600W Interleaved Boost PFC with KP2822+KP3114H

FEATURES

- Universal Input Voltage Range From 108~295Vac
- Efficiency >96.5% @230Vac Full Load
- High PF >0.99 & Low THD <8% @230Vac Full Load
- Harmonics Meets IEC61000-3-2 Class C
- Excellent Load Regulation
- Low Standby Power <0.5W

APPLICATIONS

- Interleaved Boost PFC of LED Driver

INTRODUCTION

The DEMO board is a high performance non-isolated single stage with High PF @ Low THD with interleaved Boost PFC controller KP2822, and the auxiliary power is provided with a high-performance PWM controller KP3114H.

This DEMO board is designed for the forward stage PFC of LED Driver which maximum output power reach to 600W, maximum current reach to 1.4A.

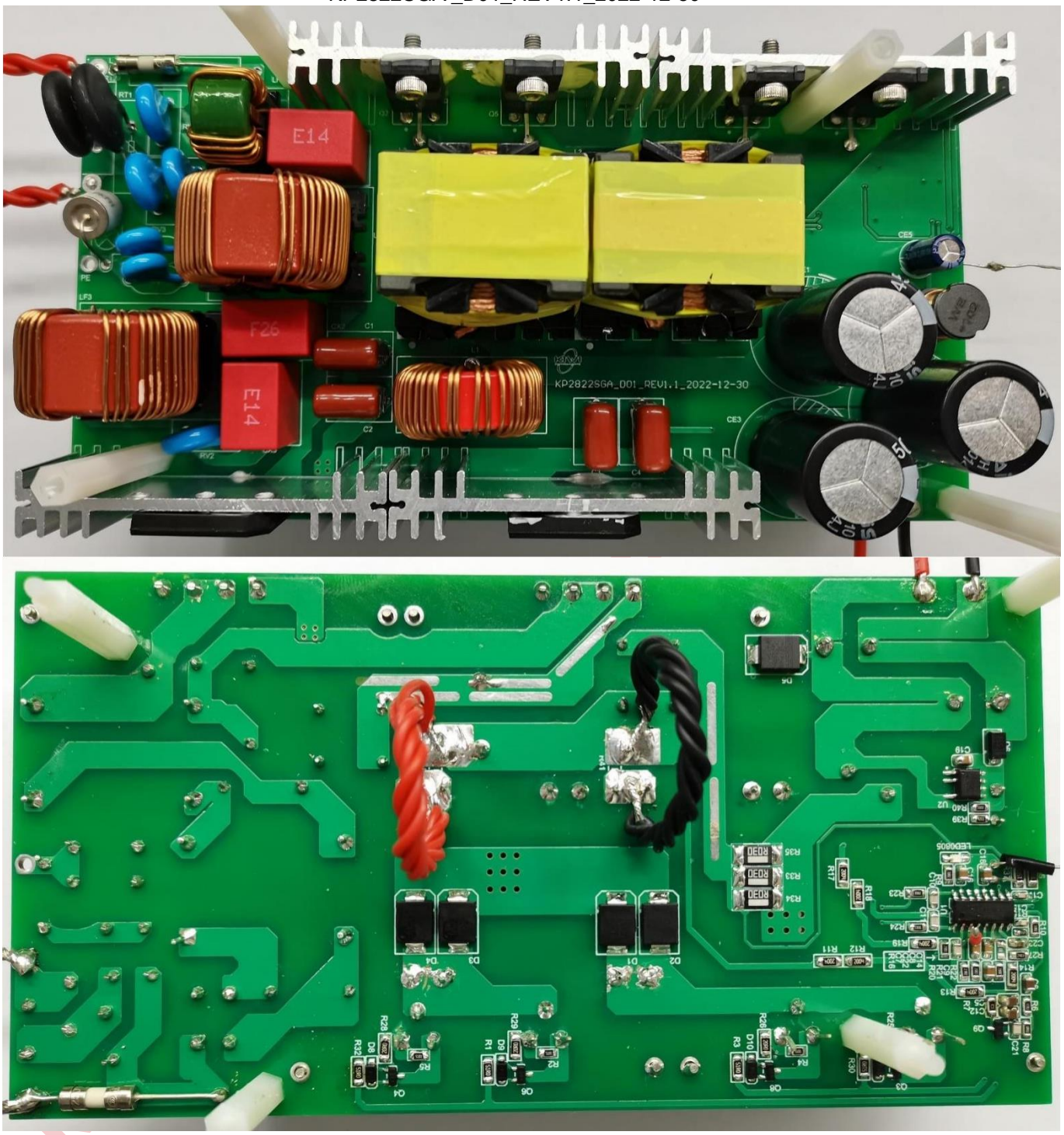
DEMO BOARD SEPCIFICATION

Description	Symbol	Min.	Typ.	Max.	Unit	Note
Input Voltage	Vin	108	120-277	295	Vac	50/60Hz
Output Voltage	Vout		430		Vdc	
Output Current	Iout			1.4	A	
Total Output Power	Pout		600		W	
Power Factor	PF	>0.95				230Vac@600W
Total Harmonic Distortion	THD	<10			%	230Vac@600W
System Average Efficiency	η	>95			%	230Vac@600W
Standby Power	Pstandby			0.5	W	108Vac-295Vac@No load
Startup Time	Tst			0.3	s	Tested at 230/277Vac
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.

