DEMO BOARD TEST REPORT

500W, Single Stage LLC Power Supply Reference Design with KP2591(A)

FEATURES

- Operating Frequency up to 350kHz
- VCO Control with High Accuracy
- Adaptive Dead-time Control
- Integrated Brown-out Detection and X-capacitor Discharge Function
- Support Application without PFC Stage
- Wide AC Input Range(180Vac~265Vac) with high efficiency up to 93.16% @ 265Vac & 10.5A Load (NTC Loss is included, which accounts for nearly 1% of total efficiency)
- Standby Power Consumption <240mW under Standby mode
- Integrated Protection Features of Auto-Recovery Mode

APPLICATIONS

- Adapter Power Supply
- TV LCD Power Supply
- LED Applications

INTRODUCTION

The KP2591(A) is a resonant switching power controller based on half-bridge LLC resonant converter, which integrates half-bridge driver with 50% duty cycle, and the maximum operating frequency is up to 350kHz.

The demo board of KP2591(A) is a single stage LLC converter without PFC stage to converter AC input voltage (180-265Vac) to isolated 48V DC output. The demo board has a regulated 48V output that can handle up to 10.5A of continuous output current for AC input range of 200-265Vac (burn-in 20 minutes @ open air of Ta=25℃ with no airflow), 9.75A of continuous output current for 190Vac, and 9A of continuous output current for 180Vac.

And the demo board is integrated with complete protection functions, such as output OVP, output short-circuit protection, output over load protection, AC brown-out protection ,and so on.

DEMO BOARD SEPCIFICATION

Description	Symbol	Min	Type	Max	Unit	Note
Input Voltage	Vin	180	230	265	Vac	
Output	Vout		48		V	
Rate Output Current	Iout	9	10.5	10.5	A	10.5A @ 200Vac~265Vac 9A @ 180Vac
Rate Output Power	Pout	432	500		W	500W @ 200Vac~265Vac 432W @ 180Vac
Ripple & Noise	Vripple			0.52	Vp-p	Board end @230Vac Full Load
Maximum Full Load Efficiency	η		93.16		%	Board end @265Vac
Standby Power Consumption	Pst			237	mW	@265Vac under Standby Mode
Startup Time	Tst			492	ms	Tested at 200Vac/50Hz and Full Load
Operating Ambient	Ta	0		40	℃	
Operating Humidity		5		95	%R.H.	

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

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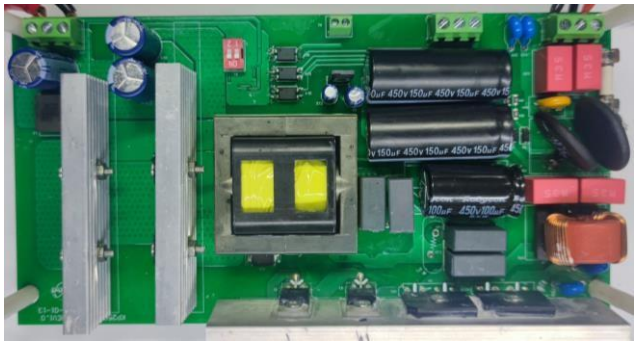
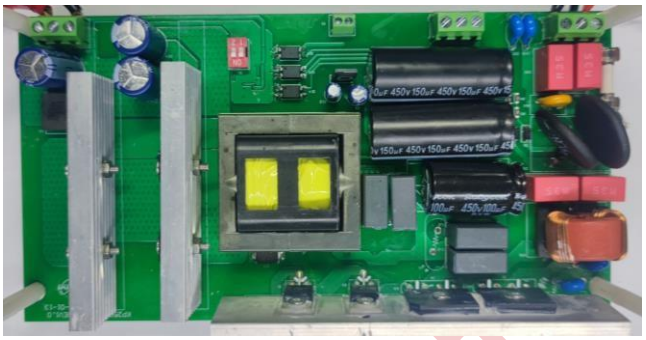
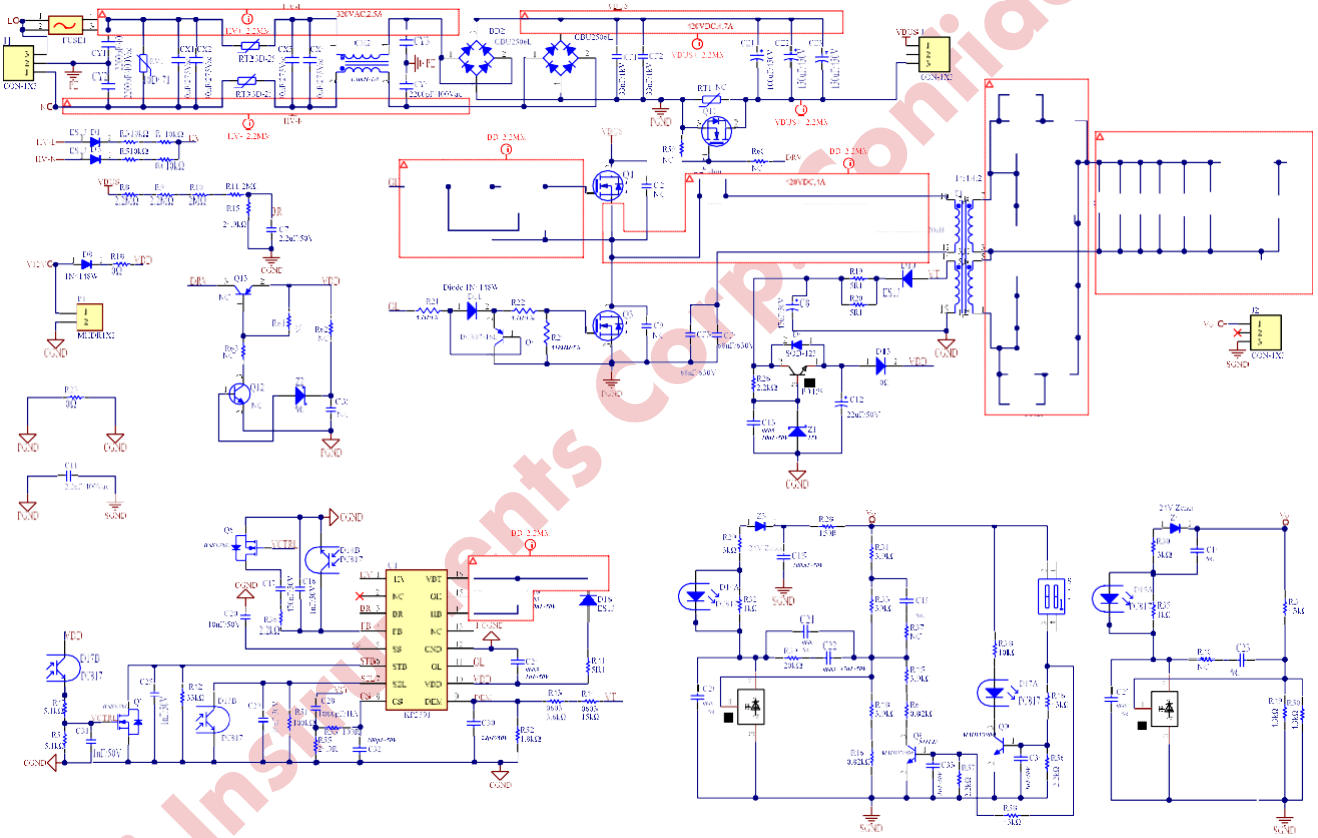
Demo Board of KP2591-D01-REV1.0





