DEMO BOARD TEST REPORT

Drain Sensing CrM Boost PFC 100W Demo Board with KP2801A

FEATURES

- Low-cost Single Winding Inductor
- Universal Input Voltage Range From 90~264Vac
- 94% Efficiency @110Vac full load
- High PF >0.95 & Low THD <10%@230Vac full load
- Harmonics Meets IEC61000-3-2 Class C
- Low Standby Power <0.5W

APPLICATIONS

- Boost PFC of LED Driver

INTRODUCTION

This DEMO Board provides 100W CrM Boost PFC Solution. The controller KP2801A enables to drive without auxiliary winding ZCD sensing by Novel Drain sensing tech, it has high voltage start up and it has HV self-powered tech without need Auxiliary winding.

This board provides high power factor and low total harmonic distortion of input current over the extended input voltage range and very wide output load range. Performance exceeds requirements for many demanding applications including LED lighting, computing power and white goods products.

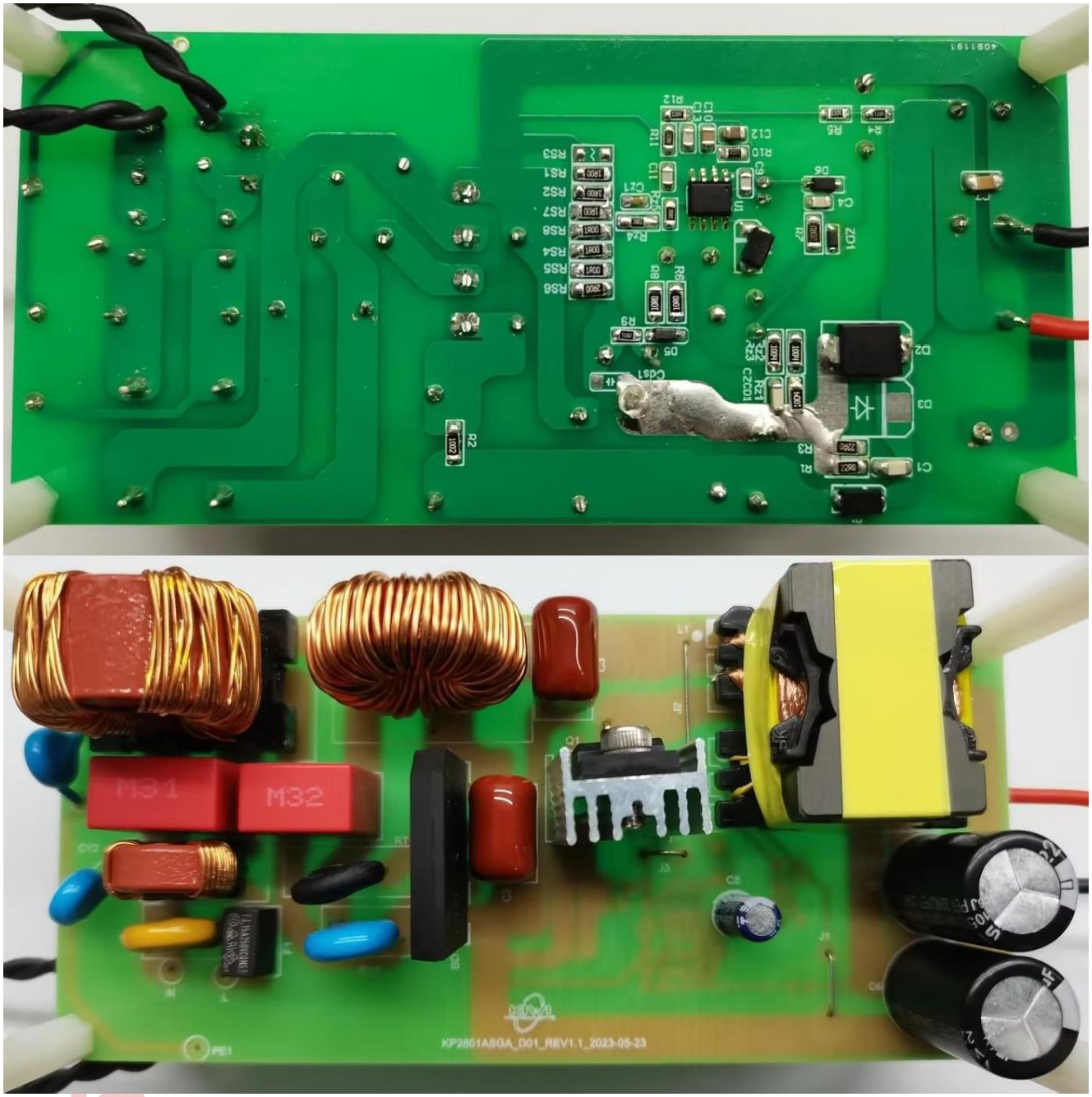
DEMO BOARD SEPCIFICATION

Description	Symbol	Min.	Typ.	Max.	Unit	Note
Input Voltage	Vin	90	110-220	264	Vac	50/60Hz
Output Voltage	Vout		410		Vdc	
Output Current	Iout		0.25		A	
Total Output Power	Pout		100		W	
Power Factor	PF	>0.95				230Vac@100W
Total Harmonic Distortion	THD	<10			%	230Vac@100W
System Average Efficiency	η	>90			%	110Vac@100W
Standby Power	Pstandby			0.5	W	90Vac-264Vac@No load
Startup Time	Tst			0.5	s	Tested at 110/230Vac
EMI Margin		6			dB	EN55015
Surge Test		4			kV	Differential Mode / Common Mode @ 230Vac/50Hz

Note: The table above shows the minimum acceptable performance of the design. Actual performance is listed in the results section.