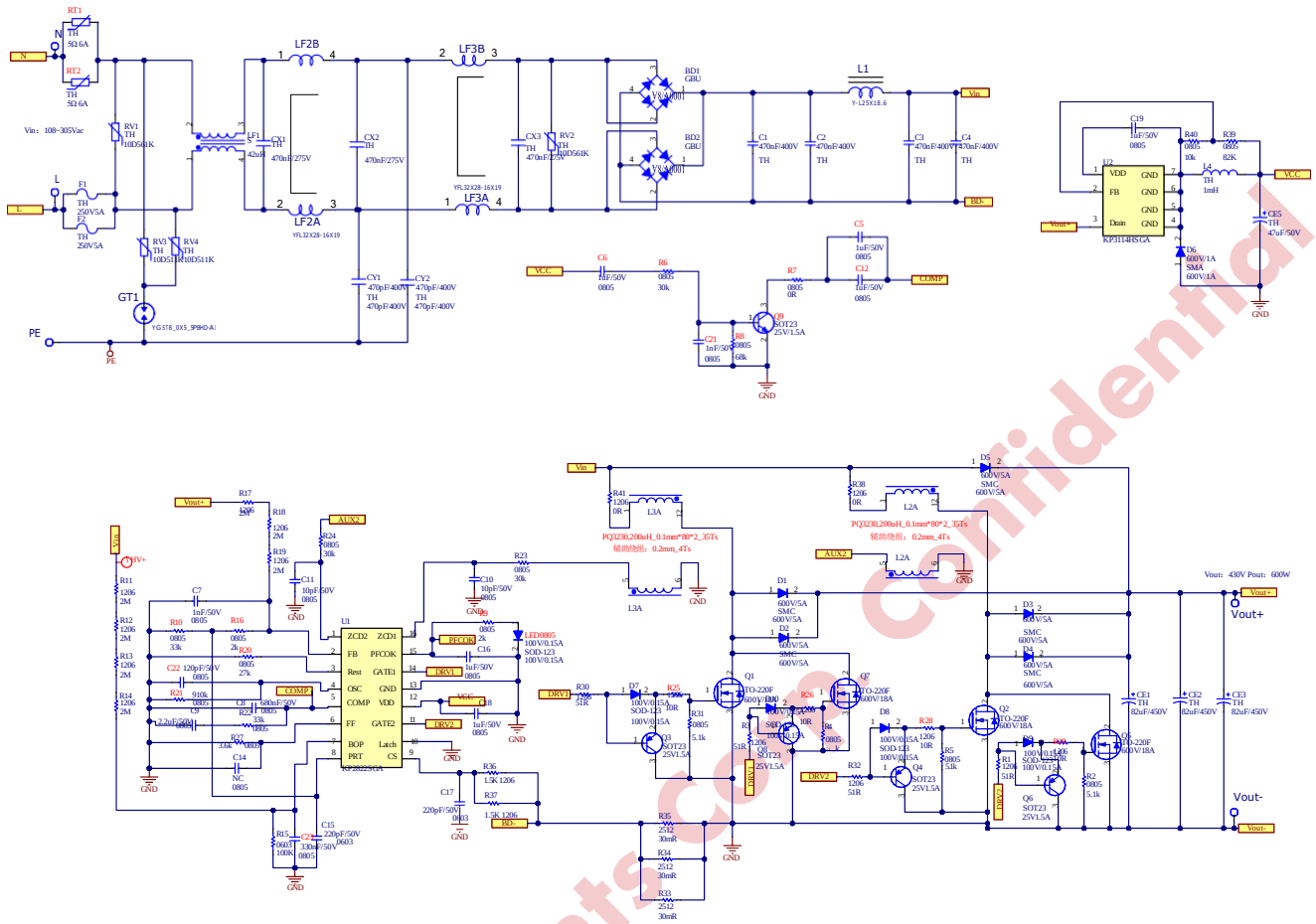
Demoboard

KP2822SGA _D01_REV1.1_2022-12-30



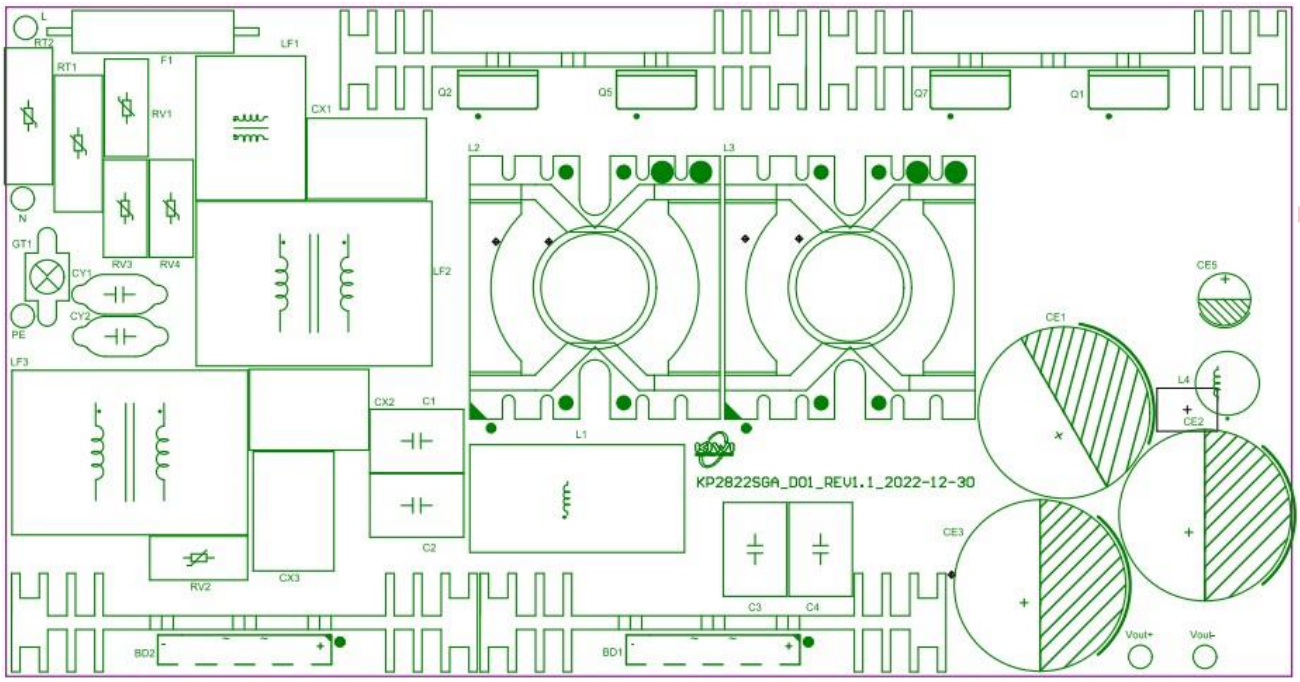
Size (mm)：142*110mm

Schematic

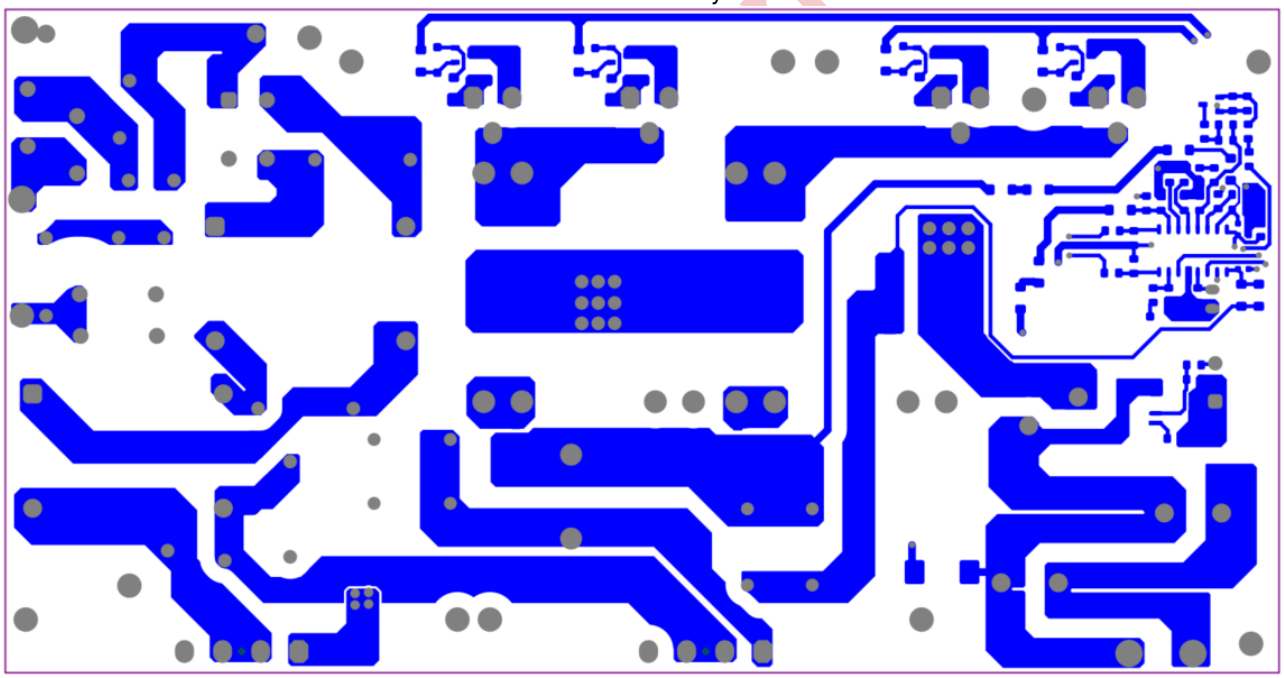


Printed Circuit Board Layout

D01-Top Layer



D01-Bottom Layer



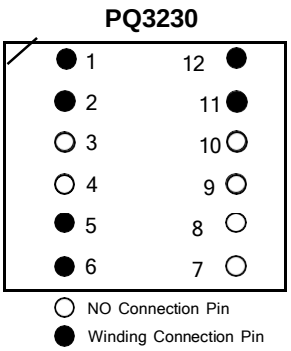
Bill of Material

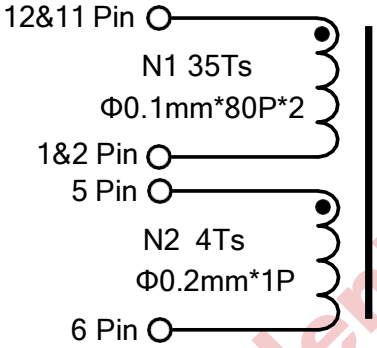
No.	Designator	Value	Description	Package	Manufacturer	Part Number
1	BD1, BD2	1000V/8A	BRD 8A 1000V 1.1V	GBU	World	GBU810
2	C1, C2, C3, C4	470nF/400 V	CBB 400Vdc 12*8*15 P10	TH	STE	B22G474JN1B0 120150080EOZ
3	C5, C6, C12, C16, C18, C19	1μF/50V	Ceramic Cap 50V ±10% X7R	0805	WE	885012207103
4	C7, C21	1nF/50V	Ceramic Cap 50V ±5% NPO	0805	WE	885012007063
5	C8	680nF/50V	Ceramic Cap 50V ±10% X7R	0805	YAGEO	CC0805KKX7R 9BB684
6	C9	2.2μF/50V	Ceramic Cap 50V ±10% X7R	0805	YAGEO	CC0805KKX7R 9BB225
7	C10, C11	10pF/50V	Ceramic Cap 50V ±5% NPO	0805	WE	885012007051
8	C14	NC	Ceramic Cap 50V ±5% NPO	0805	WE	885012007059
9	C15, C17	220pF/50V	Ceramic Cap 50V ±5% NPO	0603	WE	885012006059
10	C22	120pF/50V	Ceramic Cap 50V ±5% NPO	0805	WE	885012007059
11	C23	330nF/50V	Ceramic Cap 50V ±10% X7R	0805	WE	885012207101
12	CE1	82μF/450V	Electrolytic Cap 450V 22*46 P10	TH	AISHI	ERH2WM221O4 6OT
13	CE2, CE3	82μF/450V	Electrolytic Cap 450V 22*46 P10	TH	AISHI	ERH2WM221O4 6OT
14	CE5	47μF/50V	Electrolytic Cap 50V 6.3*11 P2.5	TH	AISHI	ERS1HM470E1 1OT
15	CX1, CX2, CX3	470nF/275 V	X2 Capacitor 275Vac 15*10*16 P12.5	TH	WE	890324024005C S
16	CY1, CY2	470pF/400 V	Y1 Capacitor 400Vac ±10% T5 P10	TH	STE	Q09B1D471KN0 B0S0N0
17	D1, D2, D3, D4, D5	600V/5A	DIO FRD 5A 600V 35nS 1.68V	SMC	MDD	ES5JC
18	D6	600V/1A	DIO FRD 1A 600V 35nS 1.7V	SMA	MDD	ES1J
19	D7, D8, D9, D10, LED0805	100V/0.15 A	DIO FRD 0.15A 100V 1.25V	SOD-123	World	1N4148W-SOD123
20	F1, F2	250V 5A	Fuse 250V 5A	TH	CONQUER	PTU 5A 250V
21	GT1	2000V	GDT 2RL2000L-8	TH	Brightking	C522321
22	L1	150μH	Inductor Isat 6.1A Rdc 0.045Ω 14*28	TH	WE	7447076
23	L2, L3	0.2mH	PQ3230, Φ0.1mm*80P*2*35Ts	ANY		
24	L4	1mH	Inductor Isat 0.51A Rdc 2.15Ω 8*9.5	TH	WE	7447720102
25	LF1	42μH	COMMON INDUCTOR Isat 6.5A Rdc 8.1mΩ 18.5*14.5*22	S	WE	744842742
26	LF2, LF3	5mH	COMMON INDUCTOR Isat 6A Rdc 45mΩ 30*15*35	XL	WE	744825605
27	Q1, Q2, Q5, Q7	600V/20A	MOSFET 600V 20A 180mohm	TO-220MF	LONTEN	LSD60R180HT
28	Q3, Q4, Q6, Q8	25V1.5A	TRansistor -25V -1.5A PNP	SOT23	LGE	SS8550
