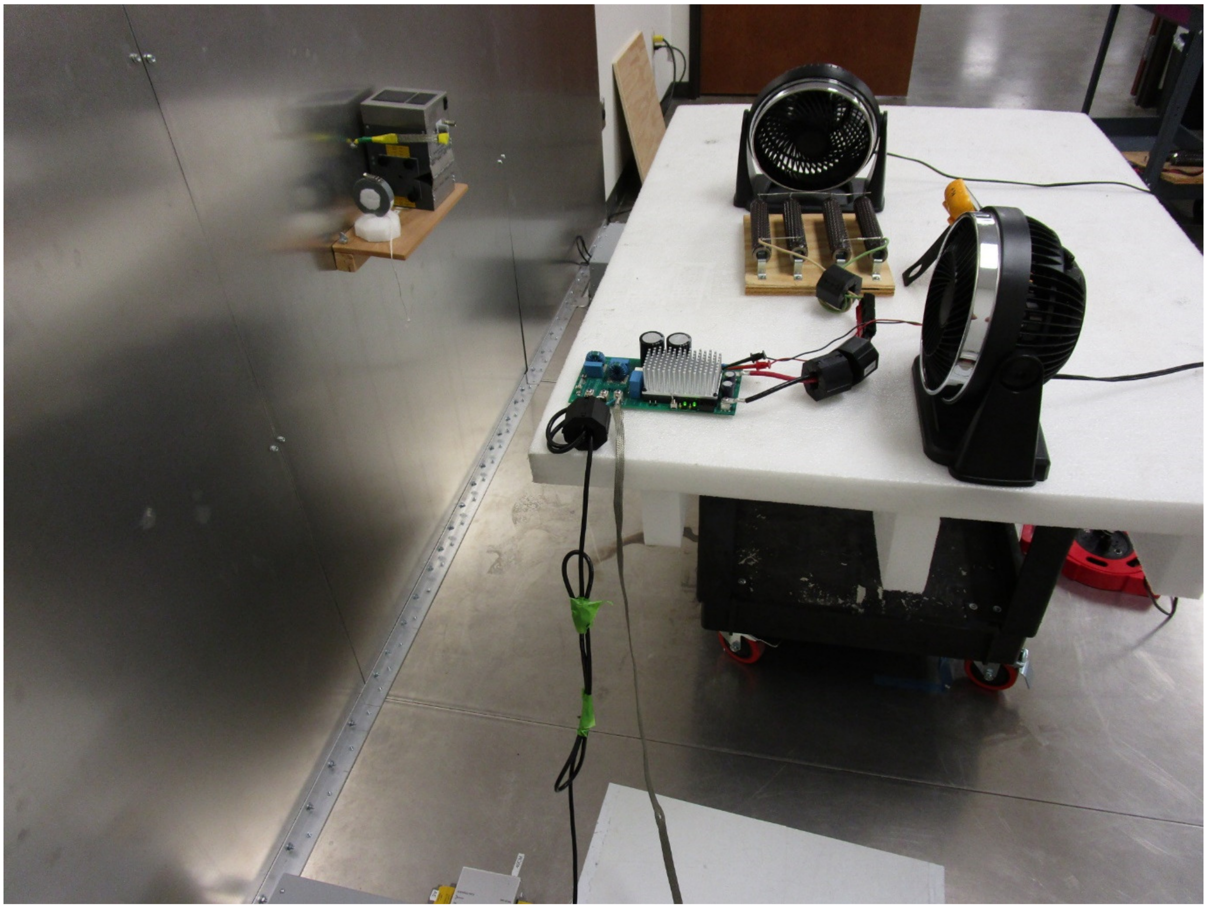
V_{IN} = 230 VAC; I_O = 10.5 A; V_O = 48 VDC
CH1: V_O / 2.0uS/div



2.13 Electro-Magnetic Interference Characteristics

Certified Laboratory Test Location	Element Materials Technology Group Limited Plano, TX
Test Board	Test performed with the PFH500 module mounted on PFH05W-001-EVK-S0 Evaluation test Board (Rev 02)

Test Setup:



Test Result

115V / 60Hz, Line

CONDUCTED EMISSIONS

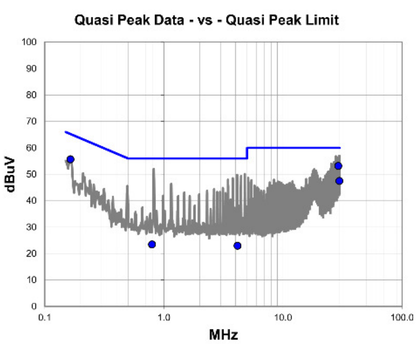
EmiR5 2019.08.01 PSA-ESCI 2019.06.10

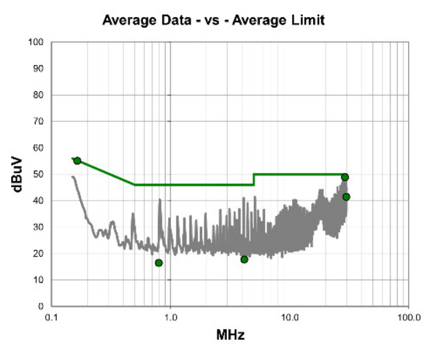
Work Order:	TDKL0025	**Date:**	4-Oct-2019	FOR REFERENCE ONLY
Project:	None	**Temperature:**	22 °C	
Job Site:	TX01	**Humidity:**	55.2% RH	
Serial Number:	None	**Barometric Pres.:**	1024 mbar	**Tested by:** Marty Martin

EUT:	PFH 500F-48V-100-R Module
Configuration:	Unknown
Customer:	TDK-Lambda Americas Inc.
Attendees:	Michael
EUT Power:	115VAC/60Hz
Operating Mode:	10 A Load
Deviations:	None
Comments:	Heatsink tied to EGND

Test Specifications	Class B	Test Method
EN 55032:2012/AC:2013		CISPR 32:2015

Run #	19	**Line:**	High Line	**Ext. Attenuation:**	0	**Results**	Pass





Quasi Peak Data - vs - Quasi Peak Limit

Freq (MHz)	Amplitude (dBuV)	Factor (dB)	Adjusted (dBuV)	Spec. Limit (dBuV)	Compared to Spec. (dB)
29.159	31.2	22.0	53.2	60.0	-6.8
0.164	35.4	20.3	55.7	65.2	-9.5
29.844	25.4	22.1	47.5	60.0	-12.5
0.796	3.3	20.2	23.5	56.0	-32.5
4.159	2.8	20.2	23.0	56.0	-33.0

Average Data - vs - Average Limit

Freq (MHz)	Amplitude (dBuV)	Factor (dB)	Adjusted (dBuV)	Spec. Limit (dBuV)	Compared to Spec. (dB)
0.164	34.8	20.3	55.1	55.2	-0.1
29.159	26.9	22.0	48.9	50.0	-1.1
29.844	19.4	22.1	41.5	50.0	-8.5
4.159	-2.4	20.2	17.8	46.0	-28.2
0.796	-3.7	20.2	16.5	46.0	-29.5