Board Size (mm): L x W x H = 206.5 x 106.5 x 28

Schematic



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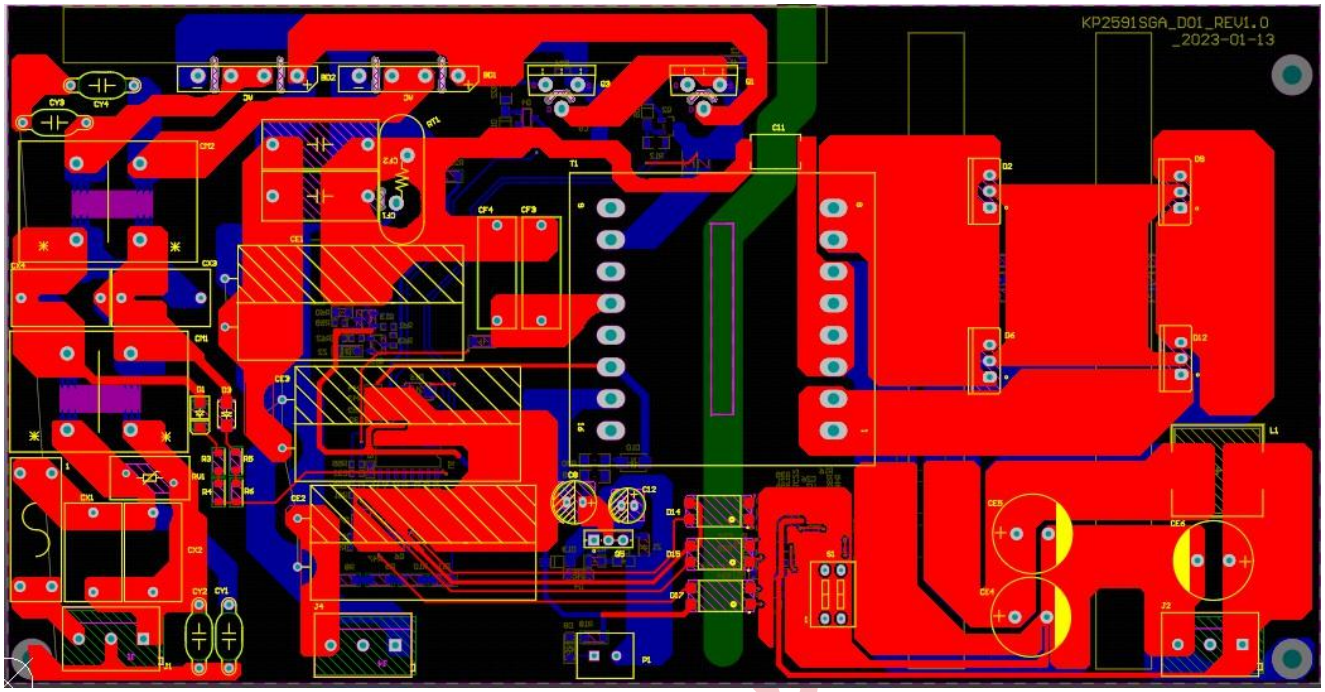
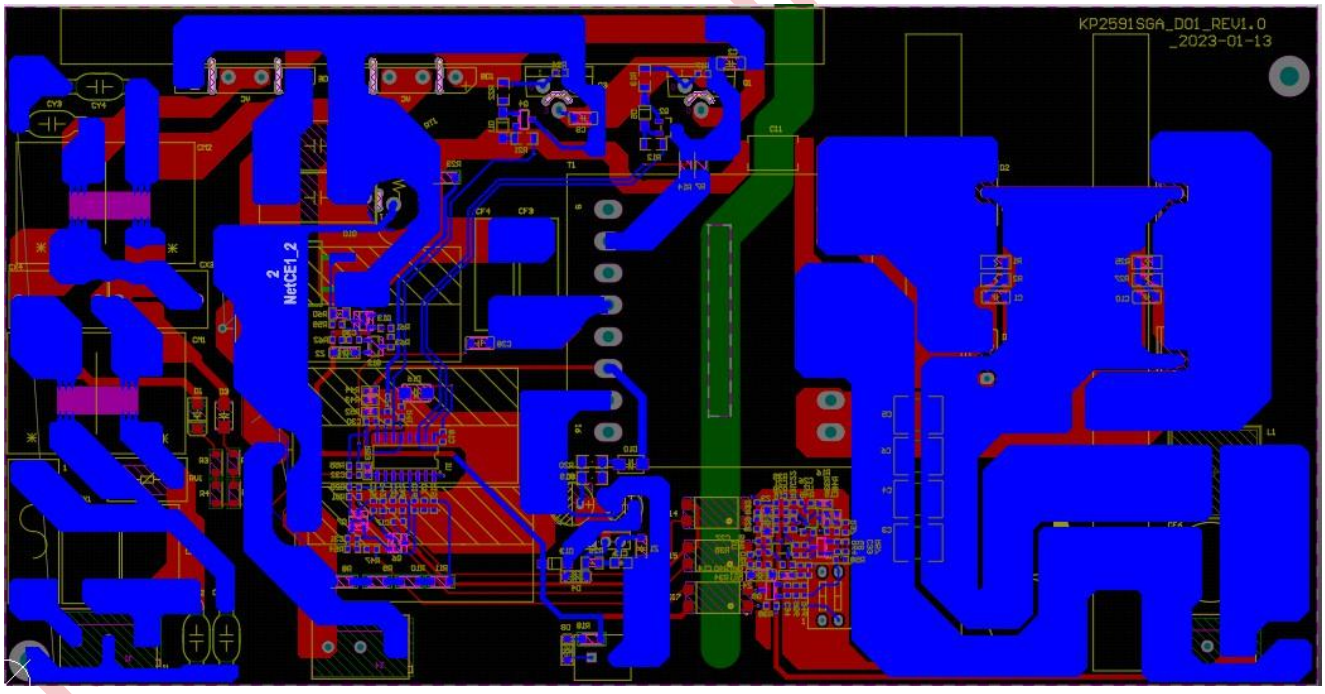
Printed Circuit Board Layout

Top Layer



Bottom Layer



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Bill of Material

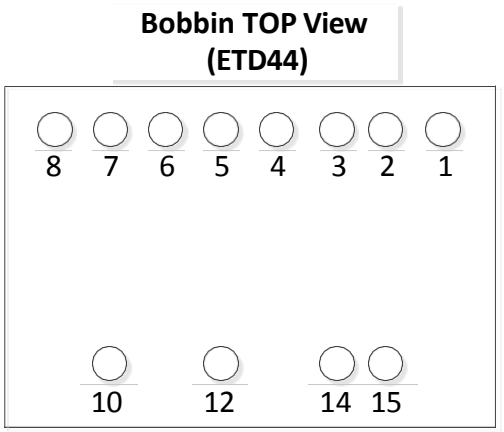
No.	Designator	Value	Description	Package	Manufacturer	Part Number
1	HS1		heart sink, 50mm*8mm*28mm	TH	KEFA	DG500-5.08-03P-14-00A(H）
2	HS2,HS3		heart sink, 80mm*8mm*28mm	TH		
3	J1 J2		Header, 3-Pin 5.08mm 300V 20A Green	TH	KEFA	DG500-5.08-03P-14-00A(H）
4	FUSE1	250Vac/10A	Spring Brass，Tin-plated，Ear for 5*20mm Fuses & 250Vac 10A Time-Lag Fuse	TH	Littlefuse	01110501Z
5	FUSE1	250V/10A	5×20mm Time-Lag surge withstand ceramic body cartridge fuse	TH	Littlefuse	0215010.MXP
6	T1	120μH	Transformer,ETD44, Pri:Sec1:Sec2:Aux = 14:4:4:2, Pri:0.1mm*100 Wire Sec:0.1mm*200 Wire	TH		
7	U1	KP2591SGA	High Voltage, Half-bridge LLC Resonant Controller	SOP-16	KIWI	KP2591SGA
8	U2, U3	TL431	Precision adjustable shunt, VREF=2.5V 1% 37V	SOT23	JSMSEMI	TL431
9	BD1, BD2	600V/25A	25A 600V BRIDGE RECTIFIER(VF=0.95V@IF=12.5A)	GBU	World	GBU2506L
10	C1, C10	1nF/1000V	Ceramic Cap 1000V ±10% X7R	1206,	WE	8.85342E+11
11	C16	1nF/50V	Ceramic Cap 50V ±5% NPO	0603	WE	8.85012E+11
12	R7,R14	Jump	/	1206	/	/
13	C3, C4, C5, C6	10μF/100V	Ceramic Cap 100V ±10% X7R	2220	PSA	FS55X106K101EHG
14	C7	2.2μF/50V	Ceramic Cap 50V ±10% X5R	0603	YAGEO	CC0603KRX5R9BB225
15	C8	47μF/50V	Electrolytic Cap 50V 6.3*11mm P2.5	TH	AISHI	ERS1HM470E11OT
16	C11	2.2nF/400V	Y1 Capacitor 400Vac SMD 7.8*5.4*2.38	SMD	TRX	TMY1222M
17	C12	22μF/50V	Electrolytic Cap 50V 5*11mm P2.0	TH	AISHI	ERS1HM220D12OT
18	C13	10nF/50V	Ceramic Cap 50V ±10% X7R	0805,	WE	8.85012E+11
19	C15, C18	100nF/50V	Ceramic Cap 50V ±10% X7R	0603	WE	8.85012E+11
20	C17	470nF/50V	Ceramic Cap 50V ±10% X7R	0603	YAGEO	CC0603KRX7R9BB474
21	C20, C29	10nF/50V	Ceramic Cap 50V ±10% X7R	0603	WE	885012206089
22	C22	47nF/50V	Ceramic Cap 50V ±10% X7R	0603	WE	885012206093
23	C24	1μF/50V	Ceramic Cap 50V ±10% X7R	0603	WE	885012206126
24	C25, C31, C33, C34	1nF/50V	Ceramic Cap 50V ±5% NPO	0603	WE	885012006063
25	C28	1nF/1000V	Ceramic Cap 1000V ±10% X7R	1206	WE	885342208018
26	C30	22pF/50V	Ceramic Cap 50V ±5% NPO	0603	WE	885012006053
27	C32	100pF/50V	Ceramic Cap 50V ±5% NPO	0603	WE	885012006057
28	CE1	100μF/450V	Electrolytic Cap 450V 18*35mm P7.5	TH	AISHI	EWH2WM101M35OT
29	CE2, CE3	150μF/450V	Electrolytic Cap 450V 18*40mm P7.5	TH	AISHI	EWH2WM151M45OT