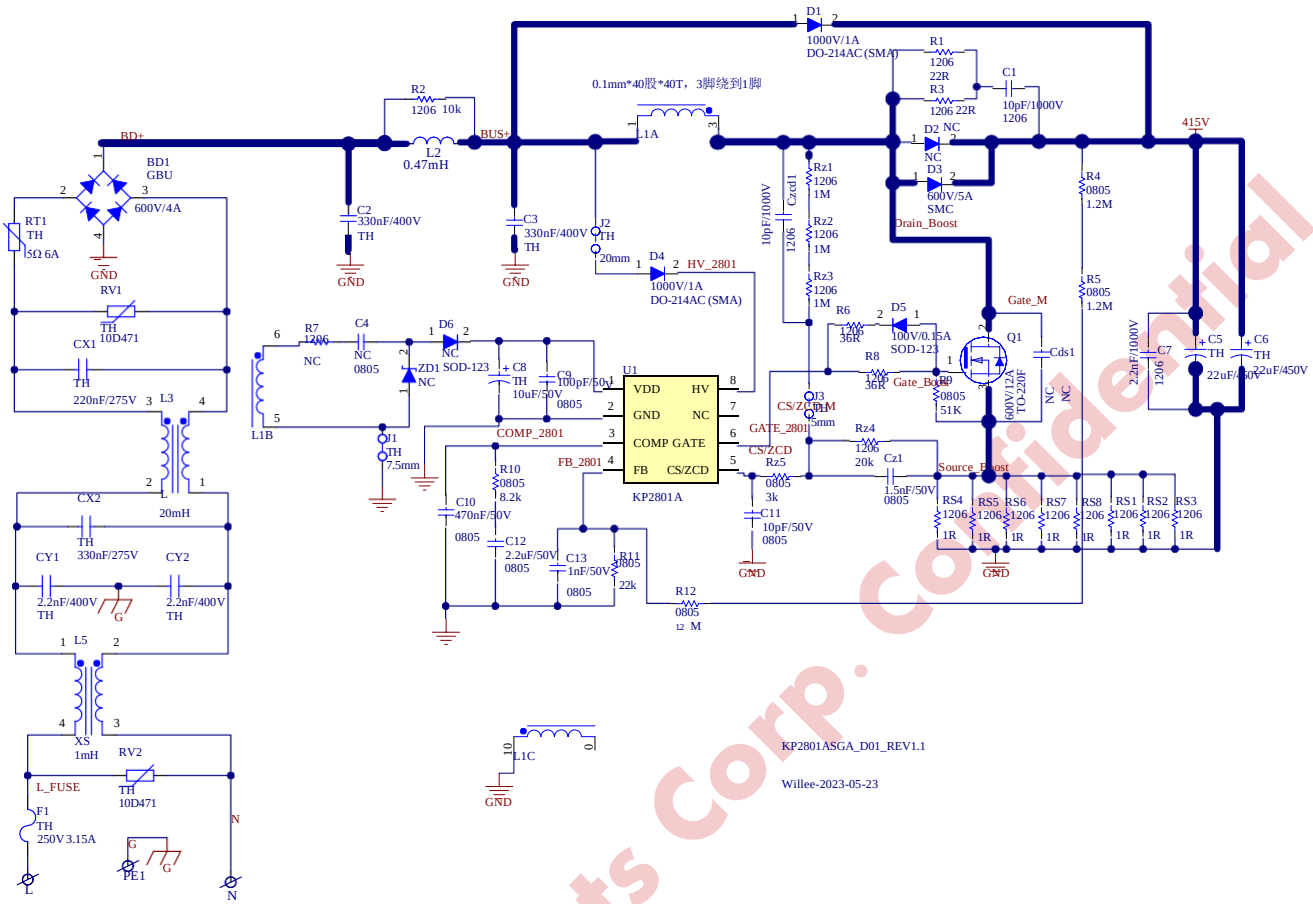
Demoboard

KP2801ASGA_D01_REV1.1_2023-05-23



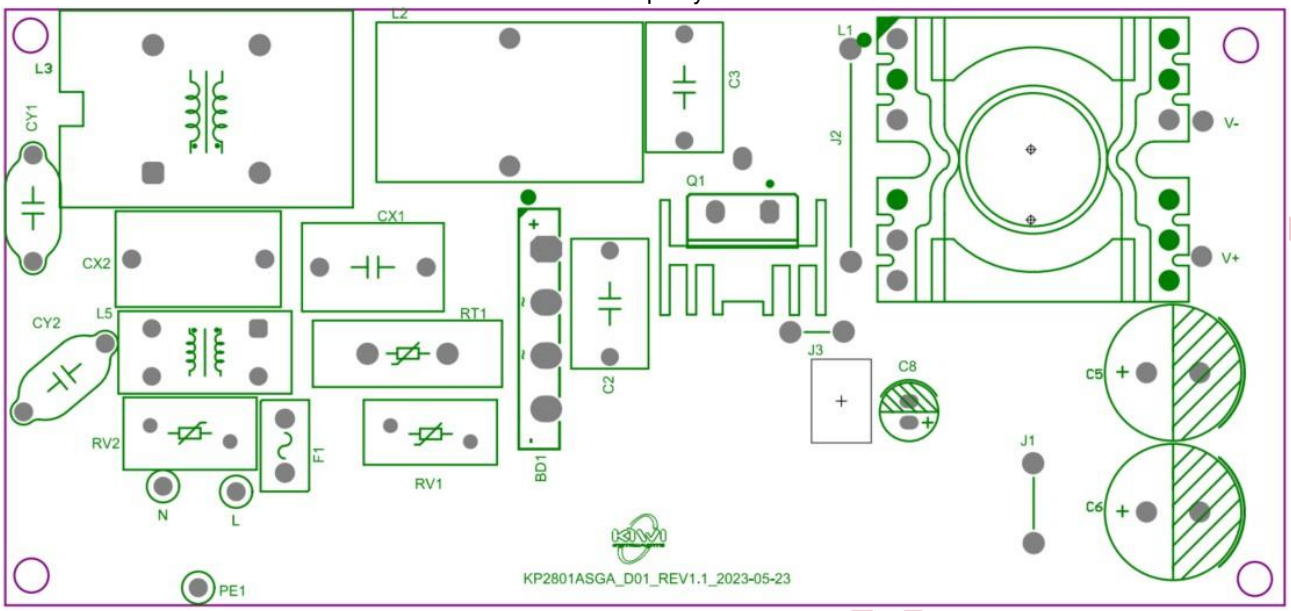
Size (mm)：120*55.956mm

Schematic

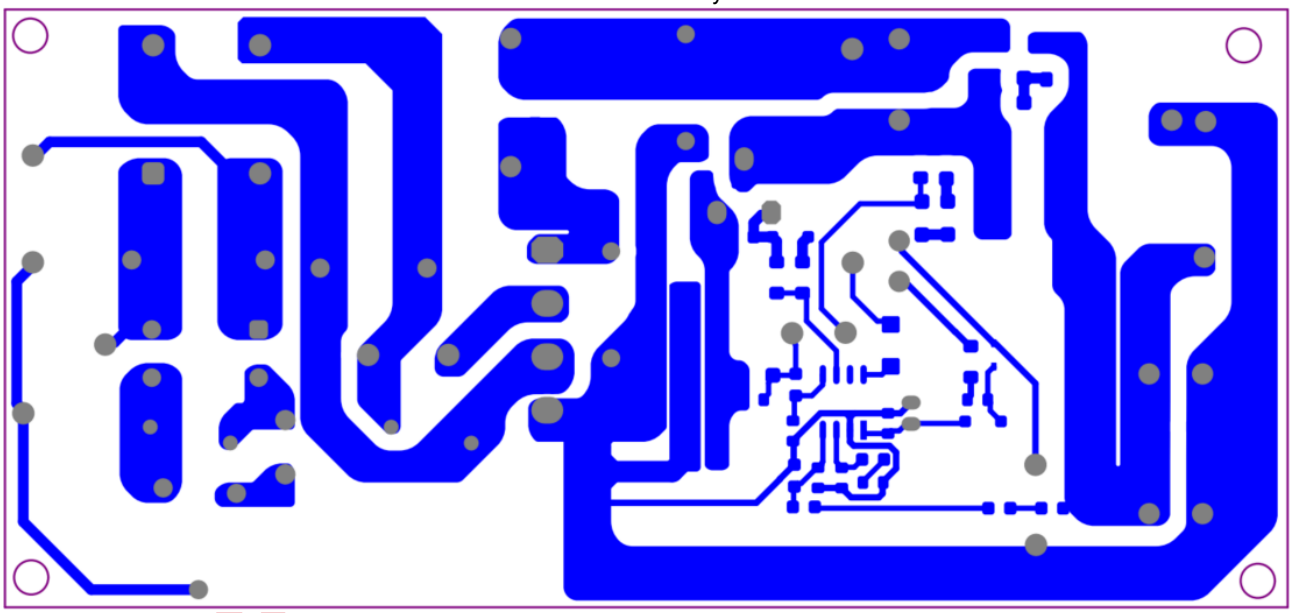


Printed Circuit Board Layout

D01-Top Layer



D01-Bottom Layer



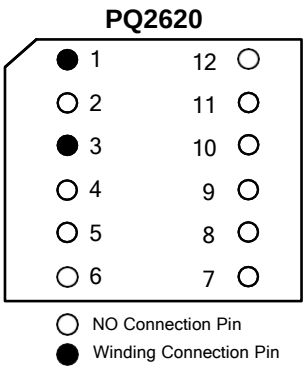
Bill of Material

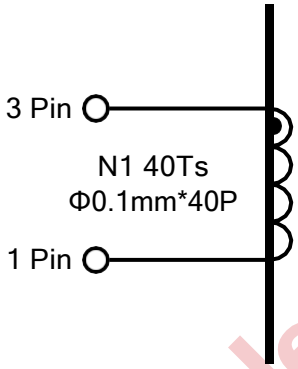
No.	Designator	Value	Description	Package	Manufacturer	Part Number
1	BD1	600V/4A	BRD 4A 600V 1V	GBU	MDD	GBU406
2	C1, Czcd1	10pF/1000V	Ceramic Cap 1000V ±5% NPO	1206	YAGEO	CC1206JKNPOCBN100
3	C2, C3	330nF/400V	CBB 400Vdc 12*7*16 P10	TH	STE	B22G334JN1B0120160070EOZ
4	C4	NC	Ceramic Cap 50V ±10% X7R	0805	WE	885012207094
5	C5, C6	22μF/450V	Electrolytic Cap 450V 12.5*20 P5.0	TH	AISHI	EWH2WM220W20OT
6	C7	2.2nF/1000V	Ceramic Cap 1000V ±10% X7R	1206	WE	885342208019
7	C8	10μF/50V	Electrolytic Cap 50V 5*11 P2.0	TH	AISHI	EWH1HM100D11OT
8	C9	100pF/50V	Ceramic Cap 50V ±5% NPO	0805	WE	885012007057
9	C10	470nF/50V	Ceramic Cap 50V ±10% X7R	0805	WE	885012207102
10	C11	10pF/50V	Ceramic Cap 50V ±5% NPO	0805	WE	885012007051
11	C12	2.2μF/50V	Ceramic Cap 50V ±10% X7R	0805	YAGEO	CC0805KKX7R9BB225
12	C13	1nF/50V	Ceramic Cap 50V ±5% NPO	0805	WE	885012007063
13	Cds1	NC	Ceramic Cap 1000V ±5% NPO	NC	YAGEO	CC1206JKNPOCBN100
14	CX1	220nF/275V	X2 Capacitor 275Vac 13*8*14 P10	TH	WE	890324023028CS
15	CX2	330nF/275V	X2 Capacitor 275Vac 15*8.5*14 P12.5	TH	WE	890324024003CS
16	CY1, CY2	2.2nF/400V	Y1 Capacitor 400Vac ±10% T5 P10	TH	STE	Q09F1D222MN0B0S0N0
17	Cz1	1.5nF/50V	Ceramic Cap 50V ±5% NPO	0805	WE	885012007064
18	D1, D4	1000V/1A	DIO FRD 1A 1000V 1.1V	DO-214AC (SMA)	MDD	M7
19	D2	600V/5A	DIO FRD 5A 600V 35nS 1.68V	NC	MDD	ES5JC
20	D3	600V/5A	DIO FRD 5A 600V 35nS 1.68V	SMC	MDD	ES5JC
21	D5	100V/0.15A	DIO FRD 0.15A 100V 8nS 1.25V	SOD-123	MDD	1N4148W-SOD123
22	D6	NC	DIO FRD 0.15A 100V 8nS 1.25V	SOD-123	MDD	1N4148W-SOD123
23	F1	250V 3.15A	Fuse 250V 3.15A	TH	CONQUER	MST 3.15A 250V