115V / 60Hz, Neutral

CONDUCTED EMISSIONS

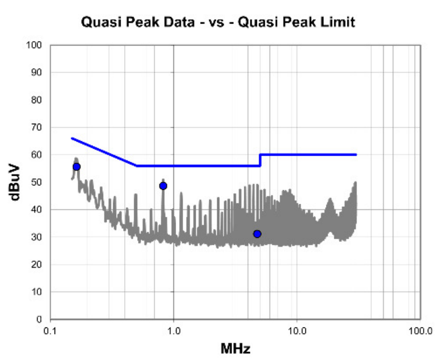
element

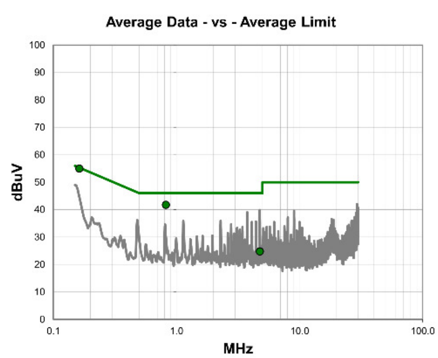
EmiR5 2019.08.01 PSA-ESCI 2019.05.10

Work Order:	TDKL0025	**Date:**	4-Oct-2019	FOR REFERENCE ONLY	
Project:	None	**Temperature:**	22 °C		
Job Site:	TX01	**Humidity:**	55.2% RH		
Serial Number:	None	**Barometric Pres.:**	1024 mbar	**Tested by:**	Marty Martin
EUT:	PFH 500F-48V-100-R Module				
Configuration:	Unknown				
Customer:	TDK-Lambda Americas Inc.				
Attendees:	Michael				
EUT Power:	115VAC/60Hz				
Operating Mode:	10 A Load				
Deviations:	None				
Comments:	Heatsink tied to EGND				

Test Specifications	**Class B**	**Test Method**
EN 55032:2012/AC:2013		CISPR 32:2015

Run #	20	**Line:**	Neutral	**Ext. Attenuation:**	0	**Results**	Pass





Quasi Peak Data - vs - Quasi Peak Limit

Freq (MHz)	Amplitude (dBuV)	Factor (dB)	Adjusted (dBuV)	Spec. Limit (dBuV)	Compared to Spec. (dB)
0.821	28.5	20.2	48.7	56.0	-7.3
0.163	35.4	20.3	55.7	65.3	-9.6
4.758	11.0	20.2	31.2	56.0	-24.8

Average Data - vs - Average Limit

Freq (MHz)	Amplitude (dBuV)	Factor (dB)	Adjusted (dBuV)	Spec. Limit (dBuV)	Compared to Spec. (dB)
0.163	34.7	20.3	55.0	55.3	-0.3
0.821	21.6	20.2	41.8	46.0	-4.2
4.758	4.6	20.2	24.8	46.0	-21.2

230V / 50Hz, Line

CONDUCTED EMISSIONS

element

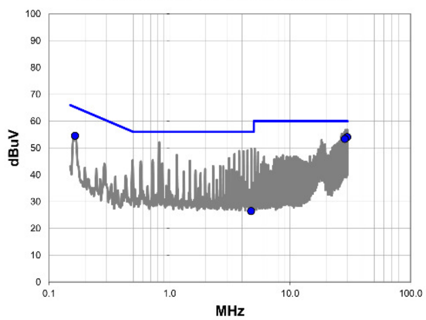
EmiR5 2019.08.01 PSA-ESCI 2019.05.10

Work Order:	TDKL0025	**Date:**	4-Oct-2019	FOR REFERENCE ONLY	
Project:	None	**Temperature:**	22 °C		
Job Site:	TX01	**Humidity:**	55.2% RH		
Serial Number:	None	**Barometric Pres.:**	1024 mbar	**Tested by:**	Marty Martin
EUT:	PFH 500F-48V-100-R Module				
Configuration:	Unknown				
Customer:	TDK-Lambda Americas Inc.				
Attendees:	Michael				
EUT Power:	230VAC/50Hz				
Operating Mode:	10 A Load				
Deviations:	None				
Comments:	Heatsink tied to EGND				

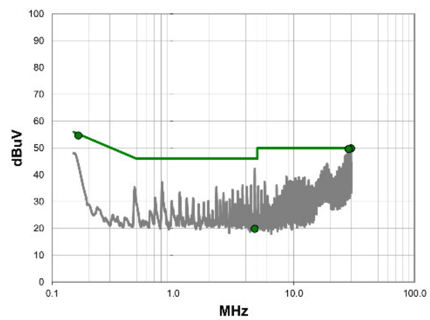
Test Specifications	**Class B**	**Test Method**
EN 55032:2012/AC:2013		CISPR 32:2015

Run #	18	**Line:**	High Line	**Ext. Attenuation:**	0	**Results**	Pass

Quasi Peak Data - vs - Quasi Peak Limit



Average Data - vs - Average Limit



Quasi Peak Data - vs - Quasi Peak Limit

Freq (MHz)	Amplitude (dBuV)	Factor (dB)	Adjusted (dBuV)	Spec. Limit (dBuV)	Compared to Spec. (dB)
29.772	32.0	22.1	54.1	60.0	-5.9
28.456	31.4	22.0	53.4	60.0	-6.6
0.165	34.3	20.3	54.6	65.2	-10.6
4.751	6.3	20.2	26.5	56.0	-29.5

