



DEMO BOARD TEST REPORT

50W High Performance LED Filament Lamp Driver with KP1352+GaN FET

FEATURES

- High Operating Frequency and High Power Density with GaN FET
- Full Input Voltage for 120~277Vac
- PF>0.9, THD<20%
- High Peak Efficiency >96%
- Excellent Line Regulation<0.5%

APPLICATIONS

- E40 LED Filament Lamp

INTRODUCTION

The demo board is designed to demonstrate a high-performance 50W LED filament lamp solution with a full input voltage range. The demonstration board is realized through a highly integrated high-frequency direct drive gallium nitride boost PFC constant current controller KP1352, with 650V power GaN FET. The highest switching frequency of KP1352 is 600kHz, and it can operate in the critical conduction mode in a full range, reducing the volume of the magnetic device and thereby increasing the power density.

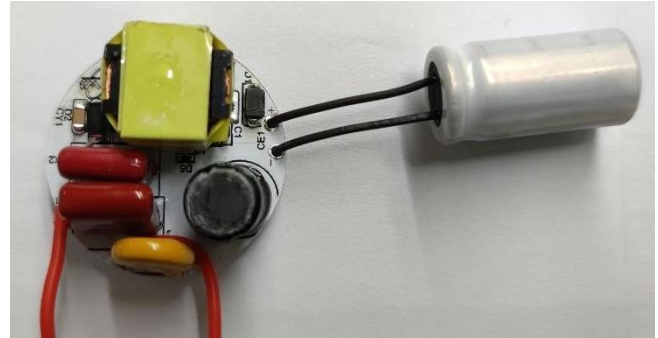
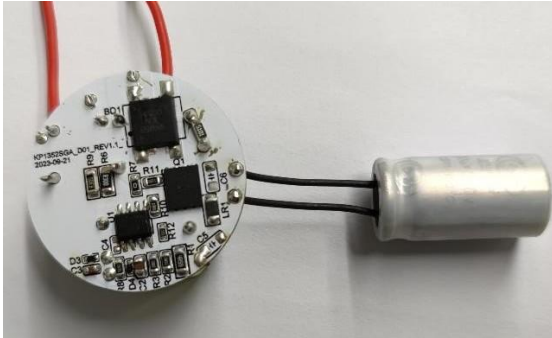
The demo board is typically designed for 50W application with 120VAC to 277VAC, High PF>0.9, THD<20%, and with output 450V/110mA within LED Filament Lamp.

DEMO BOARD SPECIFICATION

Description	Symbol	Min.	Typ.	Max.	Unit	Note
Input Voltage	V _{in}	120		277	Vac	50W
Output	V _{OUT} / I _{OUT}	450V/110mA				
System Efficiency	η	94.5			%	@120~277Vac
Power Factor	PF	0.9				@120~277Vac
Line Regulation	T _{ST}			0.5	%	@120~277Vac
EMI Margin	CE	3			dB	EN55015
	RE	6				EN55015CDN
Surge Test		4			kV	Differential Mode

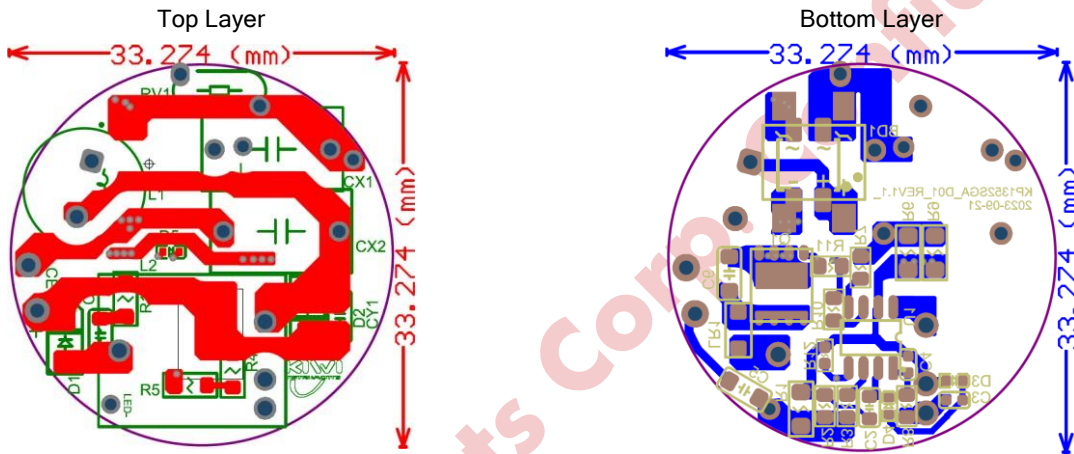
Note: The table above shows the minimum acceptable performance of the design. Actual performance is listed in the results section.