29	Q9	25V/1.5A	TRansistor 25V 1.5A NPN	SOT23	LGE	SS8050
30	R1, R3, R30, R32	51R	Chip Resistor ±1% 1/4W	1206	FH	RS-06K51R0FT
31	R2, R4, R5, R31	5.1k	Chip Resistor ±1% 1/8W	0805	FH	RS-05K5101FT

32	R6, R23, R24	30k	Chip Resistor ±1% 1/8W	0805	FH	RS-05K3002FT
33	R7	0R	Chip Resistor ±1% 1/8W	0805	FH	RS-05000FT
34	R8	68k	Chip Resistor ±1% 1/8W	0805	FH	RS-05K6802FT
35	R9, R16	2k	Chip Resistor ±1% 1/8W	0805	FH	RS-05K2001FT
36	R10, R22	33k	Chip Resistor ±1% 1/8W	0805	FH	RS-05K3302FT
37	R11, R12, R13, R14, R17, R18, R19	2M	Chip Resistor ±1% 1/4W	1206	FH	RS-06L2004FT
38	R15	100k	Chip Resistor ±1% 1/10W	0603	FH	RS-03K1003FT
39	R20	27k	Chip Resistor ±1% 1/8W	0805	FH	RS-05K2702FT
40	R21	240k	Chip Resistor ±1% 1/8W	0805	FH	RS-05K2403FT
41	R25, R26, R28, R29	10R	Chip Resistor ±1% 1/4W	1206	FH	RS-06K10R0FT
42	R27	3.6k	Chip Resistor ±1% 1/8W	0805	FH	RS-05K3601FT
43	R33, R34, R35	30mR	Chip Resistor ±1% 1/4W	2512	FH	RBF-06RR100FT
44	R36, R37	1.5k	Chip Resistor ±1% 1/4W	1206	FH	RS-06K1001FT
45	R38, R41	0R	Chip Resistor ±1% 1/4W	1206	FH	RS-06000FT
46	R39	82k	Chip Resistor ±1% 1/8W	0805	FH	RS-05K8202FT
47	R40	10k	Chip Resistor ±1% 1/8W	0805	FH	RS-05K1002FT
48	RT1, RT2	5Ω 6A	RES NTC 5ohm 6A	TH	HEL	HEL5D-15
49	RV1, RV2	10D561K	VARISTOR 350VAC 70J 1250A	TH	STE	STE10D561K1EQ0FST0R0
50	RV3, RV4	10D511K	VARISTOR 320VAC 69J 1250A	TH	STE	STE10D511K1EQ0FST0R0
51	U1		2-Phase Interleaved，Critical Conduction Mode Boost Power Factor Controller	SOP-16	KIWI	KP2822SGA
52	U2		High Performance Low Cost Off-line PWM Power Switch	SOP-8	KIWI	KP3114HSGA

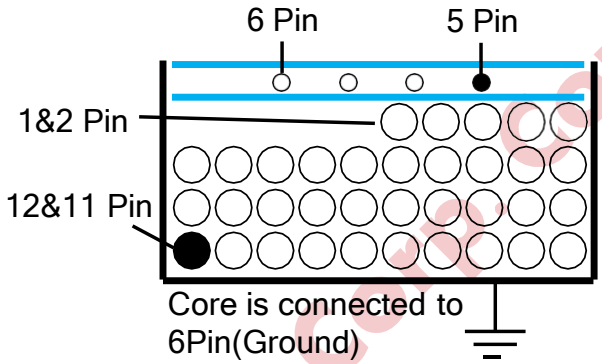
Inductor Manufacture Guide---L2/L3

1. Electrical Diagram





2. Winding Diagram



3. Winding Order

Number	Winding	Layer	Start	End	Wire Size	Turns	Note
1	N1	Primary	12&11	1&2	0.1mm*80P*2	35T	
2	N2	Aux	5	6	0.2mm*1P	4T	

4. Electrical Specification

Items	Test Condition	Test Pin	Specification
Primary Inductance	Measured at 40kHz, 1.0 VRMS	Pins 12&11 - 1&2, all other windings open	0.2mH±5%
DC Resistance	Measured at 40kHz, 1.0 VRMS	Pins 12&11 - 1&2	0.05Ω Max

5. Inductor BOM

Items	Description
1	**Core:** PQ3230, PC44 or equivalent, AE=153mm^2
2	**Bobbin:** PQ3230, 6+6 Pin
3	**Wire:** Φ0.1mm*80P*2, 2UEW, Class B
4	**Tape:** 15mm(W)×0.06mm (TH)

Test Result

1. Steady State Characteristics

1.1 Efficiency, PF and THD

Test Conditions: Input: 108/120/230/277/295Vac; Output: 10%-100% load.