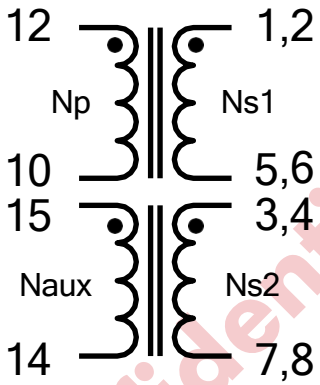
30	CE4, CE5, CE6	680μF/63V	Electrolytic Cap 100V 12.5*25mm P5	TH	AISHI	ERR1JM681W 25OT
31	CF1, CF2	33nF/1000V	Film Capacitor 1000Vdc 18*7.5*13.5mm P15	TH	KYET	KP333J1000V P15
32	CF3, CF4	68nF/630V	Film Capacitor 630Vdc 18*14.5*8.5mm P15	TH	KYET	KP683J0630V P15
33	CM2	3.3mH/4A	Würth Elektronik Inductor,Isat=4A,Rdc=35mΩ,	TH	Wurth Elektronik	744824433
34	CX1, CX2, CX3, CX4	330nF/275Vac	X2 Capacitor 275Vac 15*8.5*14 P12.5	TH	WE	890324024003 CS
35	CY1, CY2, CY3, CY4	2.2nF/400Vac	Y1 Capacitor 400Vac ±10% T5 P10	TH	STE	Q09F1D222M N0B0S0N0
36	D1, D3, D10, D16	600V/1A	DIO FRD 600V 1A 1.7V@1A	SMA	Onsemi	ES1J
37	D2, D6, D9, D12	150V/30A	DOIDE 150V 30A 1.05V@15A	TH	CJ	SBDF30150S CTB
38	D4, D5, D8, D10, D11,	100V/0.15A	DIO FRD 100V 150mA 1.25V@150mA	SOD123	CJ	1N4148W
39	D13	0Ω/5%	Chip Resistor ±1% 1/4W	SOD123	FH	RS-06000FT
40	D14, D15, D17		PHOTO TR 50mA 200%-400%	SMD-4	EVERLIGHT	EL817S1(A)(TU)-F
41	Q1, Q3,	600V/31A	MOSFET 600V 31A 105mΩ @10V, 18A	TO-220	Infineon	IPP60R099CP
42	L1	330nH	INDUCTOR Irated 26A Rdc 0.155Ω 13.8*5.4mm	SMD	WE	744305033
43	Q2, Q4	45V/500mA	PNP 45V 500mA 300mW	SOT-23	onsemi	BC807-16LT3G
44	Q5	60V/1.5A	PNP 60V 1.5A 500mV@500mA,50mA	TO-126-3	ST	BD138
45	Q6, Q7	50V/300mA	MOSFET 50V 300mA 300mW 1.5Ω@10V,500mA	SOT-23	ElecSuper	BSS138L
46	Q8, Q9	MMBT3904	NPN 40V 200mA 300mV@50mA,5mA	SO-T23	CJ	MMBT3904
47	R1, R2, R25, R27	300Ω/5%	Chip Resistor ±5% 1/4W	1206	FH	RS-06K3000FT
48	R3, R4, R5, R6	10kΩ/1%	Chip Resistor ±1% 1/4W	1206	FH	RS-06K1002FT
49	R8, R9	2.2MΩ/1%	Chip Resistor ±1% 1/4W	1206	FH	RS-06L2204FT
50	R10, R11	2MΩ/1%	Chip Resistor ±1% 1/4W	1206	FH	RS-06L2004FT
51	R12, R13, R19, R20 R21, R22, R41	5.1Ω/1%	Chip Resistor ±1% 1/4W	1206	UNI-ROYAL	1206W4F510K T5E
52	R15	24.9kΩ/1%	Chip Resistor ±1% 1/10W	0603	FH	RS-03K2492FT
53	R16, R64	820Ω/1%	Chip Resistor ±1% 1/10W	0603	FH	RS-03K8200FT
54	R17, R24	51kΩ/5%	Chip Resistor ±5% 1/10W	0603	FH	RS-03K5102FT
55	R18, R23	0Ω/1%	Chip Resistor ±1% 1/4W	1206	FH	RS-06000FT
56	R28	150Ω/1%	Chip Resistor ±1% 1/10W	0603	FH	RS-03K1500FT
57	R29, R30	3kΩ/1%	Chip Resistor ±1% 1/10W	0603	FH	RS-03K3001FT
58	R32, R35	1kΩ/1%	Chip Resistor ±1% 1/10W	0603	FH	RS-03K1001FT
59	R33	39kΩ/1%	Chip Resistor ±1% 1/10W	0603	FH	RS-03K3902FT

60	R34, R46, R58	43kΩ/1%	Chip Resistor ±1% 1/10W	0603	FH	RS-03K4302FT
61	R26, R36, R56, R57	2.2kΩ/1%	Chip Resistor ±1% 1/10W	0603	FH	RS-03K2201FT
62	R38	10kΩ/1%	Chip Resistor ±1% 1/10W	0603	FH	RS-03K1002FT
63	R39	20kΩ/1%	Chip Resistor ±1% 1/10W	0603	FH	RS-03K2002FT
64	R42	33kΩ/1%	Chip Resistor ±1% 1/10W	0603	FH	RS-03K3302FT
65	R43	3.6kΩ/1%	Chip Resistor ±1% 1/10W	0603	FH	RS-03K1601FT
66	R44	15kΩ/1%	Chip Resistor ±1% 1/10W	0603	FH	RS-03K1502FT
67	R31, R45, R48	3.9kΩ/1%	Chip Resistor ±1% 1/10W	0603	FH	RS-03K3901FT
68	R47, R54	5.1kΩ/1%	Chip Resistor ±1% 1/10W	0603	FH	RS-03K5101FT
69	R49, R50	4.3kΩ/1%	Chip Resistor ±1% 1/10W	0603	FH	RS-03K4301FT
70	R51	100kΩ/1%	Chip Resistor ±1% 1/10W	0603	FH	RS-03K1003FT
71	R52	1.8kΩ/1%	Chip Resistor ±1% 1/10W	0603	FH	RS-03K1801FT
72	R53	100Ω/1%	Chip Resistor ±1% 1/10W	0603	FH	RS-03K1000FT
73	R55	24.9Ω/1%	Chip Resistor ±1% 1/10W	0603	FH	RS-03K24R9FT
74	RT2, RT3	MF72 3D25	NTC 3Ω @ 25℃ 9A @ 25℃	TH	Shiheng	MF72 3D25
75	RV1	10D471	VARISTOR 300VAC 70J 2500A	TH	WE	820513011
76	S1	/	2.54mm 2 Position DIP Switches	TH	/	YDA02HG2
77	Z1	MMSZ5245C-E3-08	Diode Zener 15V ±2% 500mW	SOD-123	VISHAY	MMSZ5245C-E3-08
78	Z3, Z4	BZT52-B24S	Diode Zener 24V 2% 200mW	SOD-123	PANJIT	BZT52-B24S

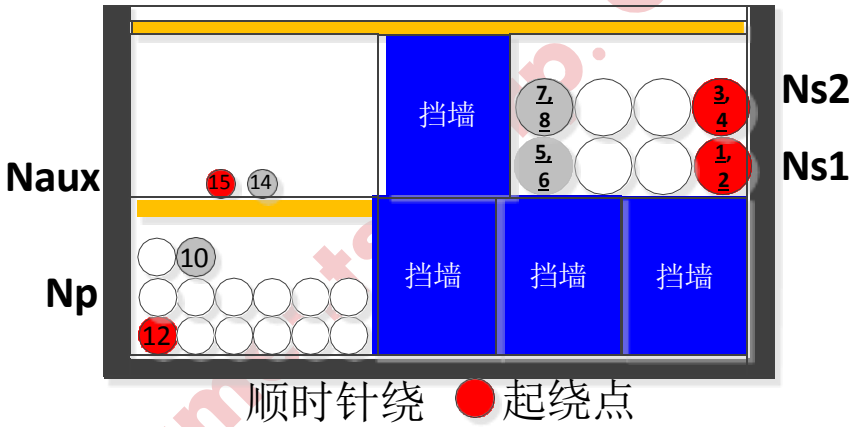
Transformer Manufacture Guide

1 Electrical Diagram





2 Winding Diagram



3 Winding Order

Number	Winding	Layer	Start	End	Wire Size (mm)	Turns	Note
1	Npri	Primary	Pin12	Pin10	0.1*100P	14Ts	Dense
2	Naux	Auxiliary	Pin15	Pin14	0.2*2P	2Ts	Dense
3	Ns1	Secondary	Pin1,2	Pin5,6	0.1*200P	4Ts	Dense
4	Ns2	Secondary	Pin3,4	Pin7,8	0.1*200P	4Ts	Dense

4 Electrical Specification

Items	Test Pin	Specification	Test Condition
Primary Inductance	100kHz,100mVAC，Ls	Pin 12 – 10	120μH (±10%)
Leakage Inductance	10kHz,100mVAC，Ls (tie 1,2,3,4,5,6,7,8)	Pin 12 – 10	20μH (±10%)
Turn Ratio		(12-10): (15-14)	14Ts:2Ts
Turn Ratio		(12-10):(1,2-5,6):(3,4-7,8)	14Ts: 4Ts:4Ts
DC Resistance	@20℃	Pin 12 – 10	0.05R Max
DC Resistance	@20℃	Pin 1,2 – 5,6	0.01R Max
DC Resistance	@20℃	Pin 3,4 - 7,8	0.01R Max

5 BOM

Number	Materials	Specifications
1	Core	ETD44, 8+8 pin, Vertical
2	Bobbin	ETD44, TPG33 or equivalent, AE=175mm^2
3	Wire	0.1mmΦ*100P, 2UEW, Litz
4	Wire	Φ0.2mm, 2UEW
5	Wire	0.1mmΦ*200, QA-1/155
6	Duct tape	W=13mm, T=0.1mm
7	Barricade	W=4mm, T=0.1mm

Test Result

1 Input Characteristics

1.1 No Load Input Power Dissipation

Standard: While input 180Vac~265Vac and the output is no load, the input power loss must be less than 1W.

Result: Pass

Test Data: (Switch S1 to ON is Normal Mode, and Switch S1 to OFF is Standby Mode)

Vin (ac)	180V	200V	230V	265V	Result
Normal Mode Ptotal(W)	1.894	1.932	2.236	0.88	
Standby Mode Ptotal(W)	0.165	0.165	0.195	0.237	PASS

1.2 Efficiency

Standard: The average efficiency tested at the board end should larger than 89% @230vac.