Demo Board

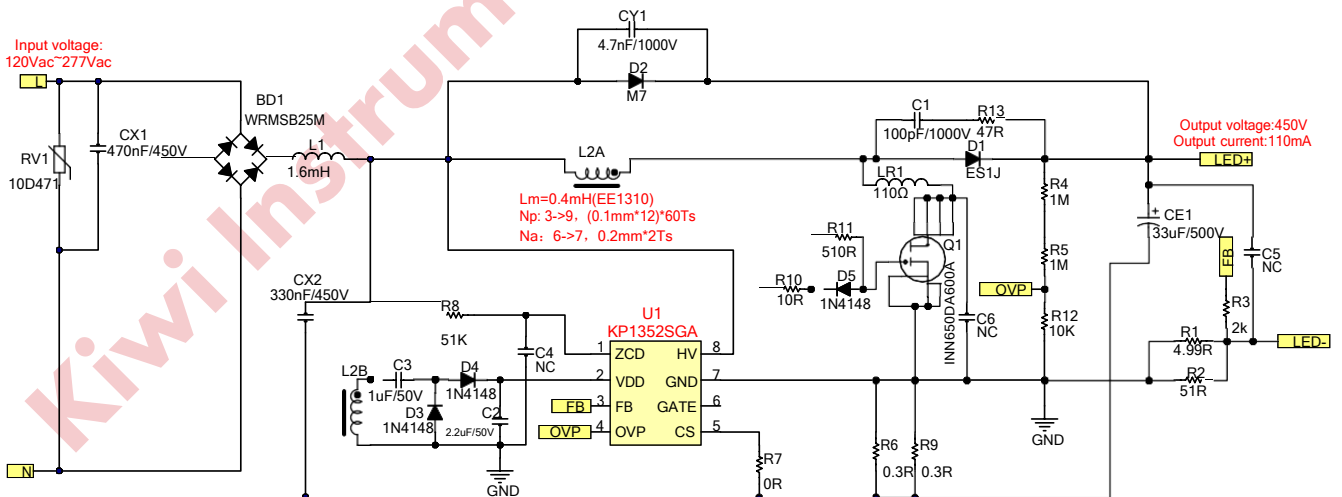


Printed Circuit Board Layout

KP1352SGA_D01_REV1.1



Schematic





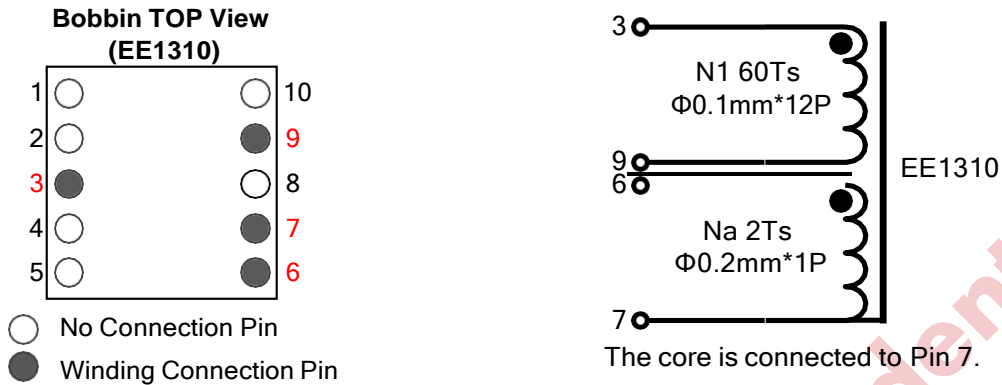
50W High Performance LED Filament Lamp Driver with KP1352+GaN FET

Bill of Material

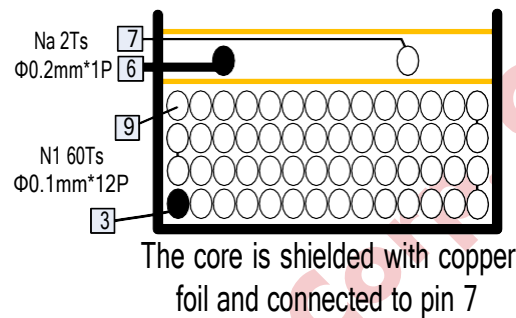
No.	Designator	Value	Description	Package	Manufacturer	Part Number
1	BD1	1000V/2.5A	BRD 2.5A 1000V 1.1V	MSB	World	WRMSB25M
2	C1	100pF/1000V	Ceramic Cap 1000V ±5% NPO	1206	WE	885342008009
3	C2	2.2uF/50V	Ceramic Cap 50V ±10% X7R	0805	YAGEO	CC0805KKX7R9BB 225
4	C3	1uF/50V	Ceramic Cap 50V ±10% X7R	0603	WE	885012206126
7	CE1	33uF/500V	Electrolytic Cap 500V 12.5*25 P7.5	TH	Any	
8	CX1	470nF/450V	CBB 450Vdc 12*5*15 P10	TH	Any	
9	CX2	330nF/450V	CBB 450Vdc 12*5*15 P10	TH	Any	
10	CY1	4.7nF/1000V	Ceramic Cap 1000V ±10% X7R	1206	WE	885342208020
11	D1	600V/1A	DIO FRD 1A 600V 35nS 1.7V	SMA	MDD	ES1J
12	D2	1000V/1A	DIO FRD 1A 1000V 1.1V	SMA	MDD	M7
13	D3, D4, D5	75V/0.15A	DIO SW 0.15A 75V 4nS 1.25V	SOD-523	CJ	1N4148WT- SOD523
14	L1	1.6mH	Inductor Isat 0.80A Rdc=11Ω 10*14	TH	Any	
15	L2	400uH	EF1310,Lp=400uH,Np:Ns=60 (0.1mm*12):2 (0.2mm)	TH	Any	
16	LR1	110Ω	Bead Core 110Ω ± 25% 100MHz 5.4A	1206	WE	74279221111
17	Q1	650V600mΩ	650V GaN Enhancement-mode Power Transistor,Rdson=600mΩ	BDF 5*6	INN	INN650DA600A
18	R1	4.99R	Chip Resistor ±1% 1/4W	1206	FH	RS-06K10R0FT
19	R2	51R	Chip Resistor ±1% 1/8W	0805	FH	RS-05K1000FT
20	R3	2k	Chip Resistor ±1% 1/8W	0805	FH	RS-05K2001FT
21	R4, R5	1M	Chip Resistor ±1% 1/4W	1206	FH	RS-06K1004FT
22	R6, R9	0.3R	Chip Resistor ±1% 1/4W	1206	RALEC	RTT06R300FTP
23	R7	0R	Chip Resistor ±1% 1/8W	0805	FH	RS-05000FT
24	R8	51K	Chip Resistor ±1% 1/8W	0805	FH	RS-05K5102FT
25	R10	10R	Chip Resistor ±1% 1/8W	0805	FH	RS-05K5102FT
26	R11	510R	Chip Resistor ±1% 1/8W	0805	FH	RS-05K5102FT
27	R12	10K	Chip Resistor ±1% 1/10W	0603	FH	RS-03K1002FT
28	R13	47R	Chip Resistor ±1% 1/4W	1206	FH	RS-06K47R0FT
29	RV1	10D471	VARISTOR 300VAC 70J 2500A	TH	WE	820513011
30	U1	KP1352	Boost LED Controller With PFC and E-Mode GaN FET Direct Driver	SOP-8	KIWI	KP1352SGA