24	L1	380μH	PQ2620/0.1mm*40P*40Ts /0.2mm*2Ts	ANY		
25	L2	0.47mH	Inductor Isat 1.6A Rdc 0.11Ω 14*25	TH	WE	7447071
26	L3	20mH	COMMON INDUCTOR Isat 2A Rdc 220mΩ 27.5*18.5*33	L	WE	744824220
27	L5	1mH	COMMON INDUCTOR Isat 2A Rdc 45mΩ 16*7.5*17.5	XS	WE	744821201
28	Q1	600V/12A	MOSFET 600V 12A 500mΩ	TO-220F	sisemi	SIF12N60F
29	R1, R3	22R	Chip Resistor ±1% 1/4W	1206	FH	RS-06K22R0FT
30	R2	10k	Chip Resistor ±1% 1/4W	1206	FH	RS-06K1002FT
31	R4, R5, R12	1.2M	Chip Resistor ±1% 1/8W	0805	FH	RS-05L1204FT
32	R6, R8	36R	Chip Resistor ±1% 1/4W	1206	FH	RS-06K36R0FT
33	R7	NC	Chip Resistor ±1% 1/4W	1206	FH	RS-06K36R0FT
34	R9	51k	Chip Resistor ±1% 1/8W	0805	FH	RS-05K5102FT

35	R10	8.2k	Chip Resistor ±1% 1/8W	0805	FH	RS-05K8201FT
36	R11	22k	Chip Resistor ±1% 1/8W	0805	FH	RS-05K2202FT
37	RS1, RS2, RS3, RS4, RS5, RS6, RS7, RS8	1R	Chip Resistor ±1% 1/4W	1206	FH	RS-06L1R00FT
38	RT1	5Ω 6A	RES NTC 5ohm 6A	TH	HEL	HEL5D-15
39	RV1, RV2	10D471	VARISTOR 300VAC 70J 2500A	TH	WE	820513011
40	Rz1, Rz2, Rz3	1M	Chip Resistor ±1% 1/4W	1206	FH	RS-06K1004FT
41	Rz4	20k	Chip Resistor ±1% 1/4W	1206	FH	RS-06K2002FT
42	Rz5	3k	Chip Resistor ±1% 1/8W	0805	FH	RS-05K3001FT
43	ZD1	NC	Diode Zener 20V 2% 200mW	SOD-323	PANJIT	BZT52-B20S

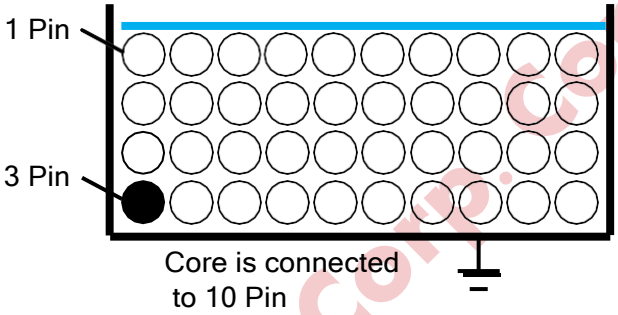
Inductor Manufacture Guide---L1

1. Electrical Diagram





2. Winding Diagram



3. Winding Order

Number	Winding	Layer	Start	End	Wire Size	Turns	Note
1	N1	Primary	3	1	0.1mm*40P	40Ts	

4. Electrical Specification

Items	Test Condition	Test Pin	Specification
Primary Inductance	Measured at 40kHz, 1.0 VRMS	Pins 1 - 3, all other windings open	0.38mH±5%
DC Resistance	Measured at 40kHz, 1.0 VRMS	Pins 1 – 3	0.1Ω Max

5. Inductor BOM

Items	Description
1	**Core:** PQ2620, PC44 or equivalent, AE=119mm^2
2	**Bobbin:** PQ2620, 6+6 Pin
3	**Wire:** Φ0.1mm*40P*40Ts, 2UEW, Class B
4	**Tape:** 10mm(W)×0.06mm (TH)

Test Result

1. Steady State Characteristics

1.1 Efficiency, PF and THD

Test Conditions: Input: 90/110/230/264; Output: 10%-100% load.