Average Data - vs - Average Limit

Freq (MHz)	Amplitude (dBuV)	Factor (dB)	Adjusted (dBuV)	Spec. Limit (dBuV)	Compared to Spec. (dB)
29.772	27.8	22.1	49.9	50.0	-0.1
28.456	27.6	22.0	49.6	50.0	-0.4
0.165	34.4	20.3	54.7	55.2	-0.5
4.751	-0.3	20.2	19.9	46.0	-26.1

230V / 50Hz, Neutral

CONDUCTED EMISSIONS

element

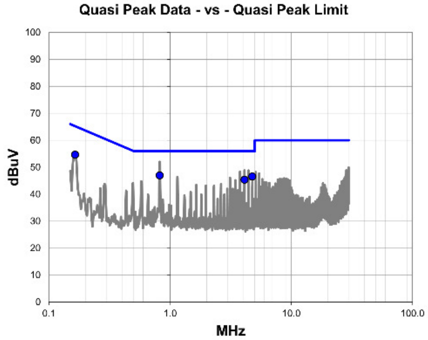
EmiR5 2019.08.01 PSA-ESCI 2019.05.10

Work Order:	TDKL0025	**Date:**	4-Oct-2019	FOR REFERENCE ONLY
Project:	None	**Temperature:**	22 °C	
Job Site:	TX01	**Humidity:**	55.2% RH	
Serial Number:	None	**Barometric Pres.:**	1024 mbar	**Tested by:** Marty Martin
EUT:	PFH 500F-48V-100-R Module			
Configuration:	Unknown			
Customer:	TDK-Lambda Americas Inc.			
Attendees:	Michael			
EUT Power:	230VAC/50Hz			
Operating Mode:	10 A Load			
Deviations:	None			
Comments:	Heatsink tied to EGND			

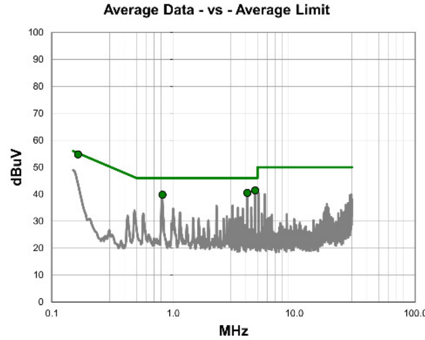
Test Specifications	**Class B**	**Test Method**
EN 55032:2012/AC:2013		CISPR 32:2015

Run #	17	**Line:**	Neutral	**Ext. Attenuation:**	0	**Results**	Pass

Quasi Peak Data - vs - Quasi Peak Limit



Average Data - vs - Average Limit



Quasi Peak Data - vs - Quasi Peak Limit

Freq (MHz)	Amplitude (dBuV)	Factor (dB)	Adjusted (dBuV)	Spec. Limit (dBuV)	Compared to Spec. (dB)
0.820	26.8	20.2	47.0	56.0	-9.0
4.770	26.4	20.2	46.6	56.0	-9.4
0.164	34.4	20.3	54.7	65.2	-10.5
4.111	25.2	20.2	45.4	56.0	-10.6

Average Data - vs - Average Limit

Freq (MHz)	Amplitude (dBuV)	Factor (dB)	Adjusted (dBuV)	Spec. Limit (dBuV)	Compared to Spec. (dB)
0.164	34.5	20.3	54.8	55.2	-0.4
4.770	21.2	20.2	41.4	46.0	-4.6
4.111	20.3	20.2	40.5	46.0	-5.5
0.820	19.6	20.2	39.8	46.0	-6.2

2.14 Leakage Current (Refer to Section 1.1.4 for Test Setup)

Condition:	V_{IN} = 265 VAC
	I_O = 0% (0 A)
$I_{LEAKAGE}$ LIMIT:	1 mA
Measured $I_{LEAKAGE}$:	0.62 mA
	PASS

3. TERMINOLOGIES

V_{IN}	Input Voltage
I_{IN}	Input Current
T_a	Ambient Temperature
F	Frequency
V_O	Output Voltage
I_O	Output Current
T_{BP}	Baseplate Temperature

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