Transformer Manufacture Guide --- L2

1. Electrical Diagram



2. Winding Diagram



3. Winding Order

Number	Winding	Layer	Start	End	Wire Size	Turns
1	N1	Primary	3	9	0.1d*12P	60Ts
2	Na	Auxiliary	6	7	0.2d*1P	2Ts

4. Electrical Specification

Items	Test Condition	Test Pin	Specification
Primary Inductance	Measured at 40kHz, 1.0 VRMS	Pins 3-9	400μH ± 5%
DC Resistance	Measured at 40kHz, 1.0 VRMS	Pins 3-9	0.44Ω

5. Transformer BOM

Items	Description
1	Core: EE1310, AE=35
2	Bobbin: EE1310, 5+5 Pin
3	Wire: Φ0.2mm, 2UEW, Class B
4	Wire: Φ0.1mm*12P, 2UEW, Class B
5	Tape: 8mm(W) × 0.06mm(TH)

Test Result

1. Steady Characteristics

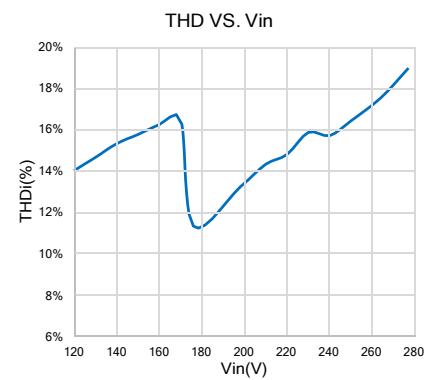
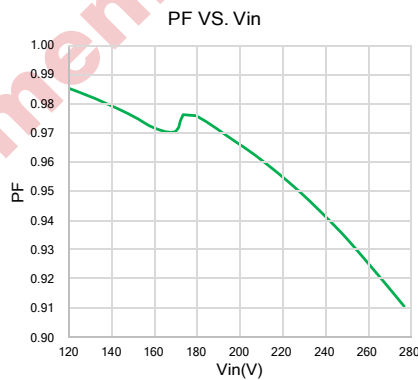
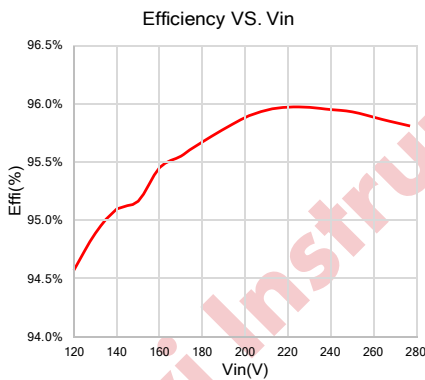
1.1 System Efficiency

Test Conditions: Input: 120-277Vac; Output: 450V110mA;

Standard: Eff > 96%, PF>0.9, THD<20%.

Result: Pass

Vin(V)	F(Hz)	PF	THD	Pin(W)	Vo(V)	Io(V)	Eff(%)
120	60	0.985	14.0%	52.04	449.15	0.110	94.57%
140	60	0.979	15.3%	51.72	449.07	0.110	95.10%
160	60	0.972	16.2%	51.53	449.16	0.109	95.45%
176	60	0.977	11.3%	51.40	449.01	0.109	95.63%
198	50	0.967	13.2%	51.26	448.97	0.109	95.86%
220	50	0.955	14.8%	51.22	448.91	0.110	95.97%
230	50	0.948	15.9%	51.21	448.88	0.109	95.97%
240	50	0.941	15.7%	51.21	448.86	0.109	95.95%
264	50	0.922	17.5%	51.23	448.82	0.109	95.86%
277	50	0.910	19%	51.32	448.82	0.110	95.81%
Line Regulaitin			0.12%				