Standard: Eff>95%, PF>0.95, THD<10% @230Vac full load.

Result: Pass

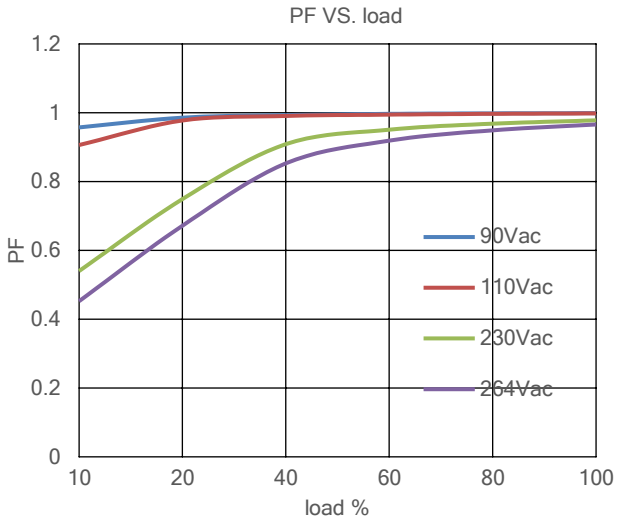
Vac	Load	F(Hz)	PF	THD	Pin(W)	Vo(V)	Io(A)	Eff
90	10%	60	0.9575	7.806%	10.555	412.23	0.025	97.64%
	20%	60	0.9858	8.506%	21.657	412.62	0.05	95.26%
	40%	60	0.9932	9.050%	43.25	412.82	0.1	95.45%
	60%	60	0.9968	5.963%	65.23	412.73	0.15	94.91%
	80%	60	0.9982	4.453%	87.93	412.55	0.2	93.84%
	100%	60	0.9988	3.752%	112.41	412.45	0.25	91.73%
110	10%	60	0.9061	9.942%	10.348	412.45	0.025	97.65%
	20%	60	0.9775	5.274%	21.301	412.55	0.05	96.84%
	40%	60	0.9907	7.802%	43.014	412.76	0.1	95.96%
	60%	60	0.9945	6.984%	64.53	412.88	0.15	95.95%
	80%	60	0.9969	5.074%	86.63	412.78	0.2	95.27%
	100%	60	0.998	4.023%	109.79	412.67	0.25	93.97%
230	10%	50	0.5401	27.571%	10.458	412.21	0.025	98.54%
	20%	50	0.7492	17.204%	20.895	412.42	0.05	98.69%
	40%	50	0.9088	10.961%	42.26	412.68	0.1	97.65%
	60%	50	0.9507	10.528%	63.18	412.88	0.15	98.02%
	80%	50	0.9682	10.147%	84.37	412.75	0.2	97.84%
	100%	50	0.9779	8.573%	105.52	412.64	0.25	97.76%
264	10%	50	0.4524	38.931%	10.439	412.41	0.025	98.77%
	20%	50	0.6718	22.524%	20.896	412.45	0.05	98.69%
	40%	50	0.853	14.203%	41.99	412.42	0.1	98.22%
	60%	50	0.9189	12.844%	63.01	412.61	0.15	98.22%
	80%	50	0.949	11.009%	84.15	412.61	0.2	98.07%
	100%	50	0.9658	8.755%	105.18	412.58	0.25	98.07%

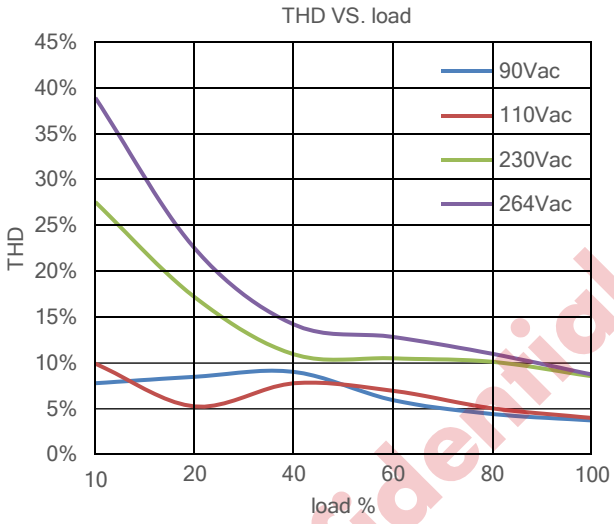
1.2 PF, THD VS. Vout

Test Conditions: Input: 90/110/230/264Vac; Output: 10%-100% load.

Standard: PF>0.95、THD<10% @ 230Vac full load.

Result: Pass





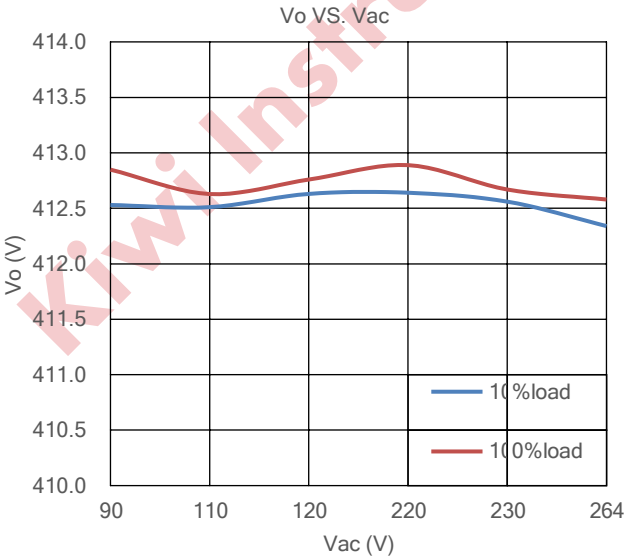
1.3 Output Load Regulation

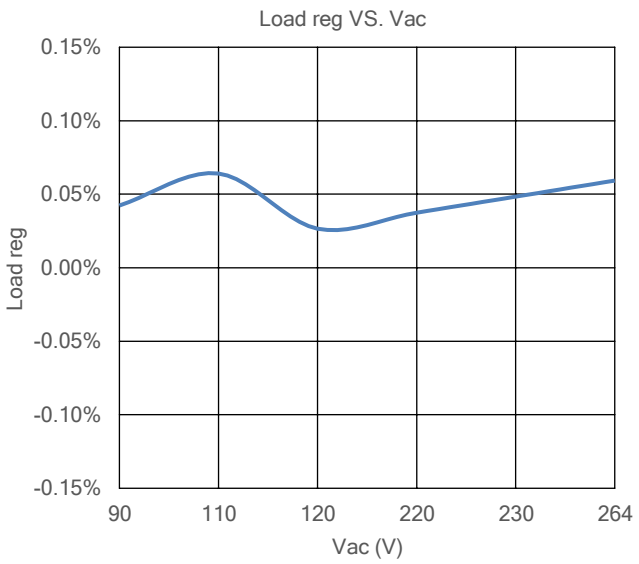
Test Conditions: Input: 90-264Vac: Output: 10%-100% of load.