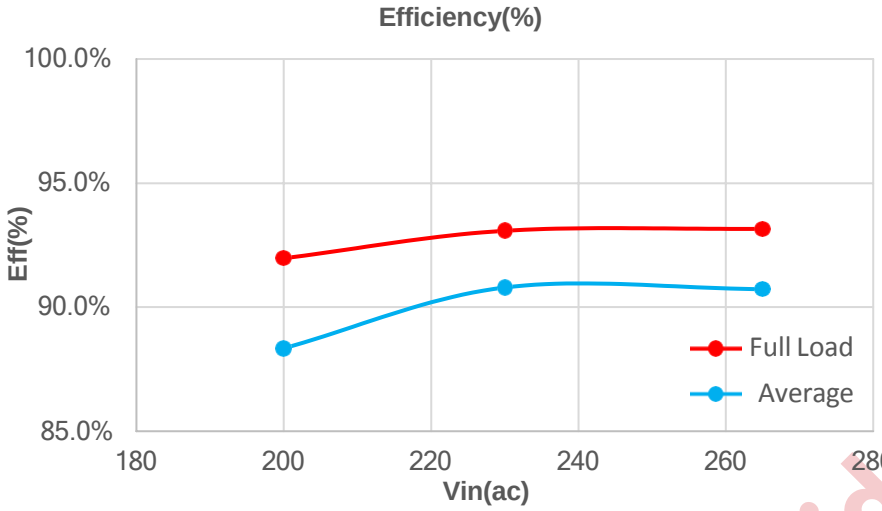
Result: The loss of NTC accounts for nearly 1% of the total efficiency.

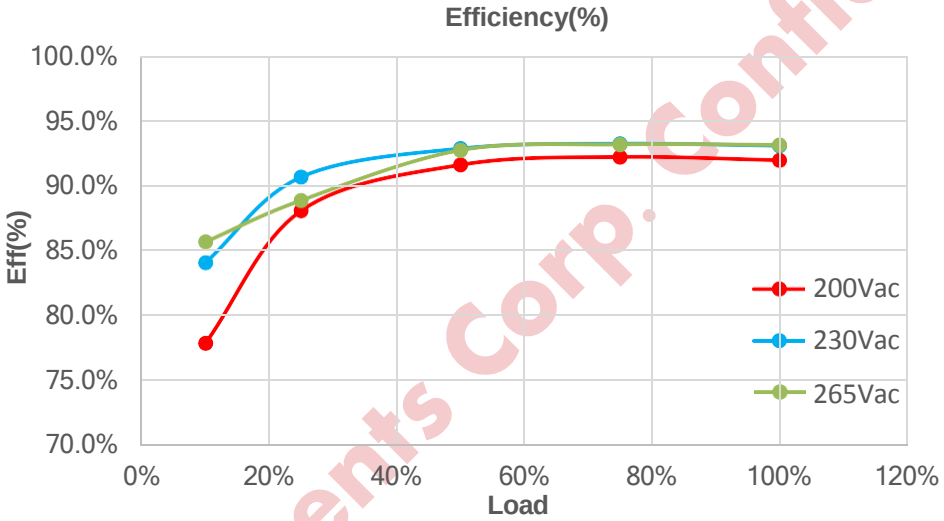
Test Data:

Output	Average Eff (%)			
	200Vac	230Vac	265Vac	Result
48V	88.34	90.79	90.72	PASS

Efficiency (48V/10.5A):

Vin (Vac)	Fline (Hz)	Pin (W)	Vout (V)	Iout(A)	Pout(W)	Eff (%)	Eff_AVG (%)
200	50	545.70	47.80	10.500	501.869	91.97	88.34
		408.20	47.80	7.875	376.433	92.22	
		273.90	47.80	5.250	250.929	91.61	
		142.40	47.78	2.625	125.417	88.07	
		64.42	47.76	1.050	50.148	77.85	
230		538.40	47.727	10.500	501.134	93.08	90.79
		403.10	47.733	7.875	375.897	93.25	
		269.80	47.728	5.250	250.572	92.87	
		138.11	47.707	2.625	125.231	90.67	
		59.58	47.702	1.050	50.087	84.07	
265		538.40	47.767	10.500	501.554	93.16	90.72
		403.70	47.769	7.875	376.181	93.18	
		270.40	47.763	5.250	250.756	92.74	
		141.05	47.755	2.625	125.357	88.87	
		58.52	47.748	1.050	50.135	85.67	





2 Output Characteristics

2.1 Output Line Regulation and Load Regulation

Standard: Under the input voltage 200Vac~265Vac, line regulation <6%, load regulation <6%. The output voltage is tested at the output cap end.

Result: Pass

Test Data:

Input Voltage	Output Voltage(V)					Load Regulation
	10% Load	25% Load	50% Load	75% Load	Full Load	
200Vac/60Hz	47.760	47.778	47.796	47.801	47.797	0.09%
230Vac/50Hz	47.702	47.707	47.728	47.733	47.727	0.06%
265Vac/50Hz	47.748	47.755	47.763	47.769	47.767	0.04%
Line Regulation	0.12%	0.15%	0.14%	0.14%	0.15%	

2.2 Ripple & Noise

Standard: Under the input voltage 180Vac~265Vac, Vripple_max<150mV.

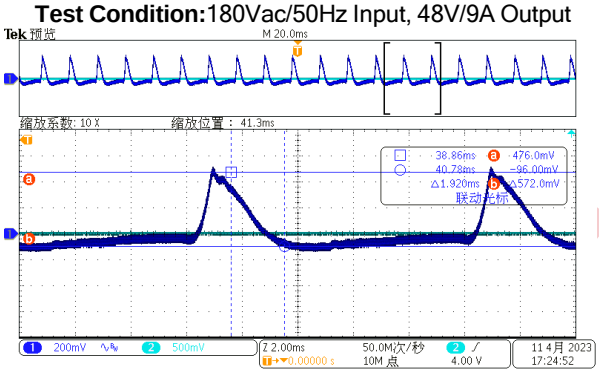
Result: Most of the ripple voltage comes from the ripple of the bus capacitors, which depends on the value of the bus capacitors.

Note: Ripple & noise are measured with minimum measurement loop. Bandwidth is limited to 20MHz.

Input Voltage	No Load Ripple(mV)	Full Load Ripple(mV)
	48V/0A	48V/10.5A
180Vac/50Hz	0.604V	0.572V(48V/9A)
200Vac/50Hz	0.592V	0.496V
230Vac/50Hz	0.292V	0.52V
265Vac/50Hz	0.202V	0.304V

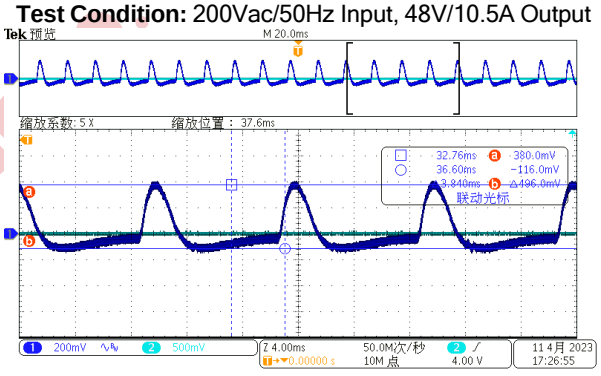
Waveforms:

Test Condition:180Vac/50Hz Input, 48V/9A Output



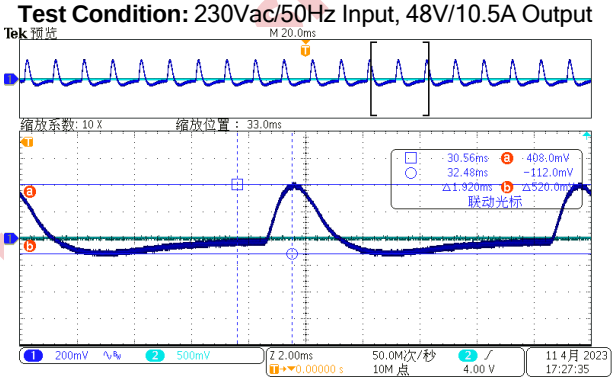
(CH2- Vripple)
Comments: Vripple=0.572V

Test Condition: 200Vac/50Hz Input, 48V/10.5A Output



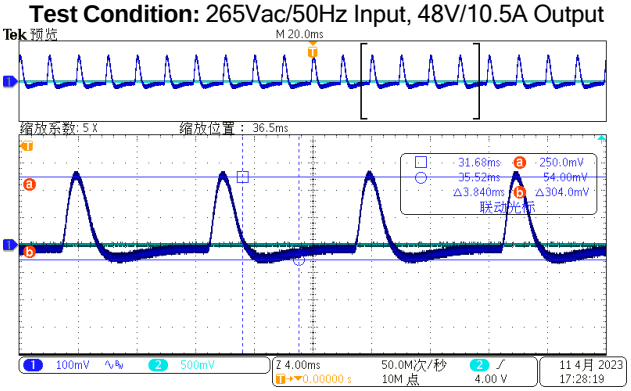
(CH2- Vripple)
Comments: Vripple=0.496V

Test Condition: 230Vac/50Hz Input, 48V/10.5A Output



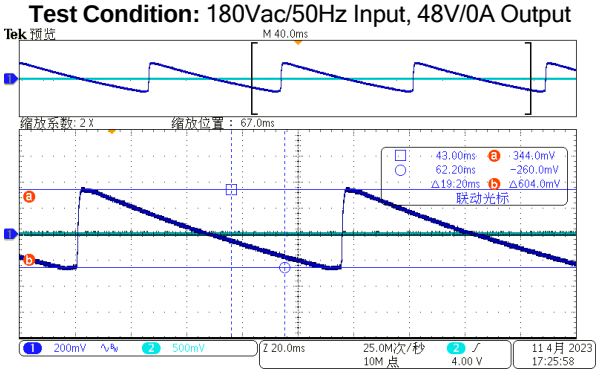
(CH2- Vripple)
Comments: Vripple=0.52V

Test Condition: 265Vac/50Hz Input, 48V/10.5A Output



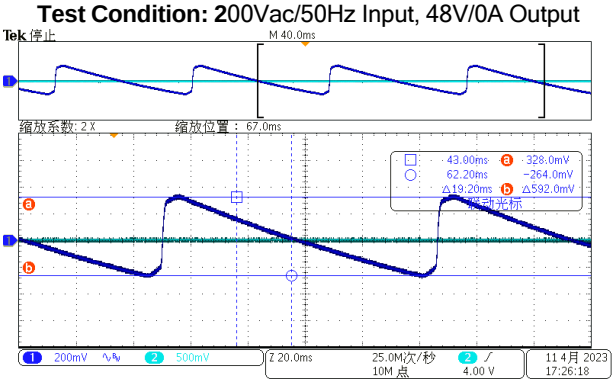
(CH2- Vripple)
Comments: Vripple=0.304V

Test Condition: 180Vac/50Hz Input, 48V/0A Output



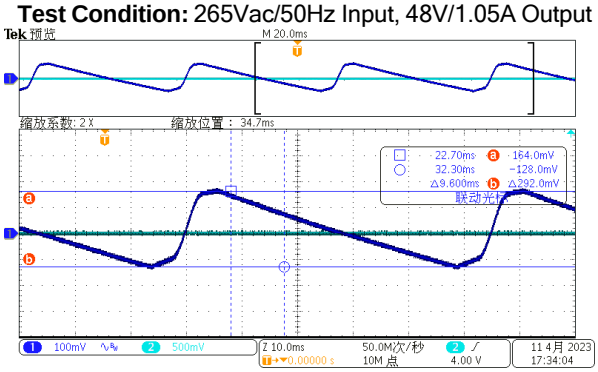
(CH2- Vripple)
Comments: Vripple=0.604V

Test Condition: 200Vac/50Hz Input, 48V/0A Output



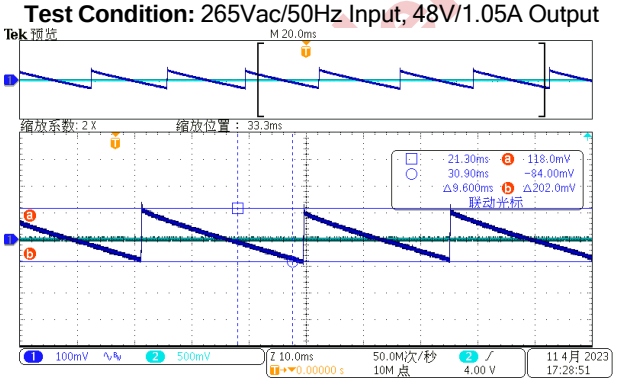
(CH2- Vripple)
Comments: Vripple=0.592V

Test Condition: 265Vac/50Hz Input, 48V/1.05A Output



(CH2- Vripple)
Comments: Vripple=0.292V

Test Condition: 265Vac/50Hz Input, 48V/1.05A Output



(CH2- Vripple)
Comments: Vripple=0.202V

2.3 Load Transient Test

Standard: Under the input voltage 180Vac~265Vac, the output voltage transient response should be within ±10% normal voltage.

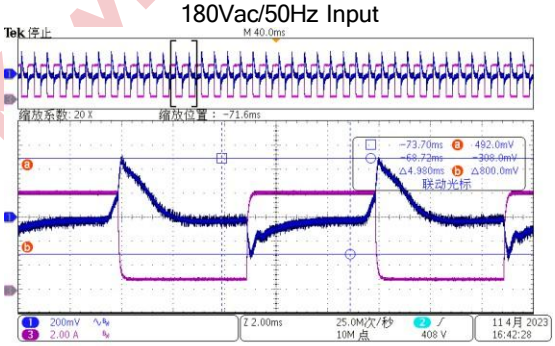
Result: Pass

Note: 10% load shift to 90% load with 0.25A/μs changing ramp and 100Hz changing frequency.

Input Voltage	180Vac/50Hz	200Vac/50Hz	230Vac/50Hz	265Vac/50Hz
△Vo	0.8V	0.744V	0.736V	4.54V

Waveforms:

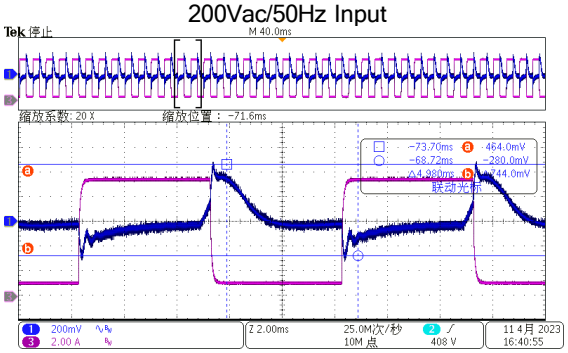
Test Condition: Load 48V/(0.09-8.1)A, frequency 100Hz, duty Cycle=50%, slew rate=0.25A/μs
180Vac/50Hz Input



(CH1-Vpfcok, CH2-Vo(AC), CH3-Io, CH4-Iac)
Comments: △Vo =0.8V

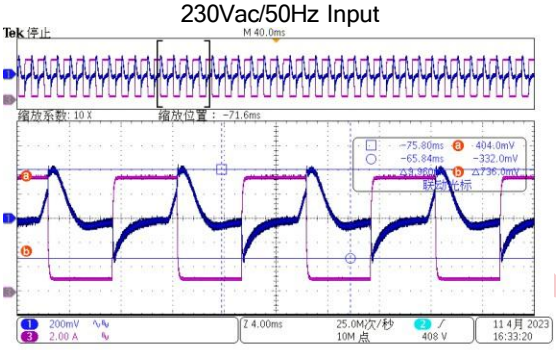
Test Condition: Load 48V/(1.05-9.45)A, frequency 100Hz, duty Cycle=50%, slew rate=0.20A/μs

200Vac/50Hz Input



(CH1-Vpfcok, CH2-Vo(AC), CH3-Io, CH4-Iac)
Comments: ΔVo =0.744V

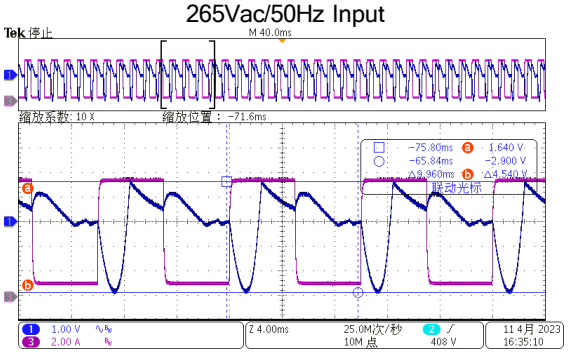
230Vac/50Hz Input



(CH1-Vpfcok, CH2-Vo(AC), CH3-Io, CH4-Iac)
Comments: ΔVo =0.736V

Test Condition: Load 48V/(1.05-9.45)A, frequency 100Hz, duty Cycle=50%, slew rate=0.25A/μs

265Vac/50Hz Input



(CH1-Vpfcok, CH2-Vo(AC), CH3-Io, CH4-Iac)
Comments: ΔVo =4.54V

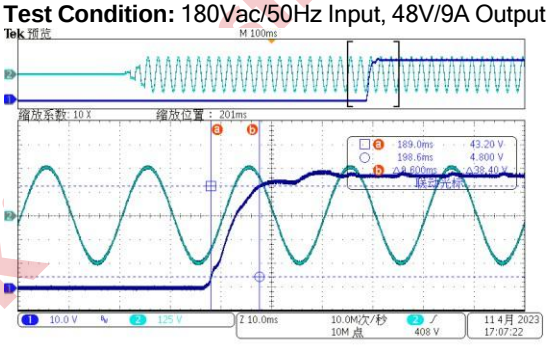
2.4 Capacitive Load Startup Test

Standard: While capacitance load is 3000μF, the power supply can turn on normally and the output is in the rated range.

Result: Pass

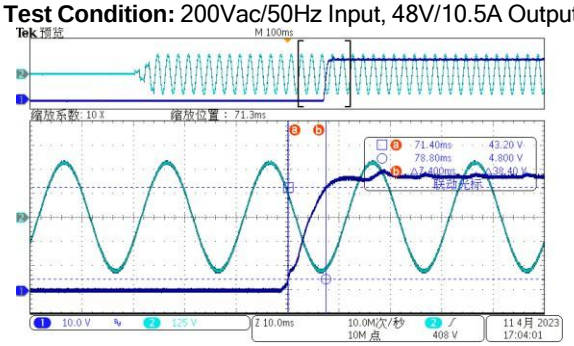
Note: Tested at the output cap end.