1.2 Output Current Ripple

Test Conditions: Input: 120-277Vac; Output: 450V110mA;

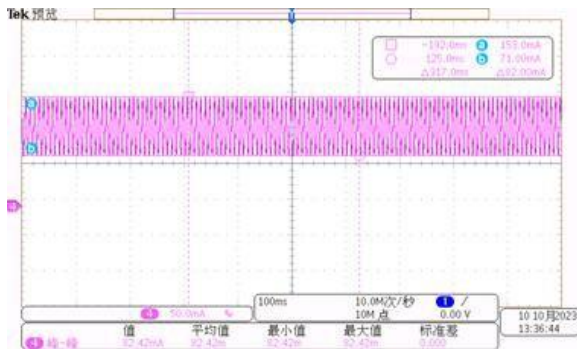
Standard: No light flicker;

Result: Pass

Vin(V)	F(Hz)	Io(mA)	Current Ripple Ipeak-peak (mA)	Pk-pk Ripple (%)
120	60	110.6	82.42	74.5%
230	50	110.6	87.83	79.4%
277	50	110.6	87.66	79.2%

Waveforms:

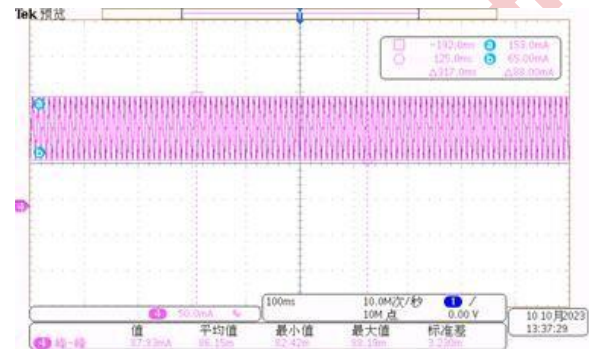
Test Condition: 120Vac/60Hz Input, 450V110mA Output



(CH4-Io)

Comments: Ipeak-peak=82.42mA

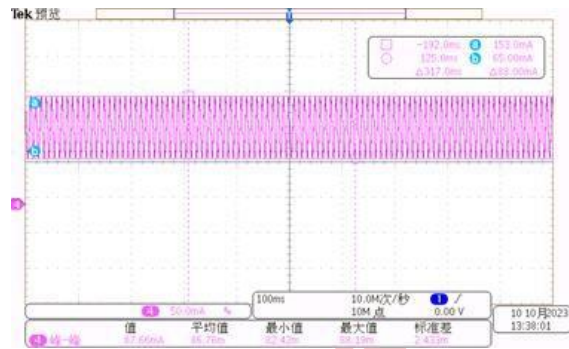
Test Condition: 230Vac/50Hz Input, 450V110mA Output



(CH4-Io)

Comments: Ipeak-peak=87.83mA

Test Condition: 277Vac/50Hz Input, 450V110mA Output



(CH4-Io)

Comments: Ipeak-peak=87.66mA

2. Dynamic Characteristics

2.1 Power On

Test Conditions: Input: 120-277Vac; Output: 450V110mA;

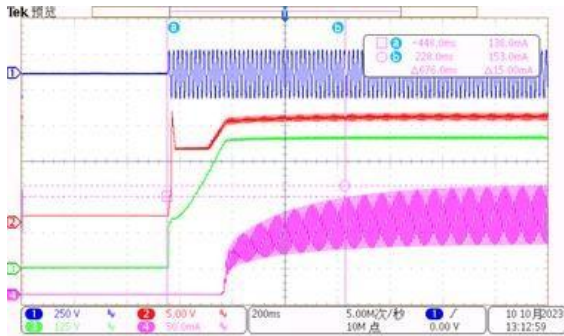
Standard: Smoothly, no flicker and no overshoot

Result: Pass

Vin(Vac)	Io(mA)	AC to Io current rise (ms)	AC to Io current rise to 90%Io (ms)
120	100%	216	676
220	100%	105	434
277	100%	36	317

Waveforms:

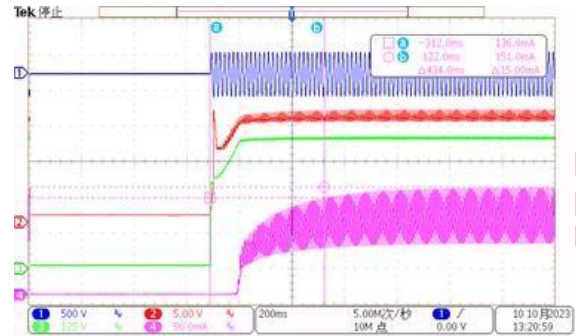
Test Condition: 120Vac/60Hz Input, 450V110mA Output



(CH1-Vin, CH2-VDD, CH3-Vo, CH4-Io)

Comments: OK, No flicker and no overshoot

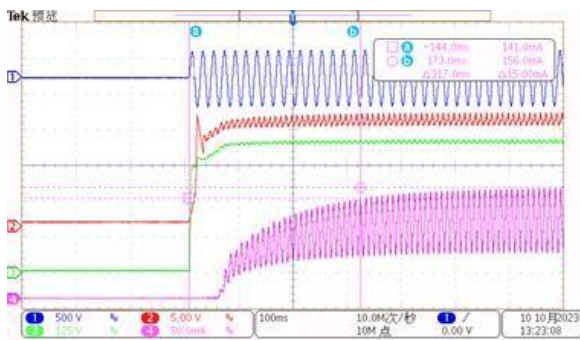
Test Condition: 220Vac/50Hz Input, 450V110mA Output