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

Result: Pass

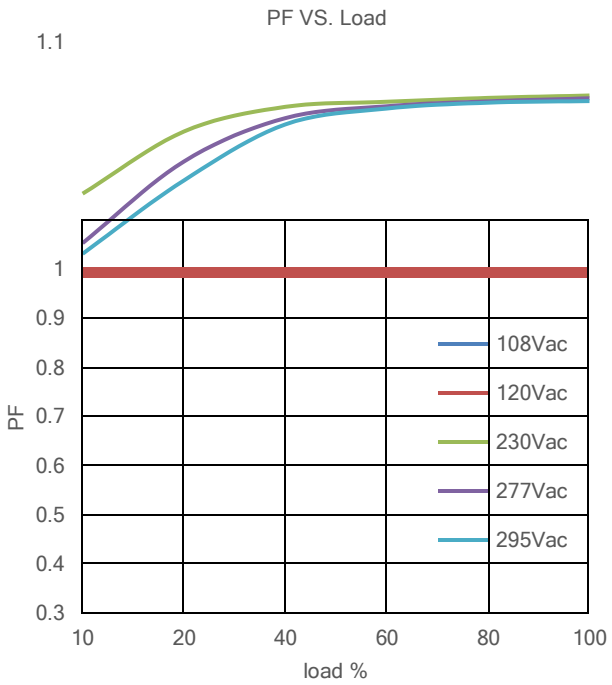
Vac	Load	F(Hz)	PF	THD	Pin(W)	Vo(V)	Io(A)	Eff
108	10%	60	0.9643	13.317%	64.13	433.58	0.14	94.66%
	20%	60	0.9824	12.563%	128.43	433.56	0.28	94.52%
	40%	60	0.9913	9.326%	256.96	433.48	0.56	94.47%
	60%	60	0.9943	8.927%	385.84	433.46	0.84	94.37%
	80%	60	0.9962	7.230%	515.14	433.51	1.12	94.25%
	100%	60	0.9963	7.347%	645.27	433.56	1.40	94.07%
120	10%	60	0.9641	13.413%	63.62	433.61	0.14	95.42%
	20%	60	0.9819	12.675%	127.53	433.56	0.28	95.19%
	40%	60	0.9907	9.459%	255.14	433.43	0.56	95.13%
	60%	60	0.9933	9.520%	383.25	433.46	0.84	95.00%
	80%	60	0.9957	7.340%	512.63	433.53	1.12	94.72%
	100%	60	0.9957	7.625%	643.19	433.57	1.40	94.37%
230	10%	50	0.7907	19.543%	63.02	433.65	0.14	96.34%
	20%	50	0.9172	13.719%	124.79	433.57	0.28	97.28%
	40%	50	0.9672	12.025%	248.88	433.45	0.56	97.53%
	60%	50	0.9775	10.352%	372.70	433.48	0.84	97.70%
	80%	50	0.9854	9.142%	497.10	433.54	1.12	97.68%
	100%	50	0.9903	7.597%	628.80	433.55	1.40	96.53%
277	10%	50	0.6902	26.325%	62.60	433.71	0.14	97.00%
	20%	50	0.8562	19.776%	124.81	433.52	0.28	97.26%
	40%	50	0.9443	14.828%	248.58	433.53	0.56	97.67%
	60%	50	0.9685	11.778%	371.61	433.49	0.84	97.99%
	80%	50	0.9784	10.191%	495.45	433.37	1.12	97.97%
	100%	50	0.9846	8.107%	621.89	433.35	1.40	97.56%
295	10%	50	0.6682	35.683%	62.66	433.84	0.14	96.93%
	20%	50	0.8174	30.791%	124.78	433.59	0.28	97.30%
	40%	50	0.9313	17.848%	249.27	433.56	0.56	97.40%
	60%	50	0.9635	12.411%	372.43	433.47	0.84	97.77%
	80%	50	0.9755	10.233%	495.86	433.43	1.12	97.90%
	100%	50	0.9787	10.372%	620.78	433.41	1.40	97.74%

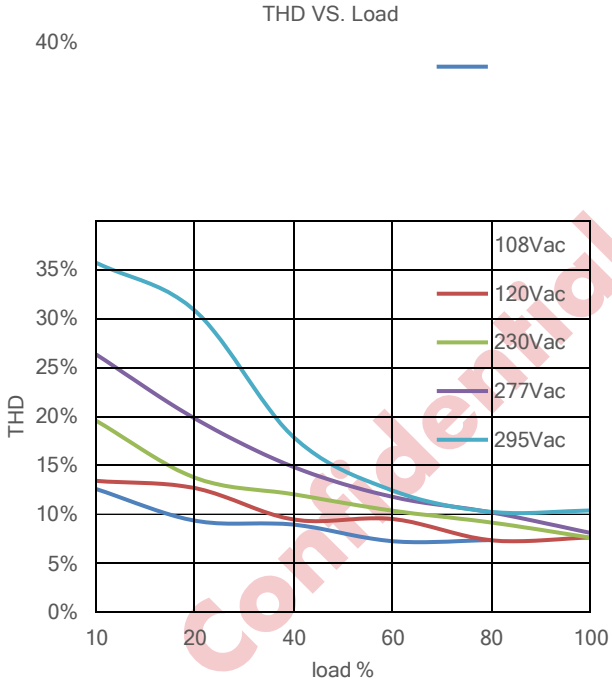
1.2 PF, THD VS. Vout

Test Conditions: Input: 108/120/230/277/295Vac; Output: 10%-100% load.

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

Result: Pass





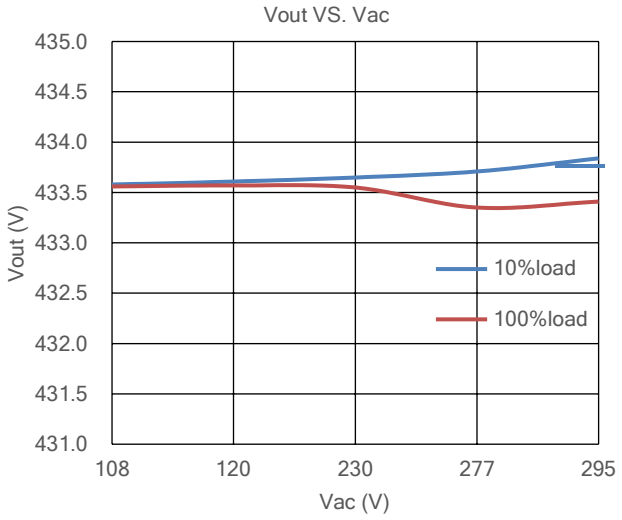
1.3 Output Voltage Regulation

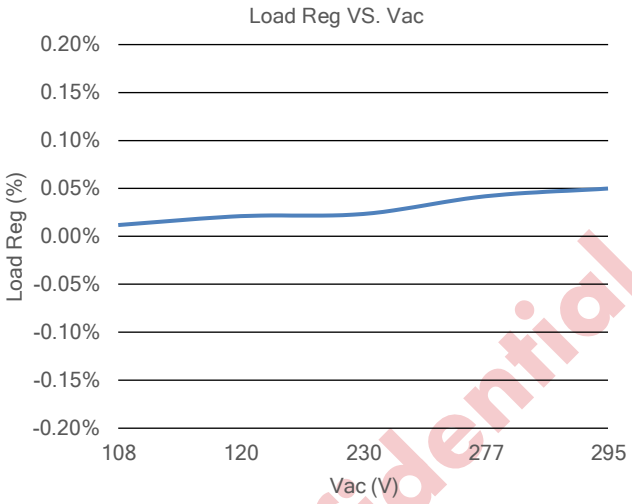
Test Conditions: Input: 108-295Vac: Output: 10%-100% load.

Standard: Load Regulation < 1%

Result: Pass

Vin(V)	Vo(V)								Load Reg
	Io= 0.14A	Io= 0.28A	Io= 0.56A	Io= 1.12A	Io= 1.40A	Max	Ave	Min	
108	433.58	433.56	433.48	433.51	433.56	433.58	433.54	433.48	0.01%
120	433.61	433.56	433.43	433.53	433.57	433.61	433.54	433.43	0.02%
230	433.65	433.57	433.45	433.54	433.55	433.65	433.55	433.45	0.02%
277	433.71	433.52	433.53	433.37	433.35	433.71	433.50	433.35	0.04%
295	434.84	433.59	433.56	433.43	433.41	433.84	433.57	433.41	0.05%





1.4 Harmonic Current

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

Standard: IEC61000-3-2 Class C.

Result: Pass

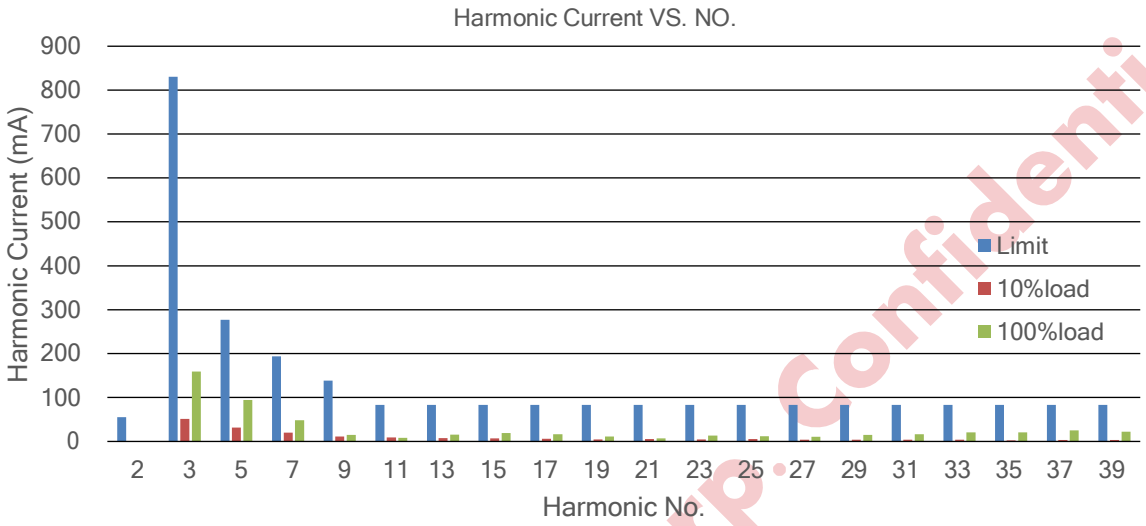
Harmonic Current Limit Value and Actual Value @10% load