Test Condition: 180Vac/50Hz Input, 48V/9A Output



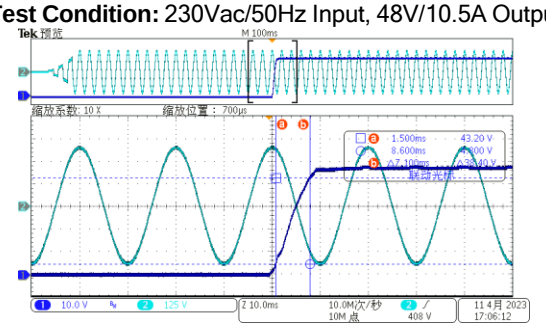
(CH1-Vo, CH2-Vinac)
Comments: Raise Time=8.6ms

Test Condition: 200Vac/50Hz Input, 48V/10.5A Output



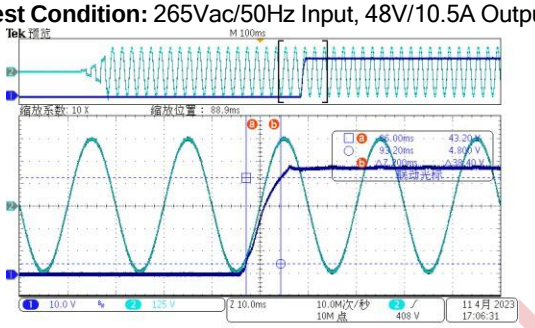
(CH1-Vo, CH2-Vinac)
Comments: Raise Time=7.4ms

Test Condition: 230Vac/50Hz Input, 48V/10.5A Output



(CH1-Vo, CH2-Vinac)
Comments: Raise Time=7.1ms

Test Condition: 265Vac/50Hz Input, 48V/10.5A Output



(CH1-Vo, CH2-Vinac, CH3-Ir)
Comments: Vo-peak=7.2V

2.5 Startup Time and Raise Time

Standard: The startup time should be less than 3s @180Vac~265Vac.

Result: Pass

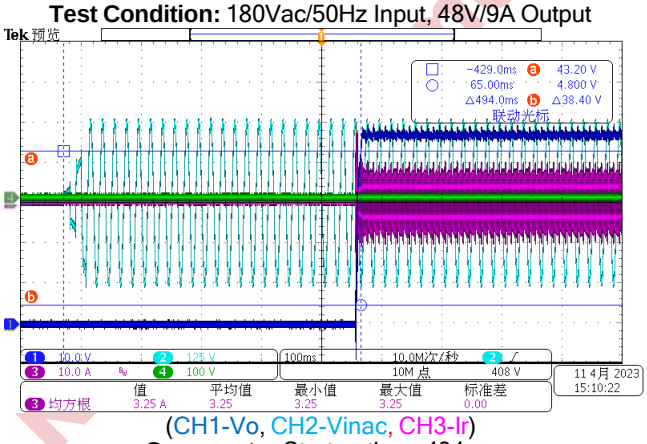
Note: The output voltage is tested at the output cap end.

Test Data:

Input Voltage	180Vac/50Hz	200Vac/50Hz	230Vac/50Hz	265Vac/50Hz
Output	**48V/9A**	**48V/10.5A**	**48V/10.5A**	**48V/10.5A**
Startup Time(ms) Full Load	494ms	492ms	476ms	473ms
Raise Time(ms) Full Load	8.1ms	5.68ms	4.88ms	5ms
Raise Time(ms) No Load	6.04ms	5.52ms	5.04ms	4.64ms

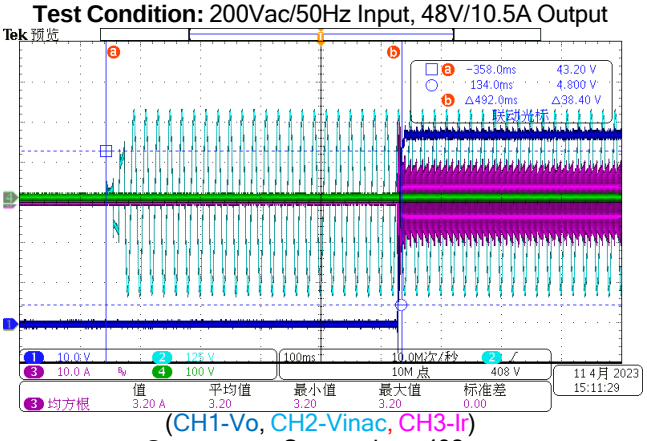
Waveforms:

Test Condition: 180Vac/50Hz Input, 48V/9A Output



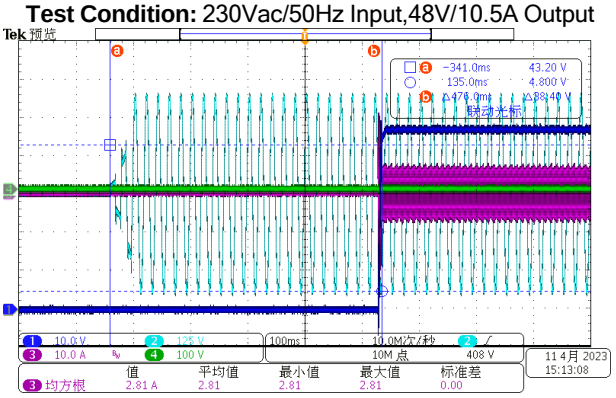
(CH1-Vo, CH2-Vinac, CH3-Ir)
Comments: Startup time=494ms

Test Condition: 200Vac/50Hz Input, 48V/10.5A Output



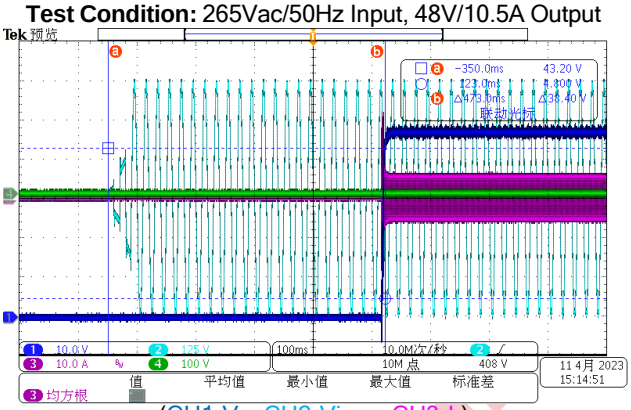
(CH1-Vo, CH2-Vinac, CH3-Ir)
Comments: Startup time=492ms

Test Condition: 230Vac/50Hz Input,48V/10.5A Output



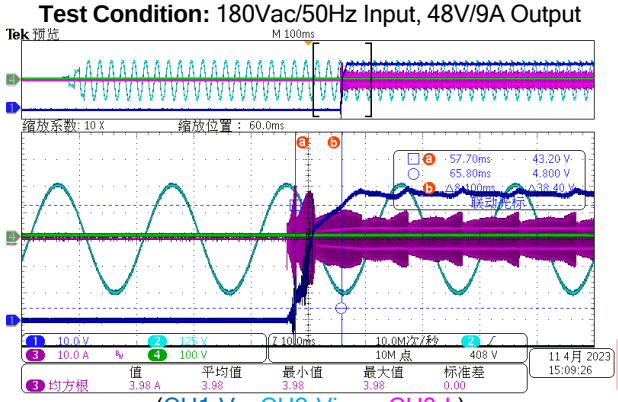
(CH1-Vo, CH2-Vinac, CH3-Ir)
Comments: Startup time=476ms

Test Condition: 265Vac/50Hz Input, 48V/10.5A Output



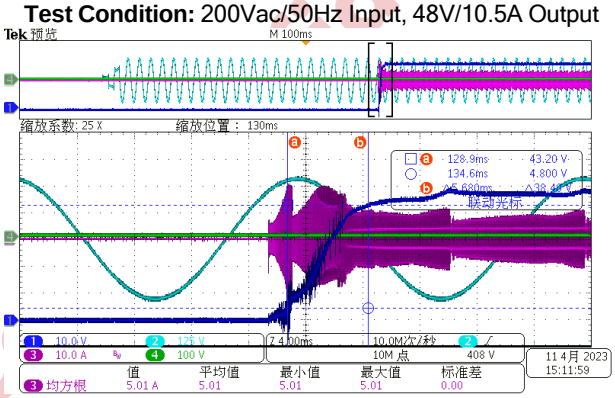
(CH1-Vo, CH2-Vinac, CH3-Ir)
Comments: Startup time=473ms

Test Condition: 180Vac/50Hz Input, 48V/9A Output



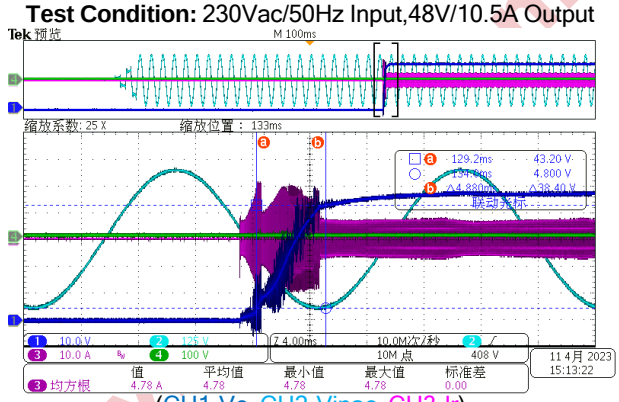
(CH1-Vo, CH2-Vinac, CH3-Ir)
Comments: Raise time=8.1ms

Test Condition: 200Vac/50Hz Input, 48V/10.5A Output



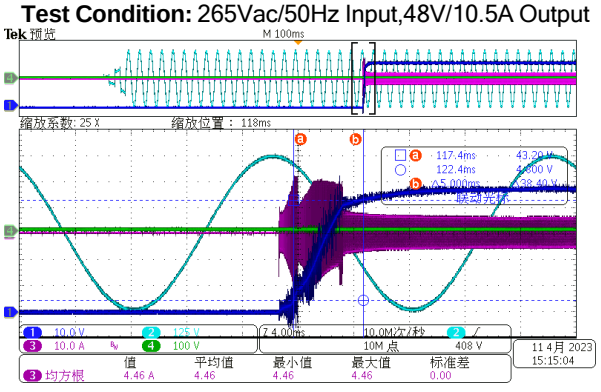
(CH1-Vo, CH2-Vinac, CH3-Ir)
Comments: Raise time=5.68ms