Standard: Load Regulation < 1%

Result: Pass

Vin(V)	Vo(V)									Load Reg
	Io= 0.025A	Io= 0.05A	Io= 0.1A	Io= 0.15A	Io= 0.20A	Io= 0.25A	Max	Ave	Min	
90	412.53	412.67	412.85	412.88	412.83	412.85	412.88	412.768	412.53	0.04%
110	412.51	412.64	412.71	413.04	412.88	412.63	413.04	412.735	412.51	0.06%
120	412.63	412.78	412.67	412.75	412.85	412.76	412.85	412.74	412.63	0.03%
220	412.64	412.63	412.58	412.68	412.84	412.89	412.89	412.71	412.58	0.04%
230	412.56	412.53	412.63	412.93	412.92	412.67	412.93	412.707	412.53	0.05%
264	412.34	412.43	412.67	412.78	412.83	412.58	412.83	412.605	412.34	0.06%





1.4 Harmonic Current

Test Conditions: Input: 230Vac; Output: 10%/100% load & 25W load.

Standard: IEC61000-3-2 Class C

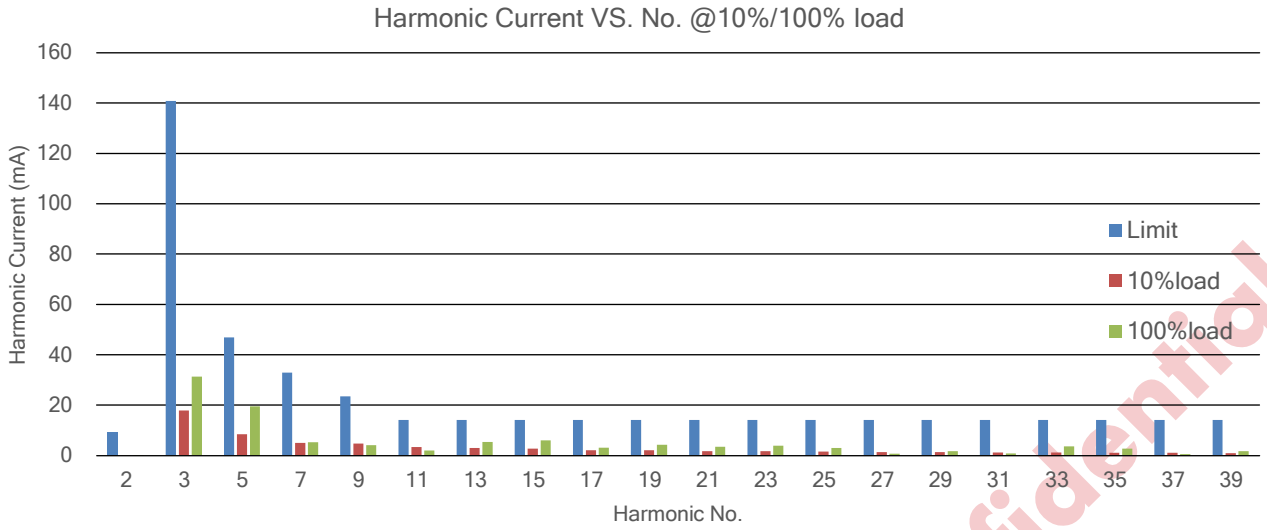
Result: Pass

Harmonic Current Limit Value and Actual Value @10% load

Harmonic NO.	Limit (mA)	Actual Value(mA)	Pass Fail	Harmonic NO.	Limit (mA)	Actual Value(mA)	Pass Fail
2	9.39	0.15	Pass	3	140.78	17.84	Pass
5	46.93	8.50	Pass	7	32.85	5.08	Pass
9	23.46	4.79	Pass	11	14.08	3.38	Pass
13	14.08	2.97	Pass	15	14.08	2.72	Pass
17	14.08	2.14	Pass	19	14.08	2.17	Pass
21	14.08	1.81	Pass	23	14.08	1.70	Pass
25	14.08	1.60	Pass	27	14.08	1.43	Pass
29	14.08	1.37	Pass	31	14.08	1.30	Pass
33	14.08	1.22	Pass	35	14.08	1.12	Pass
37	14.08	1.09	Pass	39	14.08	0.99	Pass

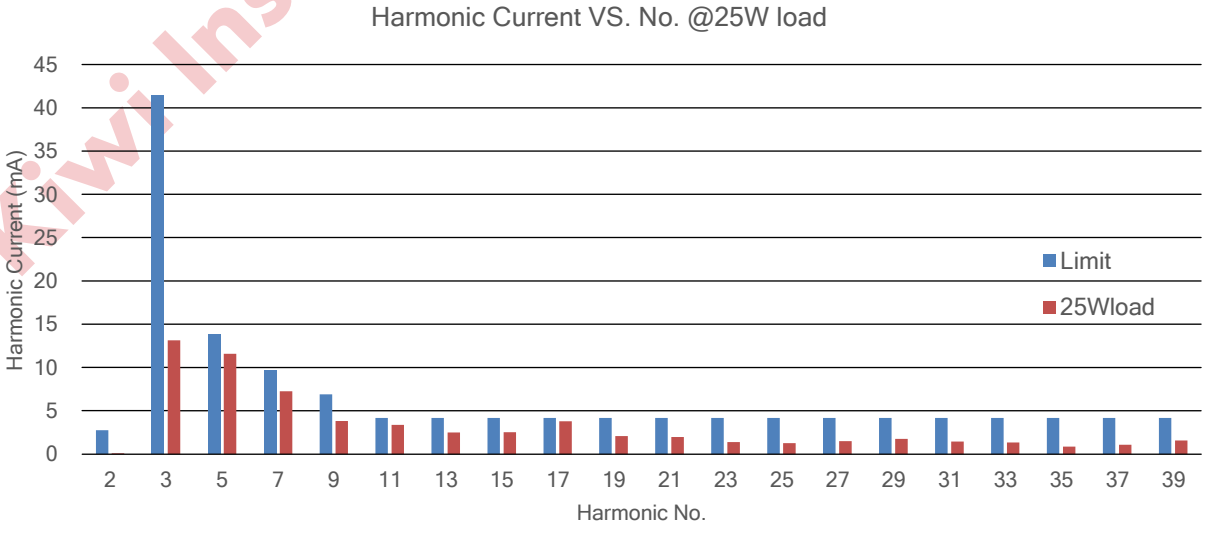
Harmonic Current Limit Value and Actual Value @100% load

Harmonic NO.	Limit (mA)	Actual Value(mA)	Pass Fail	Harmonic NO.	Limit (mA)	Actual Value(mA)	Pass Fail
2	9.39	0.20	Pass	3	140.78	31.39	Pass
5	46.93	19.53	Pass	7	32.85	5.35	Pass
9	23.46	4.17	Pass	11	14.08	2.05	Pass
13	14.08	5.49	Pass	15	14.08	6.03	Pass
17	14.08	3.17	Pass	19	14.08	4.35	Pass
21	14.08	3.52	Pass	23	14.08	3.94	Pass
25	14.08	3.08	Pass	27	14.08	0.73	Pass
29	14.08	1.75	Pass	31	14.08	0.82	Pass
33	14.08	3.69	Pass	35	14.08	2.76	Pass
37	14.08	0.65	Pass	39	14.08	1.70	Pass