Harmonic NO.	Limit (mA)	Actual Value(mA)	Pass Fail	Harmonic NO.	Limit (mA)	Actual Value(mA)	Pass Fail
2	55.39	0.37	Pass	3	830.91	51.25	Pass
5	276.97	31.75	Pass	7	193.88	19.55	Pass
9	138.49	10.98	Pass	11	83.09	8.58	Pass
13	83.09	7.58	Pass	15	83.09	6.87	Pass
17	83.09	6.09	Pass	19	83.09	4.59	Pass
21	83.09	4.94	Pass	23	83.09	4.58	Pass
25	83.09	5.10	Pass	27	83.09	3.98	Pass
29	83.09	3.46	Pass	31	83.09	3.64	Pass
33	83.09	3.52	Pass	35	83.09	2.56	Pass
37	83.09	2.95	Pass	39	83.09	3.37	Pass

Harmonic Current Limit Value and Actual Value @100% load

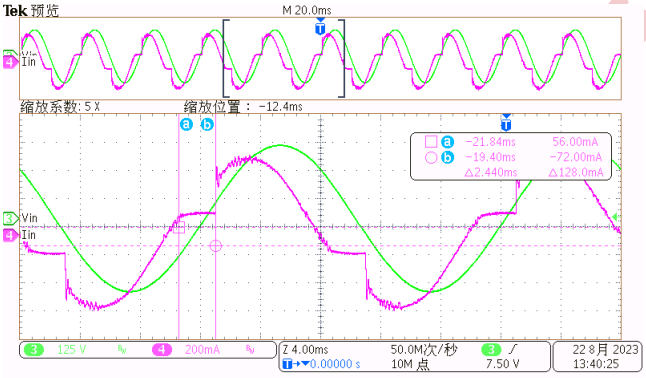
Harmonic NO.	Limit (mA)	Actual Value(mA)	Pass Fail	Harmonic NO.	Limit (mA)	Actual Value(mA)	Pass Fail
2	55.39	0.61	Pass	3	830.91	158.79	Pass
5	276.97	94.36	Pass	7	193.88	48.05	Pass
9	138.49	14.76	Pass	11	83.09	8.25	Pass
13	83.09	15.45	Pass	15	83.09	19.36	Pass
17	83.09	16.23	Pass	19	83.09	11.08	Pass

21	83.09	7.01	Pass	23	83.09	13.07	Pass
25	83.09	11.74	Pass	27	83.09	10.44	Pass
29	83.09	14.43	Pass	31	83.09	15.84	Pass
33	83.09	20.69	Pass	35	83.09	20.86	Pass
37	83.09	25.07	Pass	39	83.09	21.96	Pass



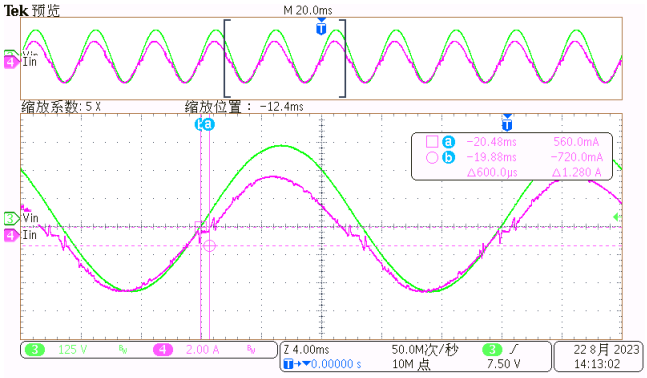
Waveforms:

Test Condition: 230Vac/50Hz Input, 60W Output



(CH3: Vin; CH4: Iin)

Test Condition: 230Vac/50Hz Input, 600W Output



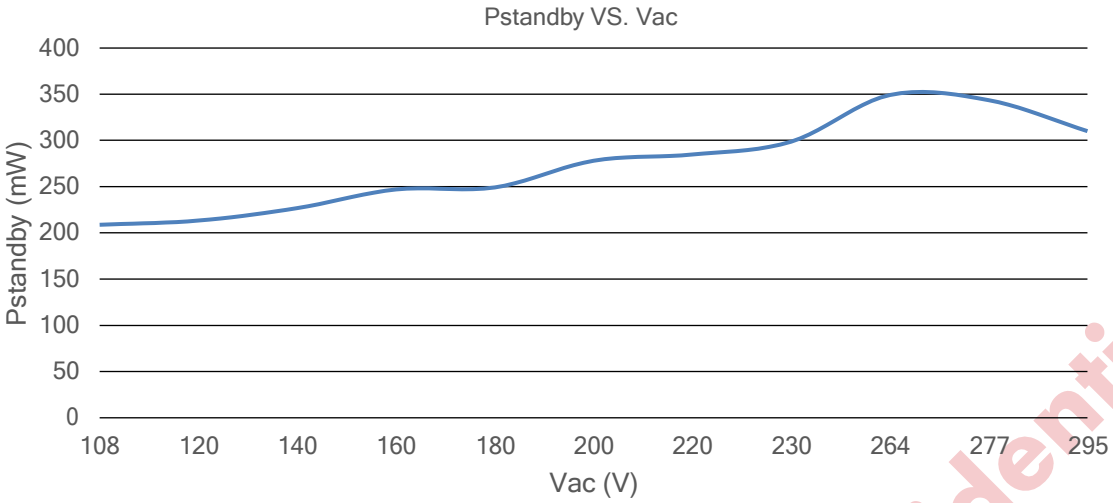
(CH3: Vin; CH4: Iin)

1.5 Standby Power

Test Conditions: Input: 108-295Vac; Output: No load.

Standard: $P_{Standby}$ < 0.5W.

Result: Pass



2 Dynamic Characteristics

2.1 Start-up Characteristics

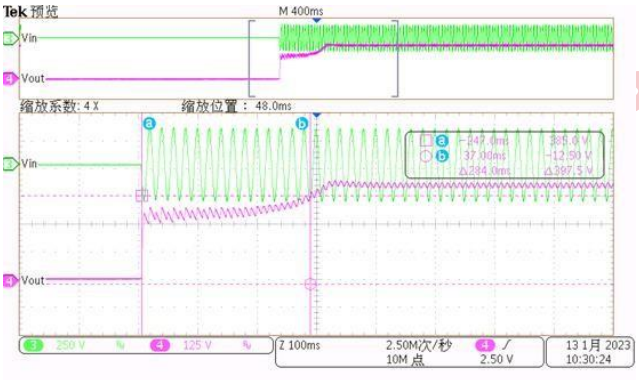
Test Conditions: Input: 230/277Vac; Output: full load.

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

Result: Pass

Waveforms:

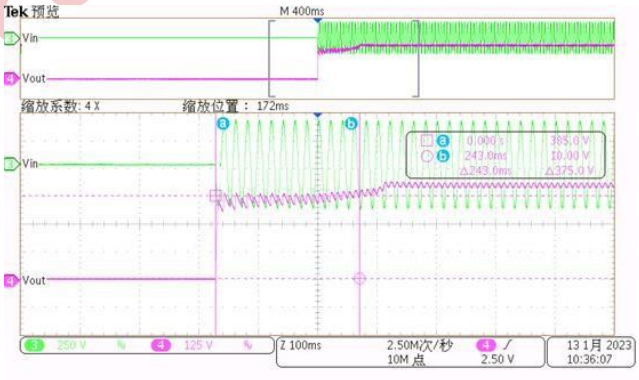
Test Condition: 230Vac/50Hz Input, 600W Output



(CH1: Gate1; CH2: OSC; CH3: Vin; CH4: Vout)

Comments: Voltage rise time 284ms, overshoot voltage not exceed 10% of load

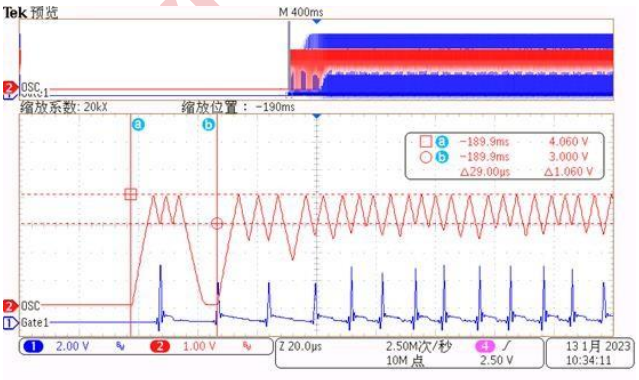
Test Condition: 277Vac/50Hz Input, 600W Output



(CH1: Gate1; CH2: OSC; CH3: Vin; CH4: Vout)