(CH1-Vin, CH2-VDD, CH3-Vo, CH4-Io)

Comments: OK, No flicker and no overshoot

Test Condition: 277Vac/50Hz Input, 450V110mA Output



(CH1-Vin, CH2-VDD, CH3-Vo, CH4-Io)

Comments: OK, No flicker and no overshoot

2.2 Power Off

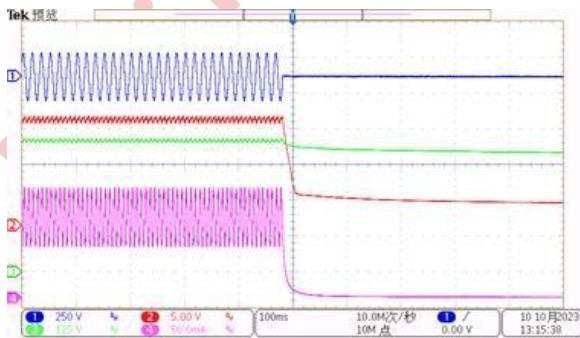
Test Conditions: Input: 120-277Vac; Output: 450V110mA;

Standard: Smoothly, no flicker and no overshoot

Result: Pass

Waveforms:

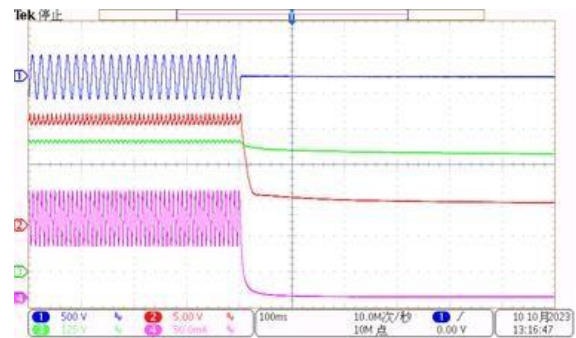
Test Condition: 120Vac/60Hz Input, 450V110mA Output



(CH1-Vin, CH2-VDD, CH3-Vo, CH4-Io)

Comments: OK, No flicker and no overshoot

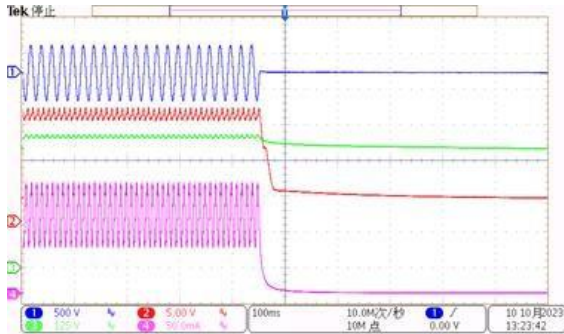
Test Condition: 220Vac/50Hz Input, 450V110mA Output



(CH1-Vin, CH2-VDD, CH3-Vo, CH4-Io)

Comments: OK, No flicker and no overshoot

Test Condition: 277Vac/50Hz Input, 450V110mA Output



(CH1-Vin, CH2-VDD, CH3-Vo, CH4-Io)
Comments: OK, No flicker and no overshoot

2.3 Fast Power ON/OFF

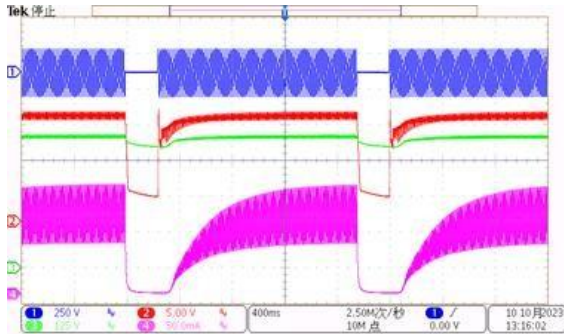
Test Conditions: Input: 120-277Vac; Output: 450V110mA;

Standard: Smoothly, no flicker and no overshoot

Result: Pass

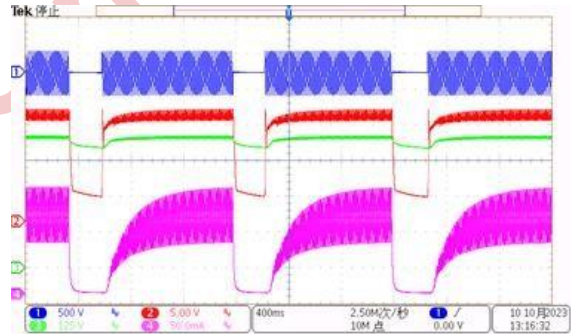
Waveforms:

Test Condition: 120Vac/60Hz Input, 450V110mA Output



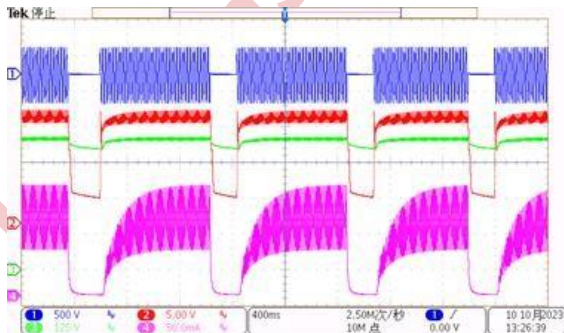
(CH1-Vin, CH2-VDD, CH3-Vo, CH4-Io)
Comments: OK, No flicker and no overshoot