Harmonic Current Limit Value and Actual Value @25W load

Harmonic NO.	Limit (mA)	Actual Value(mA)	Pass Fail	Harmonic NO.	Limit (mA)	Actual Value(mA)	Pass Fail
2	2.76	0.10	Pass	3	41.45	13.15	Pass
5	13.82	11.58	Pass	7	9.67	7.25	Pass
9	6.91	3.82	Pass	11	4.14	3.39	Pass
13	4.14	2.48	Pass	15	4.14	2.53	Pass
17	4.14	3.78	Pass	19	4.14	2.09	Pass
21	4.14	1.96	Pass	23	4.14	1.40	Pass
25	4.14	1.28	Pass	27	4.14	1.50	Pass
29	4.14	1.76	Pass	31	4.14	1.46	Pass
33	4.14	1.36	Pass	35	4.14	0.87	Pass
37	4.14	1.09	Pass	39	4.14	1.56	Pass

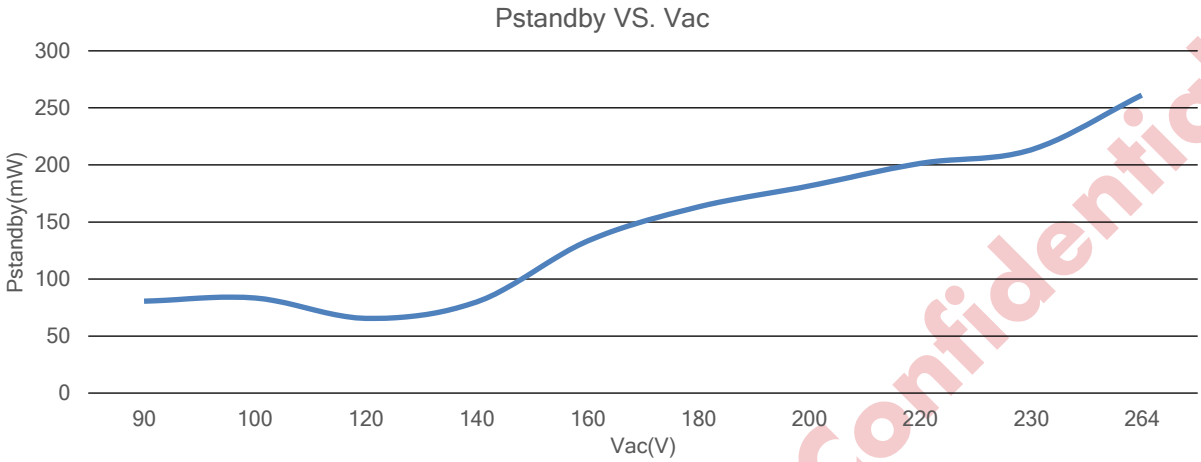


1.5 Standby Power

Test Conditions: Input: 90-264Vac; Output: No load.

Standard: $P_{Standby}$ < 0.5W

Result: Pass



2 Dynamic Characteristics

2.1 Brown-Out Protection

Load	Start-up Vac	Brown-out Vac
10%	76Vac	66Vac
100%	77Vac	68Vac

2.2 Start-up Characteristics

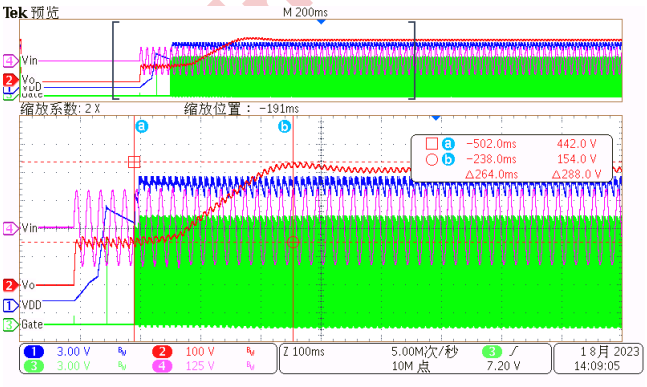
Test Conditions: Input: 110/230Vac; Output: full load.

Standard: Start up time <0.5s, and overshoot Voltage not exceed 10% of Vout typical value

Result: Pass

Waveforms:

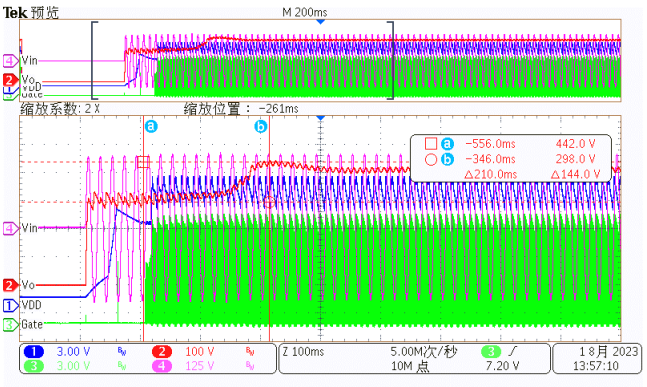
Test Condition: 110Vac/60Hz Input, 100W Output



(CH1: VDD; CH2: Vo; CH3: Gate; CH4: Vin)

Comments: Voltage rise time 264ms, overshoot voltage not exceed 10% of Vout typical value

Test Condition: 230Vac/50Hz Input, 100W Output



(CH1: VDD; CH2: Vo; CH3: Gate; CH4: Vin)

Comments: Voltage rise time 210ms, overshoot voltage not exceed 10% of Vout typical value

2.3 Power off Characteristics

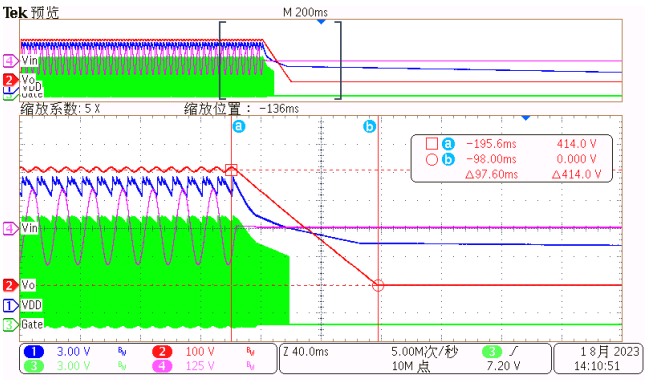
Test Conditions: Input: 110/230Vac; Output: full load.