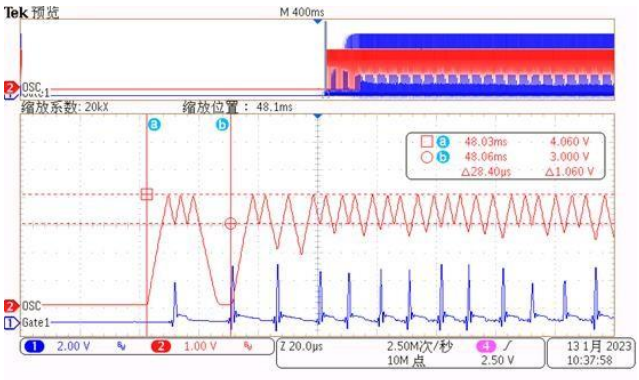
Comments: Voltage rise time 243ms, overshoot voltage not exceed 10% of load

Test Condition: 230Vac/50Hz Input, 600W Output



(CH1: Gate1; CH2: OSC; CH3: Vin; CH4: Vout)

Test Condition: 277Vac/50Hz Input, 600W Output



(CH1: Gate1; CH2: OSC; CH3: Vin; CH4: Vout)

2.2 Power off Characteristics

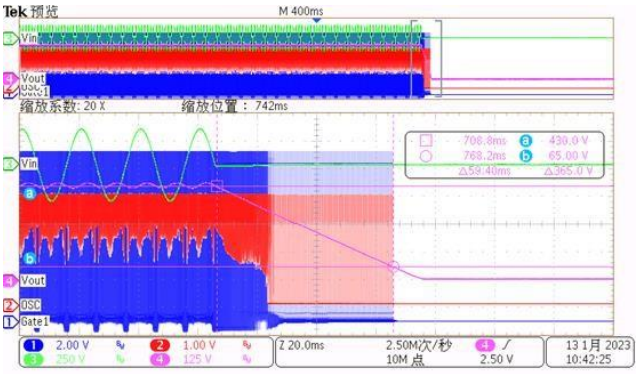
Test Conditions: Input: 230/277Vac; Output: full load.

Standard: No overshoot.

Result: Pass

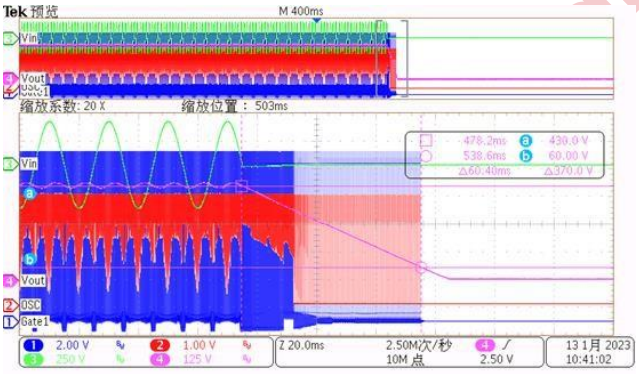
Waveforms:

Test Condition: 230Vac/50Hz Input, 600W Output



(CH1: Gate1; CH2: OSC; CH3: Gate2; CH4: Vout)
Comments: OK, No overshoot

Test Condition: 277Vac/50Hz Input, 600W Output



(CH1: Gate1; CH2: OSC; CH3: Gate2; CH4: Vout)
Comments: OK, No overshoot

3 Reliability Testing

3.1 Maximum Stress of Boost MOSFET

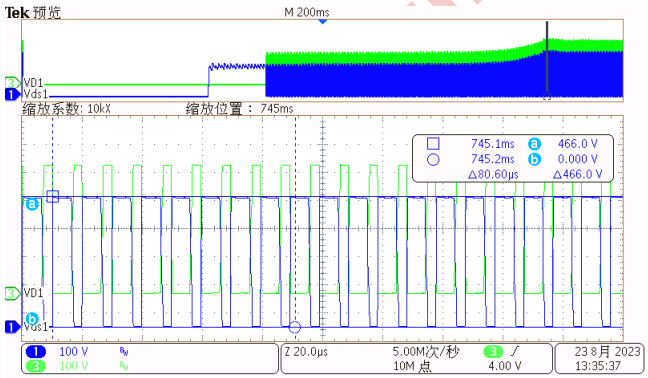
Test Conditions: Input: 120/230/277Vac; Output: full load; MOSFET: LSD60R180HT.

Standard: VDS_peak < 90% *Vdsmax.

Result: Pass

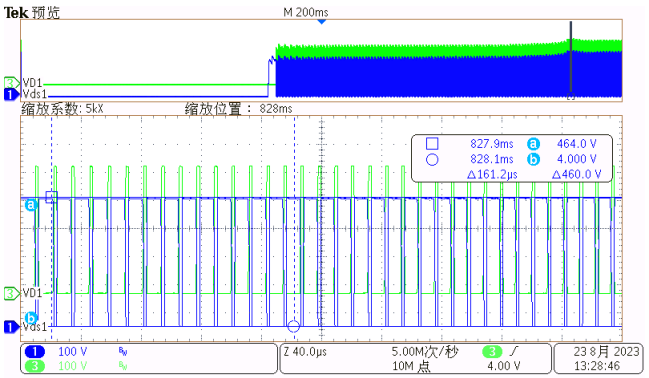
Waveforms:

Test Condition: 230Vac/50Hz Input, 600W Start-up



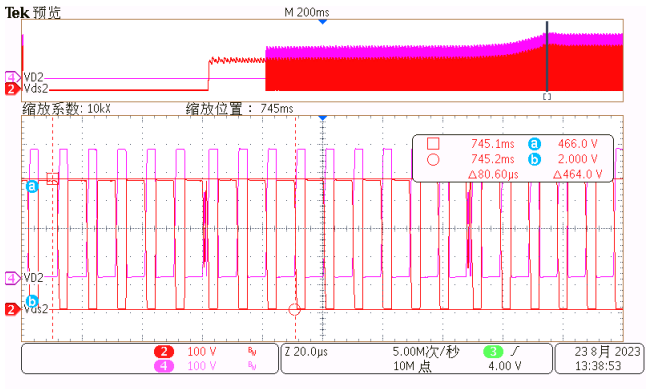
(CH1: Vds1; CH2: Vds2; CH3: VD1; CH4: VD2)
Comments: OK,Vds1_peak=466V

Test Condition: 277Vac/50Hz Input, 600W Start-up



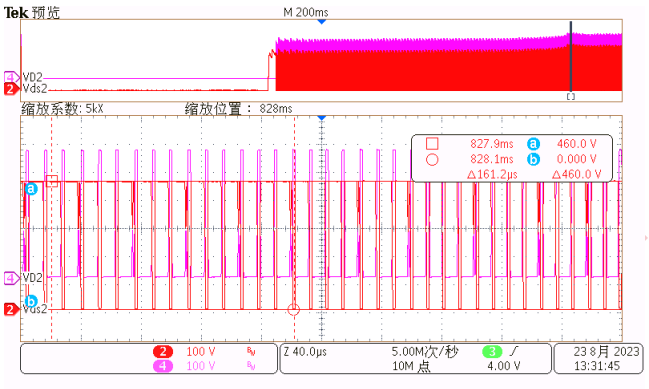
(CH1: Vds1; CH2: Vds2; CH3: VD1; CH4: VD2)
Comments: OK,Vds1_peak=464V

Test Condition: 230Vac/50Hz Input, 600W Start-up



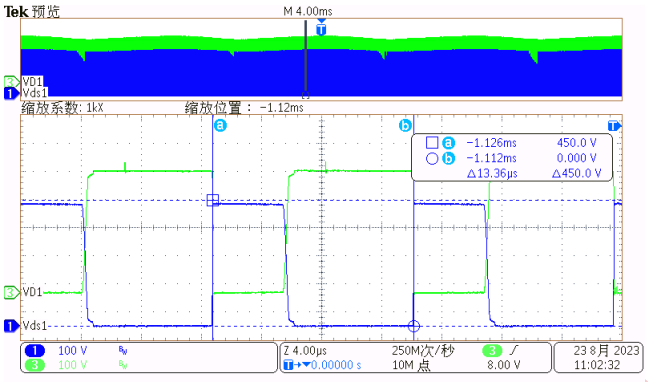
(CH1: Vds1; CH2: Vds2; CH3: VD1; CH4: VD2)
Comments: OK,Vds2_peak=466V

Test Condition: 277Vac/50Hz Input, 600W Start-up



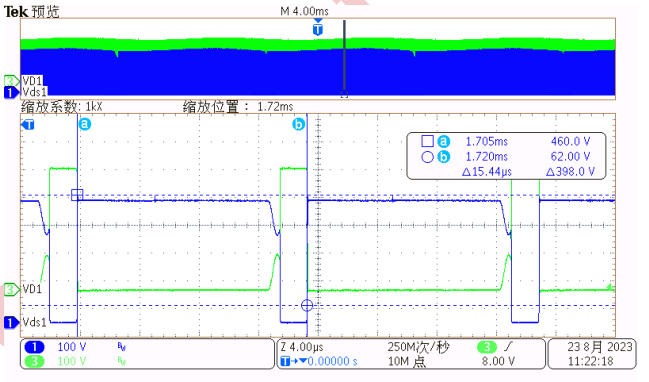
(CH1: Vds1; CH2: Vds2; CH3: VD1; CH4: VD2)
Comments: OK,Vds2_peak=460V