Test Condition: 220Vac/50Hz Input, 450V110mA Output



(CH1-Vin, CH2-VDD, CH3-Vo, CH4-Io)
Comments: OK, No flicker and no overshoot

Test Condition: 277Vac/50Hz Input, 450V110mA Output



(CH1-Vin, CH2-VDD, CH3-Vo, CH4-Io)
Comments: OK, No flicker and no overshoot

3. Reliability Testing

3.1 Open Load Protection

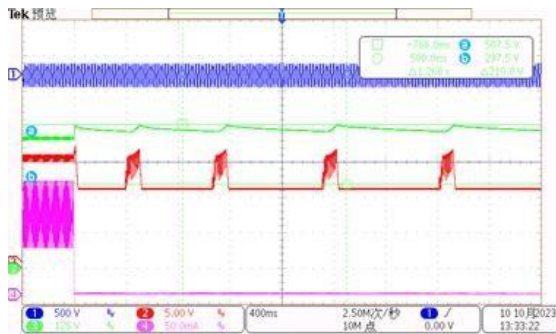
Test Conditions: Input: 120-277Vac; Output: 450V110mA;

Standard: Output is recoverable and no component damaged.

Result: Pass

Waveforms:

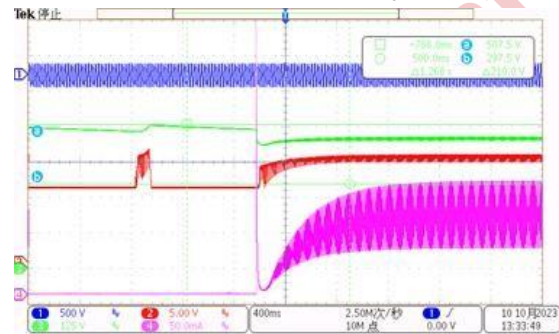
Test Condition: 120Vac/60Hz Input, 450V110mA Output
Open Load



(CH1-Vin, CH2-VDD, CH3-Vo, CH4-Io)

Comments: OK, $V_{OVP}=507.5V$

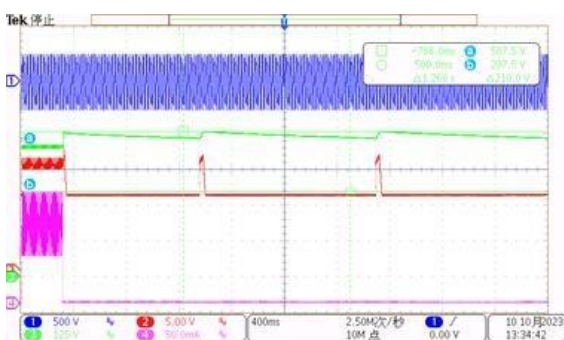
Test Condition: 120Vac/60Hz Input, 450V110mA Output
Open Load Recovery



(CH1-Vin, CH2-VDD, CH3-Vo, CH4-Io)

Comments: OK

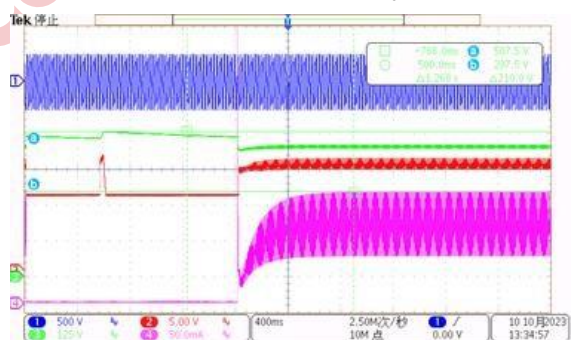
Test Condition: 277Vac/50Hz Input, 450V110mA Output
Open Load



(CH1-Vin, CH2-VDD, CH3-Vo, CH4-Io)

Comments: OK, $V_{OVP}=507.5V$

Test Condition: 277Vac/50Hz Input, 450V110mA Output
Open Load Recovery



(CH1-Vin, CH2-VDD, CH3-Vo, CH4-Io)

Comments: OK

3.2 Maximum Stress of GaN FET

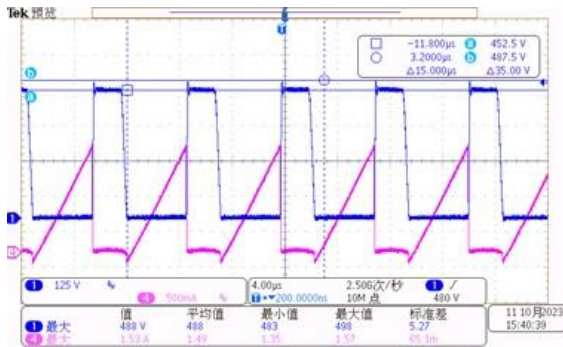
Test Conditions: Input: 120-277Vac; Output: 450V110mA; GaN FET: INN650DA600A (650V600mΩ)

Standard: $V_{DS_peak} < 90\% * V_{DSmax}=585V$.