Standard: No overshoot

Result: Pass

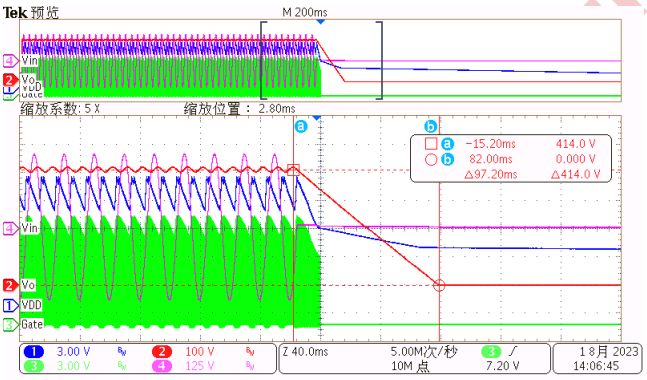
Waveforms:

Test Condition: 110Vac/60Hz Input, 100W Output



(CH1: VDD; CH2: Vo; CH3: Gate; CH4: Vin)
Comments: OK, no overshoot

Test Condition: 230Vac/50Hz Input, 100W Output



(CH1: VDD; CH2: Vo; CH3: Gate; CH4: Vin)
Comments: OK, no overshoot

3 Reliability Testing

3.1 Maximum Stress of Boost MOSFET

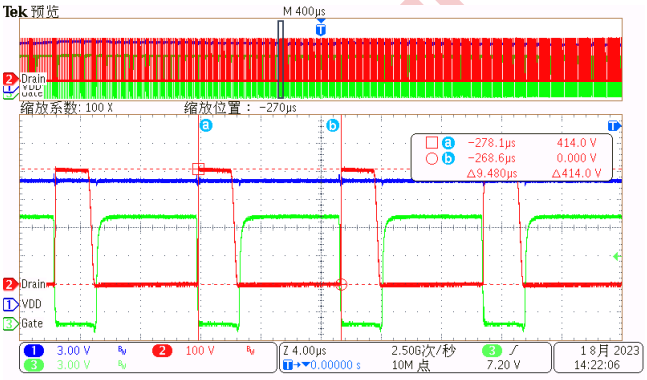
Test Conditions: Input: 110/230Vac; Output: full load.

Standard: VDS_peak < 90% *Vdsmax

Result: Pass

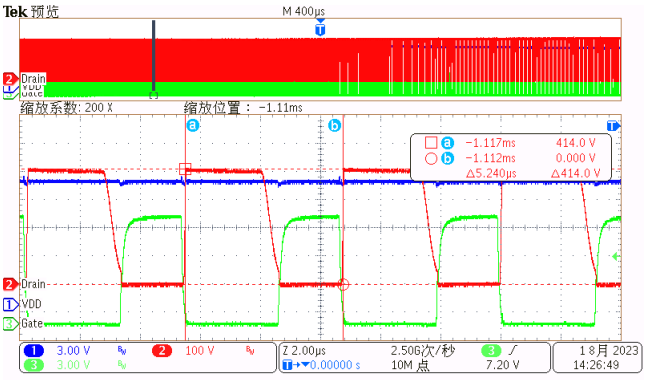
Waveforms:

Test Condition: 110Vac/60Hz Input, 100W Output



(CH1: VDD; CH2: VDS; CH3: Gate; CH4: VD)
Comments: OK, VDS_peak=414V

Test Condition: 230Vac/50Hz Input, 100W Output



(CH1: VDD; CH2: VDS; CH3: Gate; CH4: VD)
Comments: OK, VDS_peak=414V

3.2 Maximum Stress of Boost Output Diode

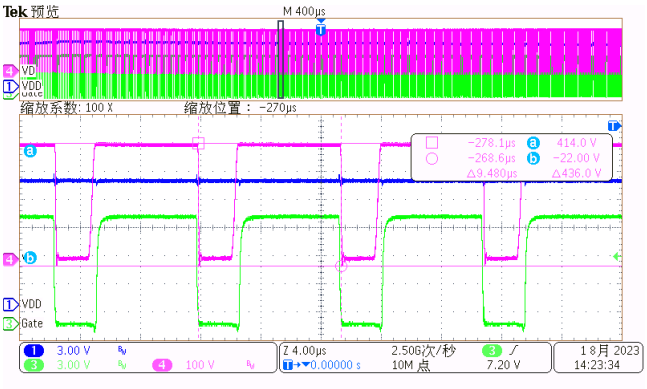
Test Conditions: Input: 110/230Vac; Output: full load.

Standard: VD_peak < 90% *VDmax

Result: Pass

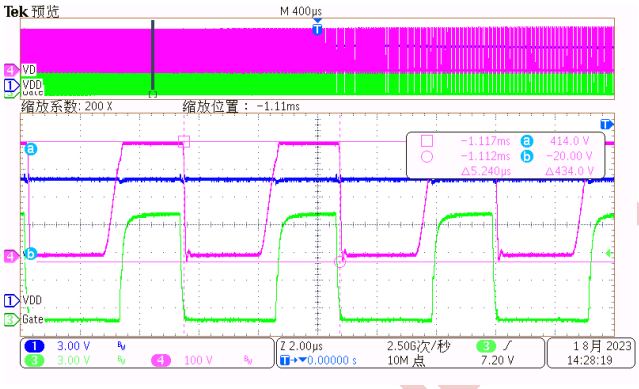
Waveforms:

Test Condition: 110Vac/60Hz Input, 100W Output



(CH1: VDD; CH2: VDS; CH3: Gate; CH4: VD)
Comments: OK, VD_peak=414V

Test Condition: 230Vac/50Hz Input, 100W Output



(CH1: VDD; CH2: VDS; CH3: Gate; CH4: VD)
Comments: OK, VD_peak=414V

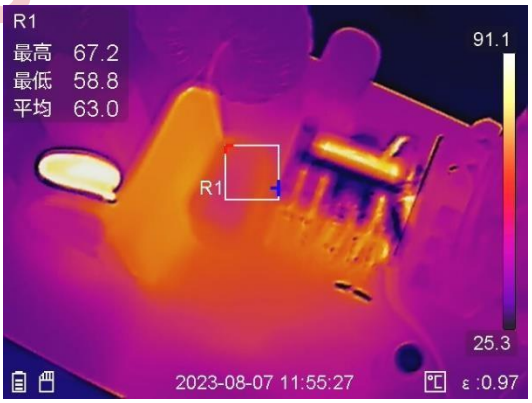
3.3 Thermal Test

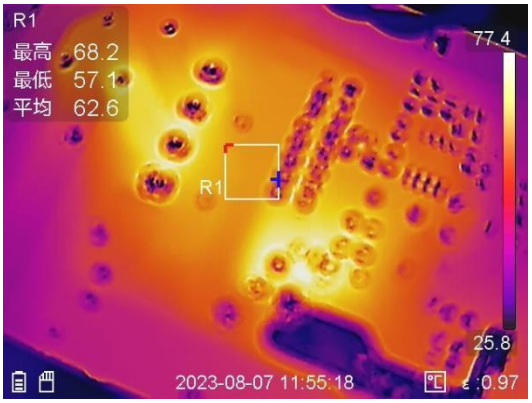
Test Conditions: Input: 110/230Vac; Output: full load. Burn-in 0.5Hour @ confined container and steady environment with no airflow, Ta is the temperature inside the cardboard box.

Standard: Final product will be cased and potted, the open frame thermal test data is only for reference.