Test Condition: 120Vac/60Hz Input, 600W Steady Output



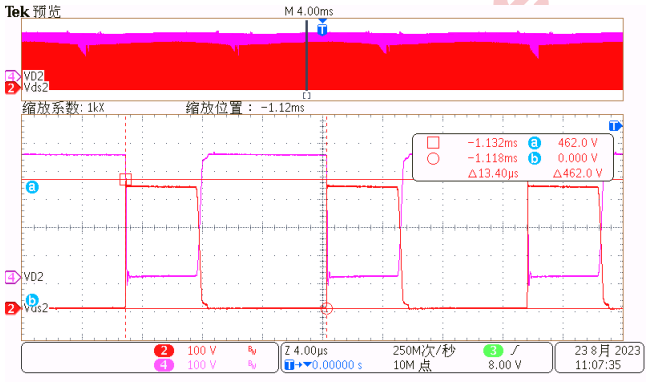
(CH1: Vds1; CH2: Vds2; CH3: VD1; CH4: VD2)
Comments: OK,Vds1_peak=450V

Test Condition: 277Vac/50Hz Input, 600W Steady Output



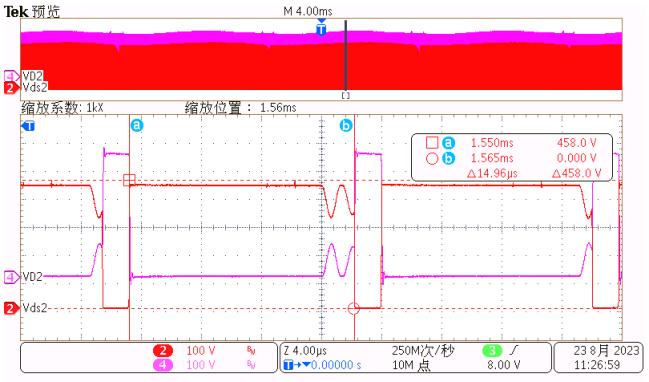
(CH1: Vds1; CH2: Vds2; CH3: VD1; CH4: VD2)
Comments: OK,Vds1_peak=460V

Test Condition: 120Vac/60Hz Input, 600W Steady Output



(CH1: Vds1; CH2: Vds2; CH3: VD1; CH4: VD2)
Comments: OK,Vds2_peak=462V

Test Condition: 277Vac/50Hz Input, 600W Steady Output



(CH1: Vds1; CH2: Vds2; CH3: VD1; CH4: VD2)
Comments: OK,Vds2_peak=458V

3.2 Maximum Stress of Boost Output Diode

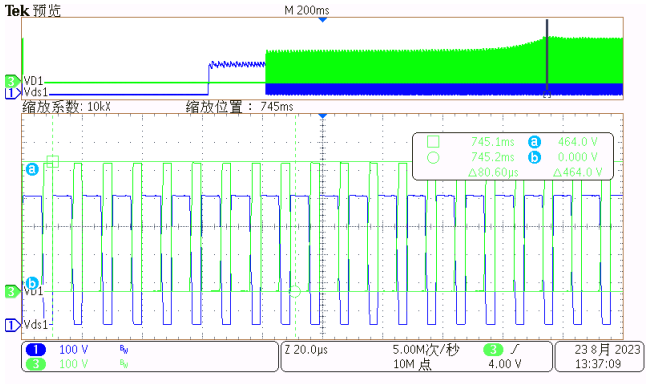
Test Conditions: Input: 120/230/277Vac; Output: full load; Diode: ES5J (SMC)

Standard: VD_peak < 90% *VDmax.

Result: Pass

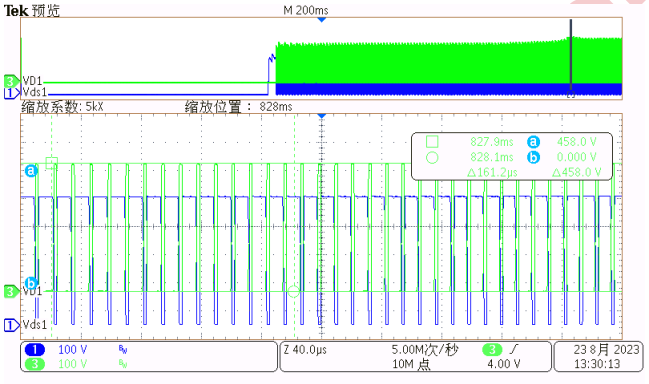
Waveforms:

Test Condition: 230Vac/50Hz Input, 600W Start-up



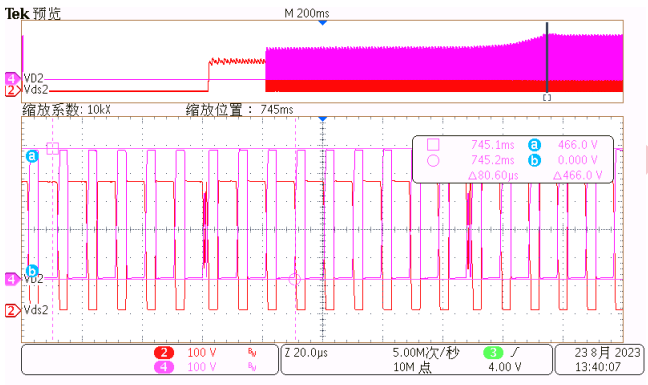
(CH1: Vds1; CH2: Vds2; CH3: VD1; CH4: VD2)
Comments: OK, VD1_peak=464V

Test Condition: 277Vac/50Hz Input, 600W Start-up



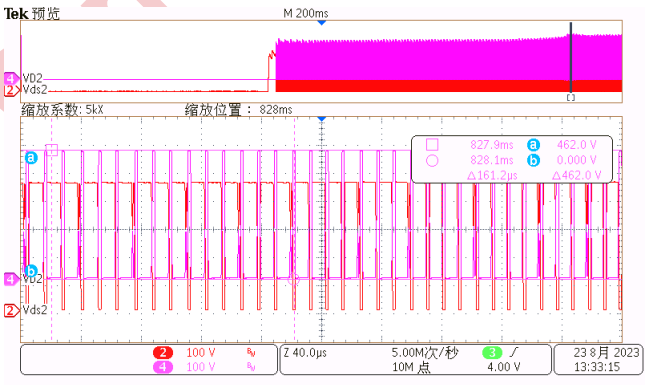
(CH1: Vds1; CH2: Vds2; CH3: VD1; CH4: VD2)
Comments: OK, VD1_peak=458V

Test Condition: 230Vac/50Hz Input, 600W Start-up



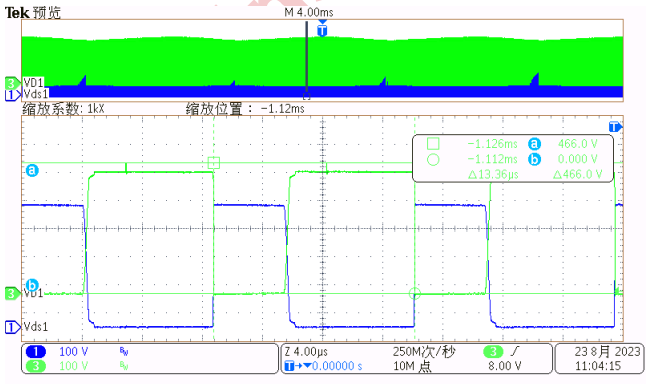
(CH1: Vds1; CH2: Vds2; CH3: VD1; CH4: VD2)
Comments: OK, VD2_peak=466V

Test Condition: 277Vac/50Hz Input, 600W Start-up



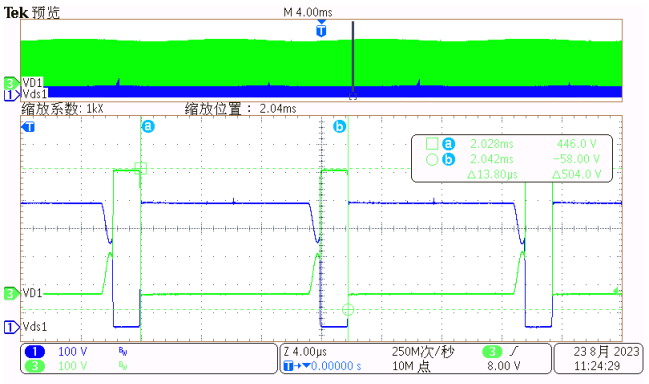
(CH1: Vds1; CH2: Vds2; CH3: VD1; CH4: VD2)
Comments: OK, VD2_peak=462V