Test Condition: 230Vac/50Hz Input,48V/10.5A Output



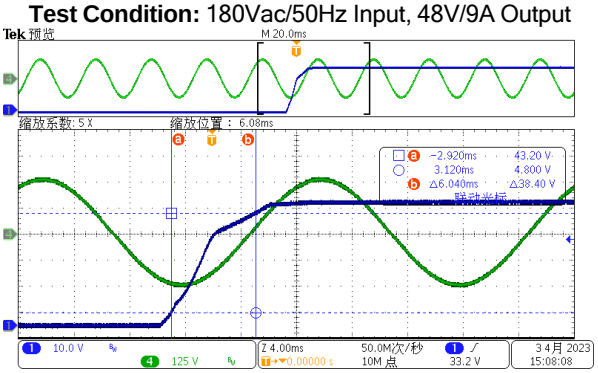
(CH1-Vo, CH2-Vinac, CH3-Ir)
Comments: Raise time=4.88ms

Test Condition: 265Vac/50Hz Input,48V/10.5A Output



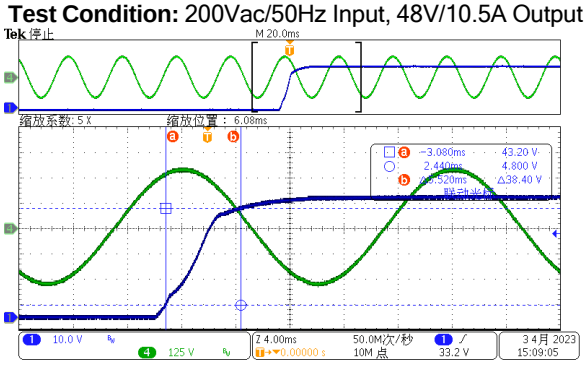
(CH1-Vo, CH2-Vinac, CH3-Ir)
Comments: Raise time=5ms

Test Condition: 180Vac/50Hz Input, 48V/9A Output



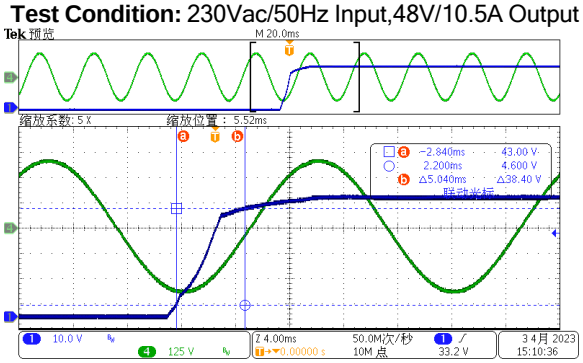
(CH1-Vo, CH2-Vinac, CH3-Ir)
Comments: Raise time=6.04ms

Test Condition: 200Vac/50Hz Input, 48V/10.5A Output



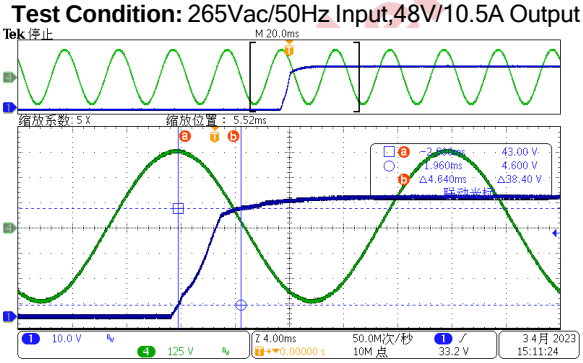
(CH1-Vo, CH2-Vinac, CH3-Ir)
Comments: Raise time=5.52ms

Test Condition: 230Vac/50Hz Input,48V/10.5A Output



(CH1-Vo, CH2-Vinac, CH3-Ir)
Comments: Raise time=5.04ms

Test Condition: 265Vac/50Hz Input,48V/10.5A Output



(CH1-Vo, CH2-Vinac, CH3-Ir)
Comments: Raise time=4.64ms

2.6 Holdup Time and Fall Time

Standard: The holdup time should be larger than 5ms@180-265Vac.

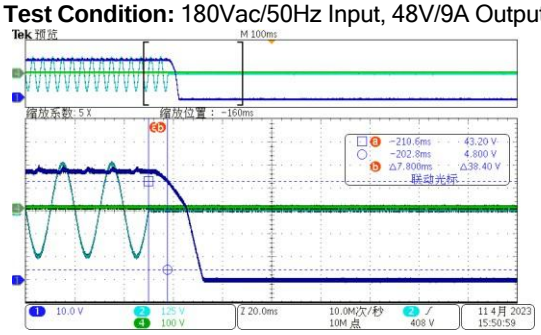
Result: Pass

Note: The output voltage is tested at the output cap end.

Input Voltage	180Vac/50Hz	200Vac/60Hz	230Vac/50Hz	265Vac/50Hz
Output	48V/9A	48V/10.5A	48V/10.5A	48V/10.5A
Hold-up Time(ms)	7.8ms	8.6ms	15.6ms	26.2ms
Fall Time(ms)	13.4ms	21ms	28.6ms	33.4ms

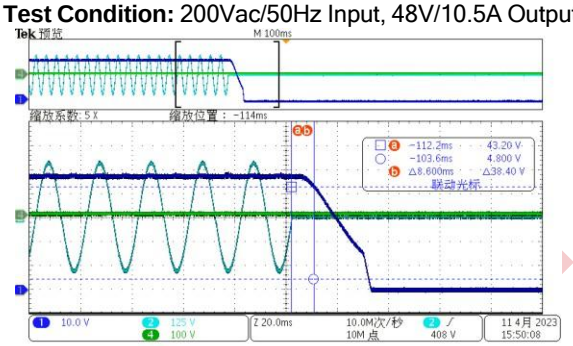
Waveforms:

Test Condition: 180Vac/50Hz Input, 48V/9A Output



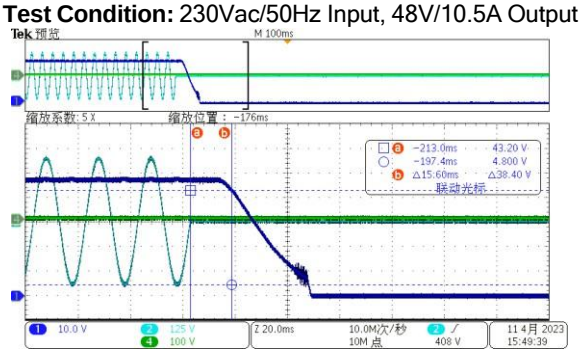
(CH1-Vo, CH2-Vinac)
Comments: Holdup time=7.8ms

Test Condition: 200Vac/50Hz Input, 48V/10.5A Output



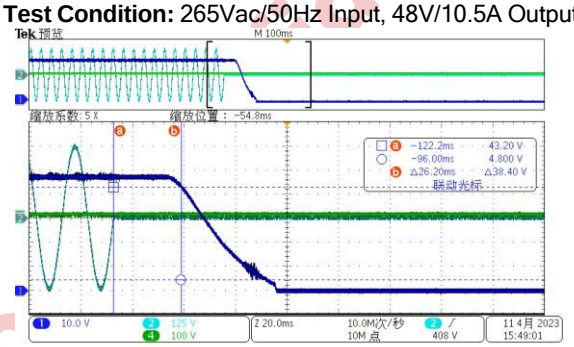
(CH1-Vo, CH2-Vinac)
Comments: Holdup time=8.6ms

Test Condition: 230Vac/50Hz Input, 48V/10.5A Output



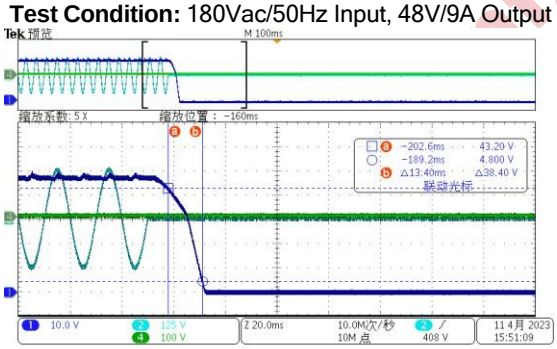
(CH1-Vo, CH2-Vinac)
Comments: Comments: Holdup time=15.6ms

Test Condition: 265Vac/50Hz Input, 48V/10.5A Output



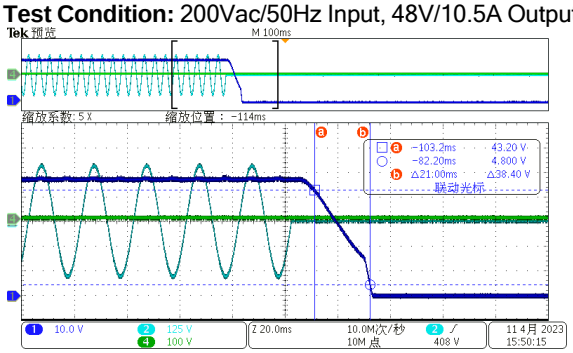
(CH1-Vo, CH2-Vinac)
Comments: Comments: Holdup time=26.2ms