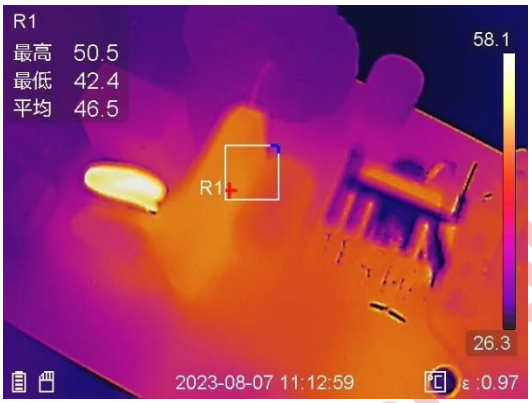
Result: Pass

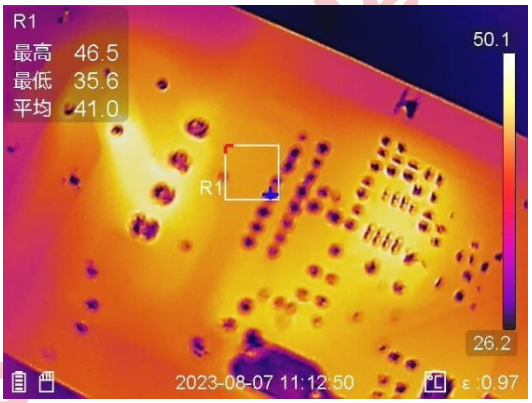
110Vac/50Hz, Ta=25.6℃





230Vac/50Hz, Ta=24.8℃





3.4 EMC Test

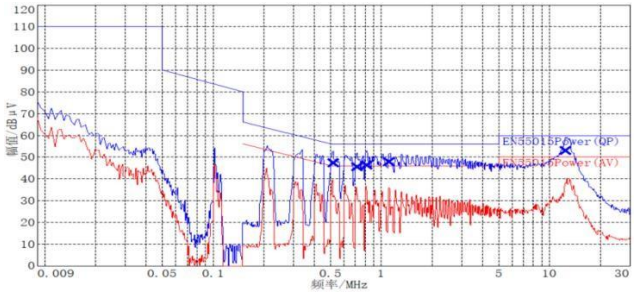
Test Conditions: Input: 110/220Vac; Output: full load.

Standard:

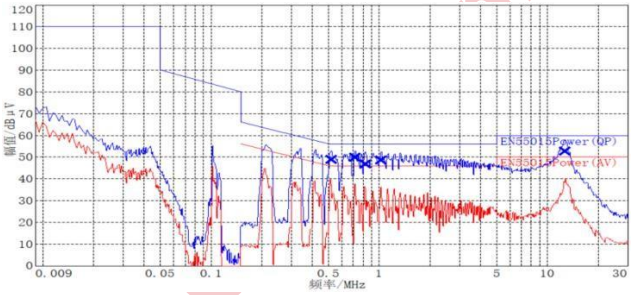
Standard	EN55015
Content	CE/CDN
Requirement	>6dB Margin

Result: CE test Pass; CDN test no Pass

Test Condition: Vin=110Vac/60Hz, CE

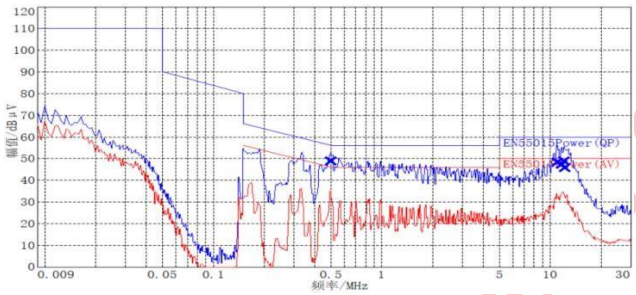


CE EMI---LINE

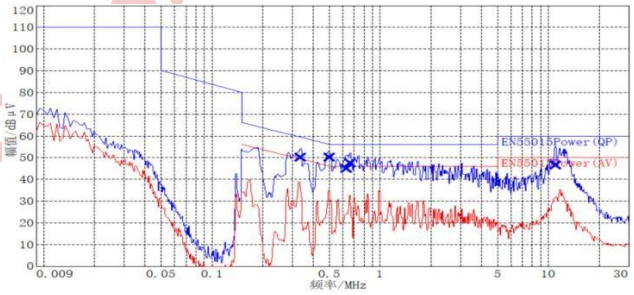


CE EMI---NEUTRAL

Test Condition: Vin=220Vac/50Hz, CE

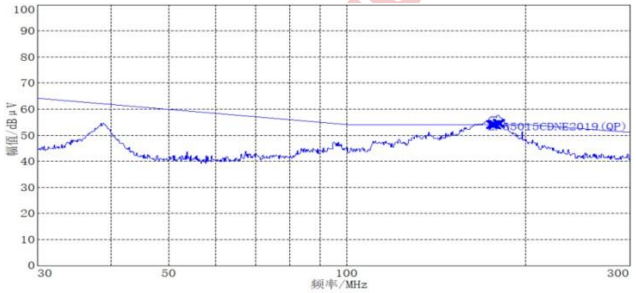


CE EMI---LINE

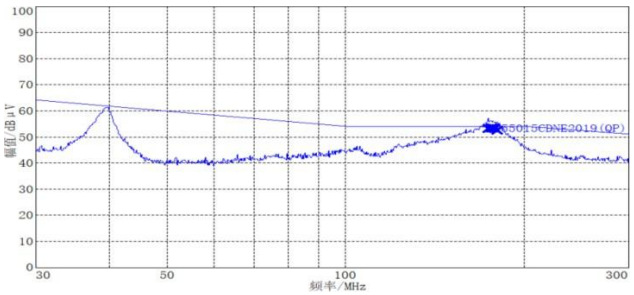


CE EMI---NEUTRAL

Test Condition: CDN



Conduction CDN---110Vac/60Hz



Conduction CDN---220Vac/50Hz

3.5 Surge Test

Test Conditions: Input: 230Vac; Output: full load.

Standard: >4000V

Result: Pass

Input Voltage (Vac)	Surge Level (V)	Injection Location	Injection Phase (°)	Test Result (Pass/Fail)
230Vac/50Hz	+4000	L to N	0	Pass
	+4000	L to N	90	Pass
	+4000	L to N	180	Pass
	+4000	L to N	270	Pass
	-4000	L to N	0	Pass
	-4000	L to N	90	Pass
	-4000	L to N	180	Pass
	-4000	L to N	270	Pass
230Vac/50Hz	+4000	L to PE	0	Pass
	+4000	L to PE	90	Pass
	+4000	L to PE	180	Pass
	+4000	L to PE	270	Pass
	+4000	N to PE	0	Pass
	+4000	N to PE	90	Pass
	+4000	N to PE	180	Pass
	+4000	N to PE	270	Pass

A: Normal performance within limits specified by the manufacturer, requestor or purchaser;

B: Temporary loss of function or degradation of performance, which ceases after the disturbance ceases, and from which the equipment under test recovers its normal performance, without operation intervention;

C: Temporary loss of function or degradation of performance, the correction of which requires operator intervention;

D: Loss of function or degradation of performance which is not recoverable, owing to damage to hardware or software, or loss of data.

Test Result: A (A/B/C/D)

Test Setup Guide

1. Connect the “V+” and “V-” terminal to the positive and negative end of the load.
2. Set the AC Power Source between 90Vac and 264Vac.
3. Connect the AC Power Source terminal to the “L” and “N” terminals on the Demo Board.

Turn on the AC Power Source to make system startup; and Turn off the AC Power Source to make system shutdown.

Revision History

DATE	REV	DESCRIPTION
2023/08/07	1.0	First Release

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