Result: Pass

Waveforms:

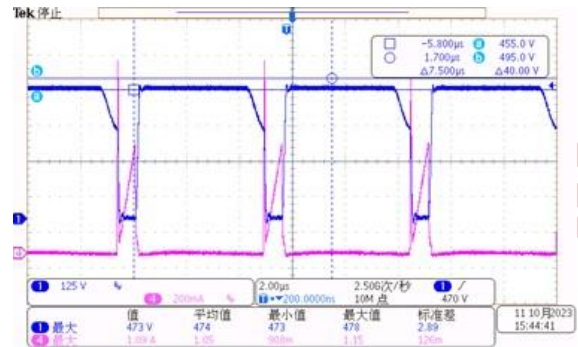
Test Condition: 120Vac/60Hz Input, 450V110mA Output



(CH1-V_{DS}, CH4-I_{DS})

Comments: OK, V_{DS_peak}=488V, I_{DS_peak}=1.53A;

Test Condition: 277Vac/50Hz Input, 450V110mA Output



(CH1-V_{DS}, CH4-I_{DS})

Comments: OK, V_{DS_peak}=473V, I_{DS_peak}=1.09A;

3.3 Maximum Stress of Output Diode

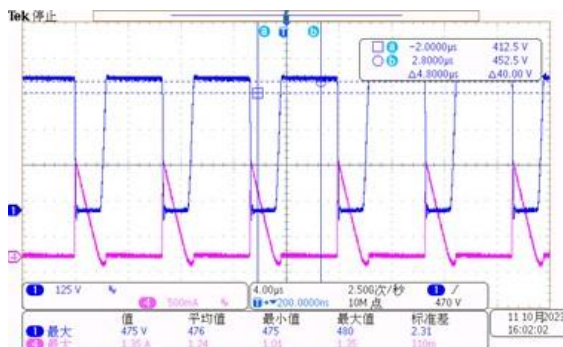
Test Conditions: Input: 120-277Vac; Output: 450V110mA; Diode: ES1J (600V1A).

Standard: V_{D_peak} < 90% * V_{Dmax}=540V.

Result: Pass

Waveforms:

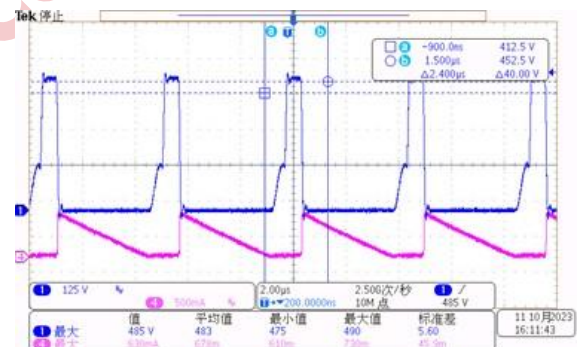
Test Condition: 120Vac/60Hz Input, 450V110mA Output



(CH1-V_D, CH4-I_D)

Comments: OK, V_{DS_peak}=475V

Test Condition: 277Vac/50Hz Input, 450V110mA Output



(CH1-V_D, CH4-I_D)

Comments: OK, V_{DS_peak}=485V

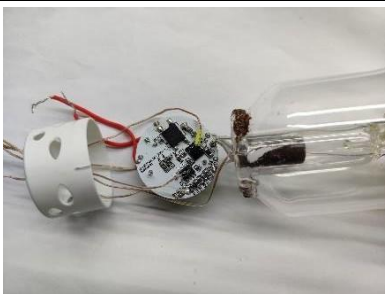

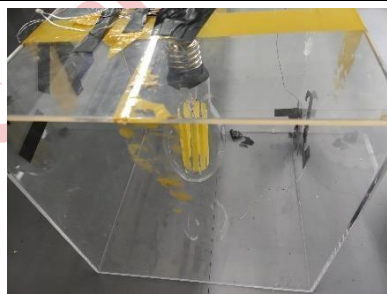
3.4. Thermal Test

Test Condition: Burn in for 1 hour within E40 LED filament lamp cavity @ confined container (60cm*40cm*40cm plastic box) and steady environment with no airflow, T_a is the temperature inside the plastic box.

Standard: The temperature of the IC is below 120°C;

Result: Pass

Test Condition: CW Mode, Input Power 5W						
Component	120Vac		220Vac		277Vac	
	Ta=34.4°C		Ta=36.2°C		Ta=35.3°C	
	T(°C)	Trise(°C)	T(°C)	Trise(°C)	T(°C)	Trise(°C)
KP1352SG	116.2	81.8	103.8	67.6	102.5	67.2
GaN FET	129.8	95.4	111.5	75.3	118	82.7
L1(1.6mH, 1014)	118.2	83.8	94	57.8	90	54.7
L2(400uH, EE1310)	116	81.6	103.5	67.3	99.3	64
Cout	85.3	50.9	82.5	46.3	82.6	47.3
Screw Lamp Holder	76.5	42.1	72.2	36	71.2	35.9