Test Condition: 120Vac/60Hz Input, 600W Steady Output



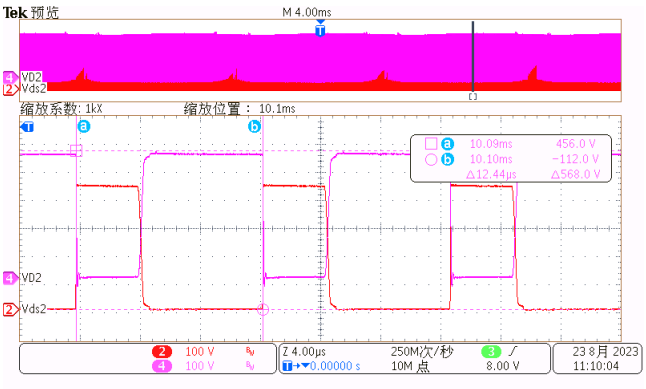
(CH1: Vds1; CH2: Vds2; CH3: VD1; CH4: VD2)
Comments: OK, VD1_peak=466V

Test Condition: 277Vac/50Hz Input, 600W Steady Output



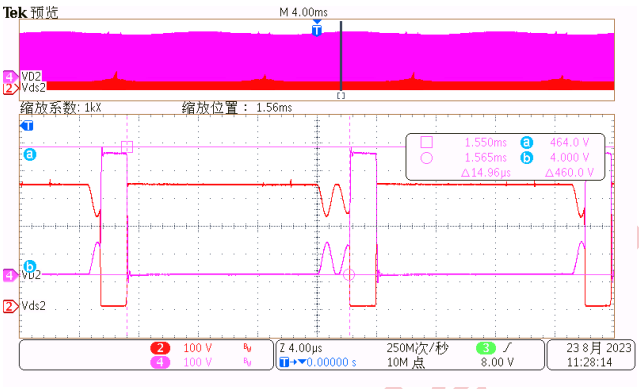
(CH1: Vds1; CH2: Vds2; CH3: VD1; CH4: VD2)
Comments: OK, VD1_peak=446V

Test Condition: 120Vac/60Hz Input, 600W Steady Output



(CH1: Vds1; CH2: Vds2; CH3: VD1; CH4: VD2)
Comments: OK, VD2_peak=456V

Test Condition: 277Vac/50Hz Input, 600W Steady Output



(CH1: Vds1; CH2: Vds2; CH3: VD1; CH4: VD2)
Comments: OK, VD2_peak=464V

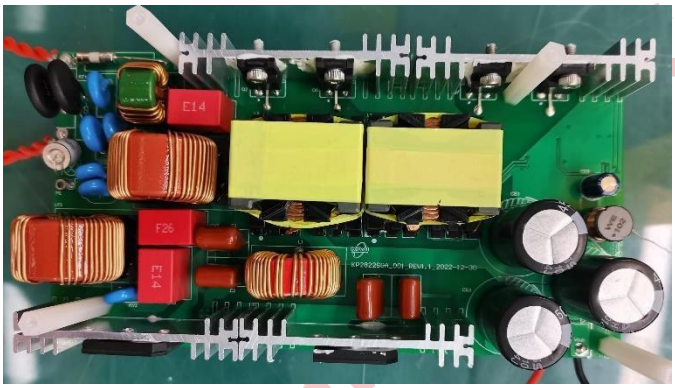
3.3 Thermal Test

Test Conditions: Input: 120/277Vac; Output: full load. Burn-in 0.5Hour @ confined container and steady environment with no airflow, Ta is the temperature inside the cardboard box.

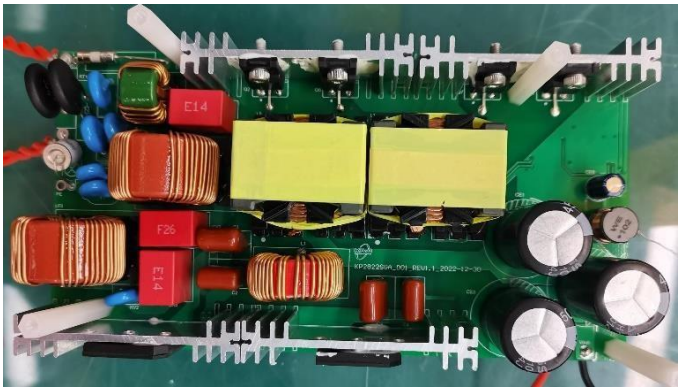
Standard: Final product will be cased and potted, the open frame thermal test data is only for reference.

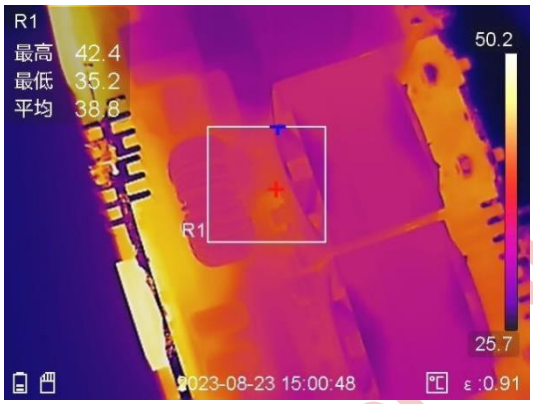
Result: Pass

120Vac/60Hz, Ta=31.9℃



277Vac/50Hz, Ta=27.6℃





3.4 EMC Test

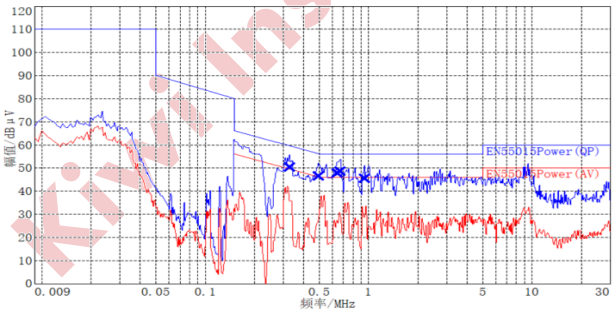
Test Conditions: Input: 110/220Vac; Output: full load.

Standard:

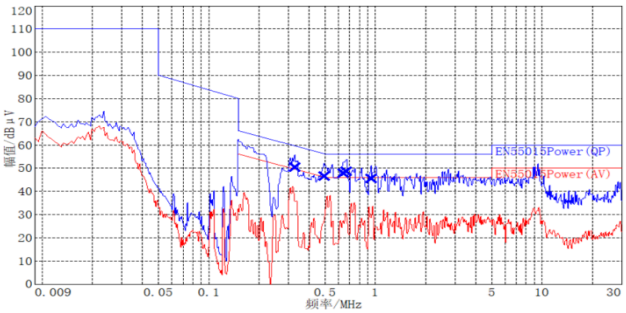
Standard	EN55015
Content	CE
Requirement	>6dB Margin

Result: CE test Pass

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

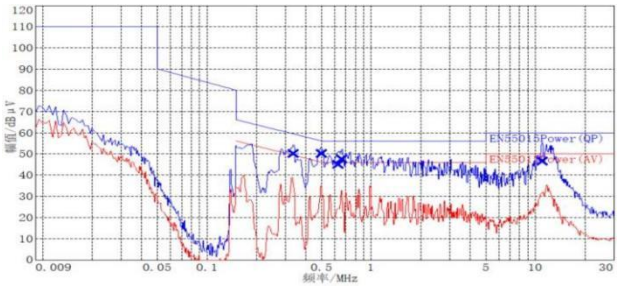


CE EMI---LINE

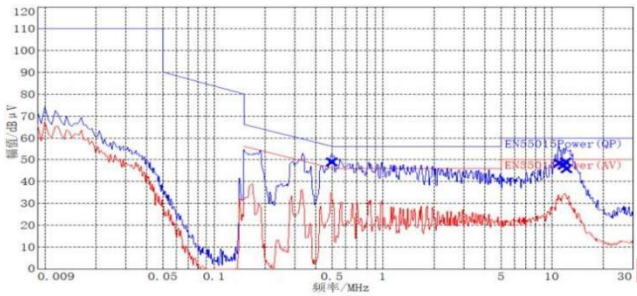


CE EMI---NEUTRAL

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



CE EMI---LINE



CE EMI---NEUTRAL

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 “Vout+” and “Vout-” terminal to the positive and negative end of the load.
2. Set the AC Power Source between 108Vac and 300Vac.
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
2023/08/25	1.1	First Release

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