3.5. EMC Test Result

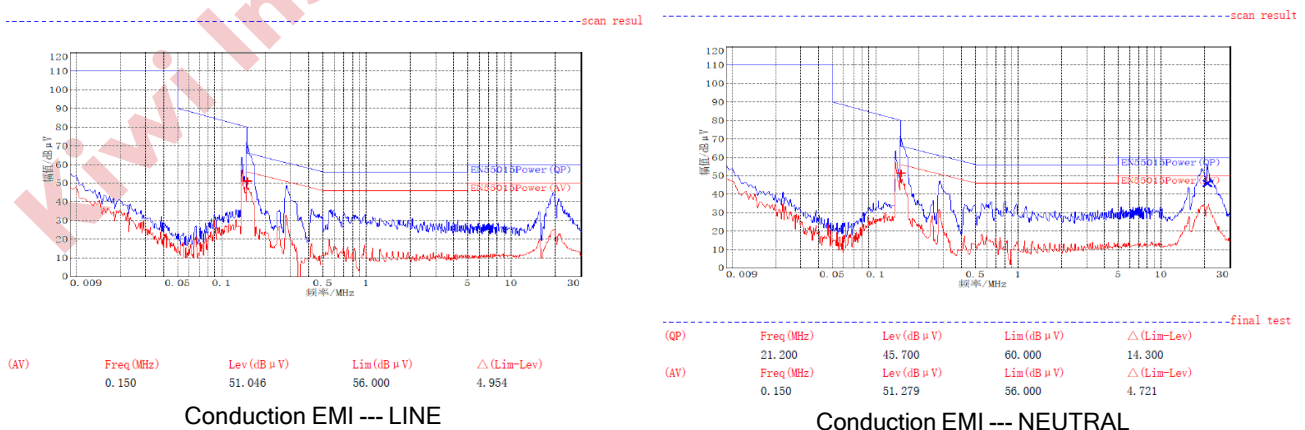
Test Conditions: Input :120/220VAC; Output: 450V110mA

Standard:

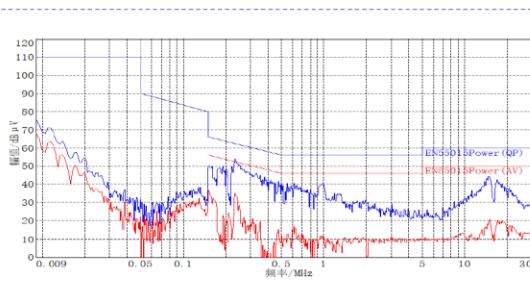
Standard	EN5015
Content	CE/CDN
Requirement	CE Margin>=3dB CDN Margin>=6dB

Result: Pass

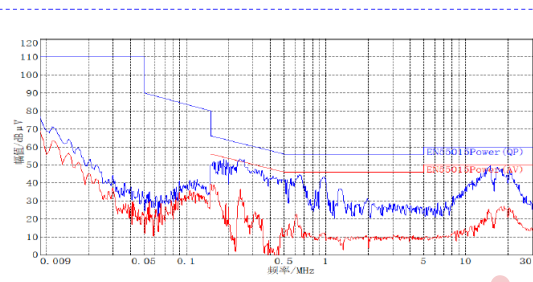
Test Condition: Vin=120VAC/60Hz, CE



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

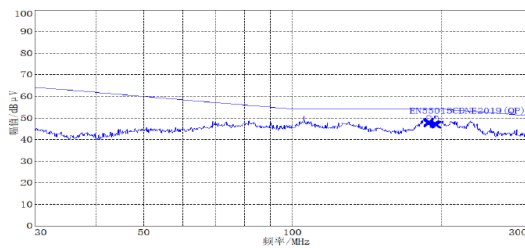


Radiation EMI --- LINE

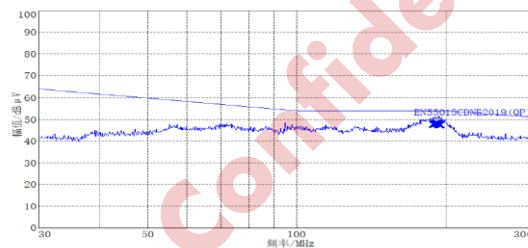


Radiation EMI --- NEUTRAL

Test Condition: CDN



Conduction CDN --- 120VAC/60Hz



Conduction CDN --- 220VAC/50Hz

(QP)	Freq(MHz)	Lev(dB uV)	Lim(dB uV)	Δ(Lim-Lev)
	189.000	47.380	54.000	6.620
	189.600	47.992	54.000	6.008
	194.700	47.100	54.000	6.900
	195.800	46.832	54.000	7.168
	196.000	46.640	54.000	7.360

(QP)	Freq(MHz)	Lev(dB uV)	Lim(dB uV)	Δ(Lim-Lev)
	189.200	47.784	54.000	6.216
	190.700	48.000	54.000	6.000
	192.100	48.100	54.000	5.900
	193.900	47.700	54.000	6.300
	194.500	47.500	54.000	6.500

3.6. Surge Test

Line to Line 4kV surge testing was completed according to IEC61000-4-5. Input voltage was set at 220VAC/50Hz. Output was loaded at full load and operation was verified following each surge event. Each injection phase below is tested with 5 times and hold for 30 seconds before next one.

Input Voltage (VAC)	Surge Level (V)	Injection Location	Injection Phase (°)	Test Result (Pass/Fail)
220Vac/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

Test Setup Guide

1. Set the AC Power Source between 120VAC and 277VAC.
2. Connect the AC Power Source terminal to the "L" and "N" terminals on the Demo Board.



Revision History

DATE	REV	DESCRIPTION
2023/10/12	1.0	First Release

Disclaimer

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