Test Condition: 180Vac/50Hz Input, 48V/9A Output



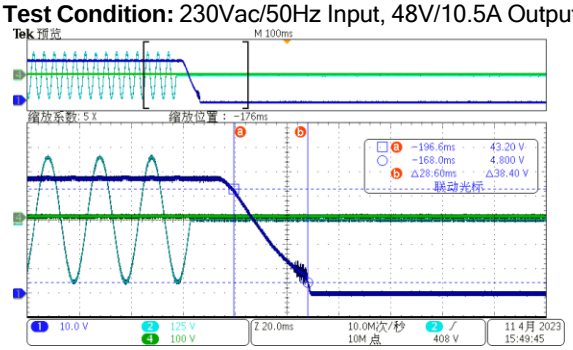
(CH1-Vo, CH2-Vinac)
Comments: Comments: Fall time=13.4ms

Test Condition: 200Vac/50Hz Input, 48V/10.5A Output



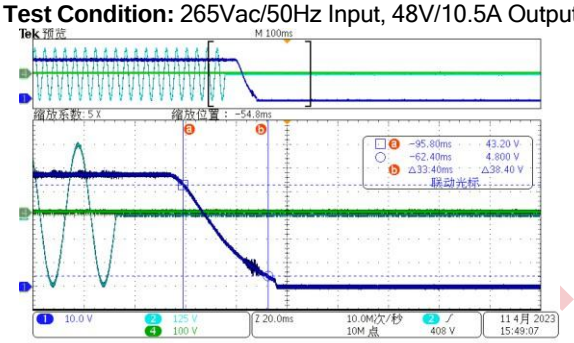
(CH1-Vo, CH2-Vinac)
Comments: Comments: Fall time=21ms

Test Condition: 230Vac/50Hz Input, 48V/10.5A Output



(CH1-Vo, CH2-Vinac)
Comments: Comments: Fall time=28.6ms

Test Condition: 265Vac/50Hz Input, 48V/10.5A Output



(CH1-Vo, CH2-Vinac)
Comments: Comments: Fall time=33.4ms

2.7 Output Overshoot Test

Standard: Vo-peak < output voltage*110%.

Result: Pass

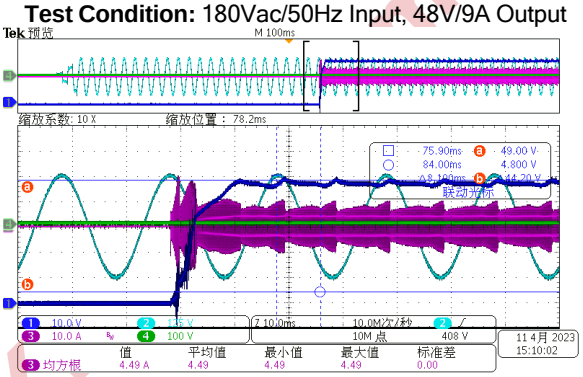
Note: The output voltage is tested at the output cap end.

Test Data:

Input Voltage	180Vac/50Hz	200Vac/50Hz	230Vac/50Hz	265Vac/50Hz
Output	**48V/9A**	**48V/10.5A**	**48V/10.5A**	**48V/10.5A**
Overshoot (V) Full Load	49V	48.8V	47.8V	47.8V
Overshoot (V) No Load	47.6V	47.2V	47.4V	47.6V

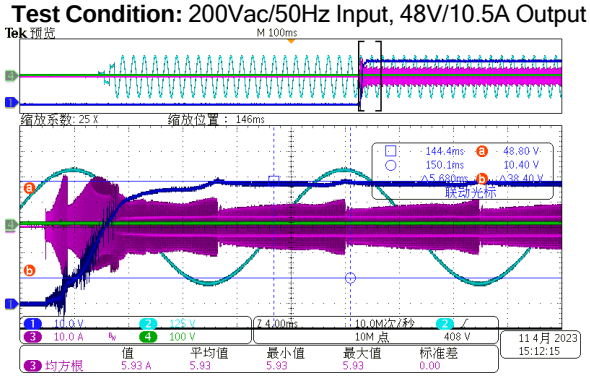
Waveforms:

Test Condition: 180Vac/50Hz Input, 48V/9A Output



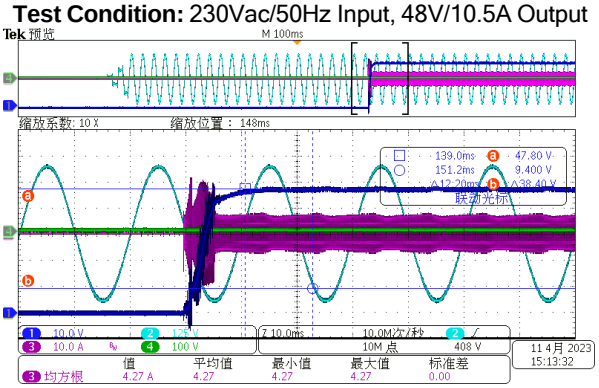
(CH1-Vo, CH2-Vinac, CH3-Ir)
Comments: Vo-peak=49V

Test Condition: 200Vac/50Hz Input, 48V/10.5A Output



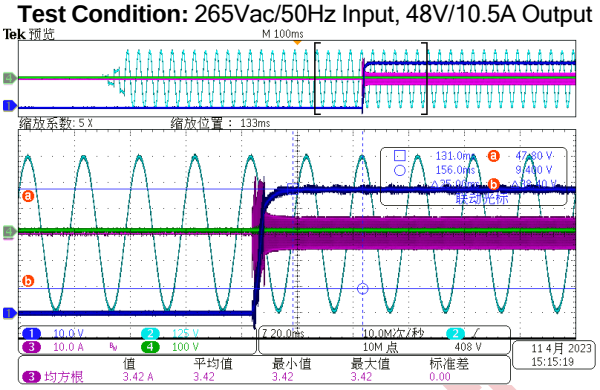
(CH1-Vo, CH2-Vinac, CH3-Ir)
Comments: Vo-peak=48.8V

Test Condition: 230Vac/50Hz Input, 48V/10.5A Output



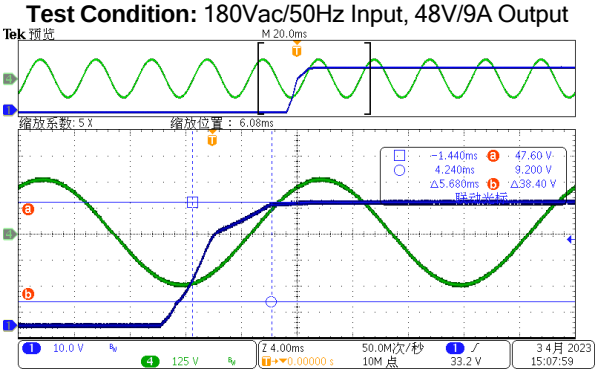
(CH1-Vo, CH2-Vinac, CH3-Ir)
Comments: Vo-peak=47.8V

Test Condition: 265Vac/50Hz Input, 48V/10.5A Output



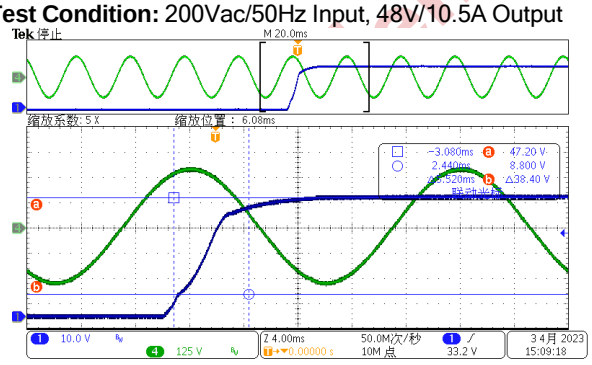
(CH1-Vo, CH2-Vinac, CH3-Ir)
Comments: Vo-peak=47.8V

Test Condition: 180Vac/50Hz Input, 48V/9A Output



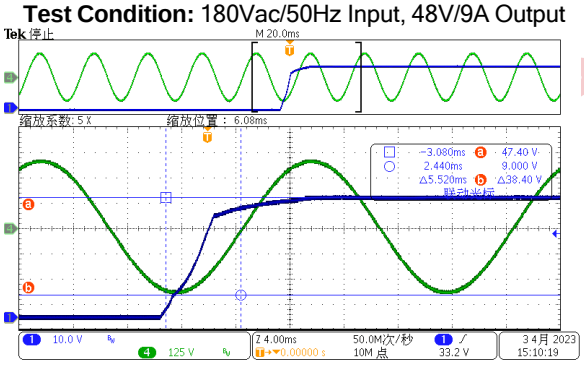
(CH2-Vo, CH4-Vinac)
Comments: Vo-peak=47.6V

Test Condition: 200Vac/50Hz Input, 48V/10.5A Output



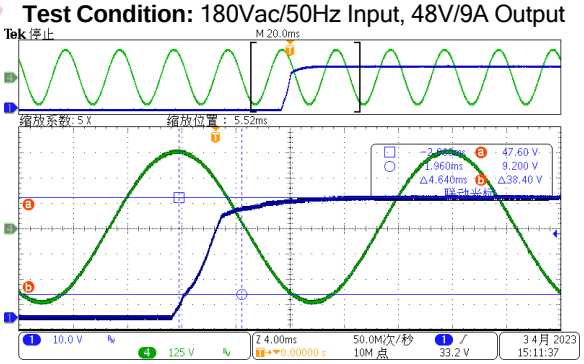
(CH2-Vo, CH4-Vinac)
Comments: Vo-peak=47.2V

Test Condition: 180Vac/50Hz Input, 48V/9A Output



(CH2-Vo, CH4-Vinac)
Comments: Vo-peak=47.4V

Test Condition: 180Vac/50Hz Input, 48V/9A Output



(CH2-Vo, CH4-Vinac)
Comments: Vo-peak=47.6V

3 Protection Test

3.1 Over Load Protection

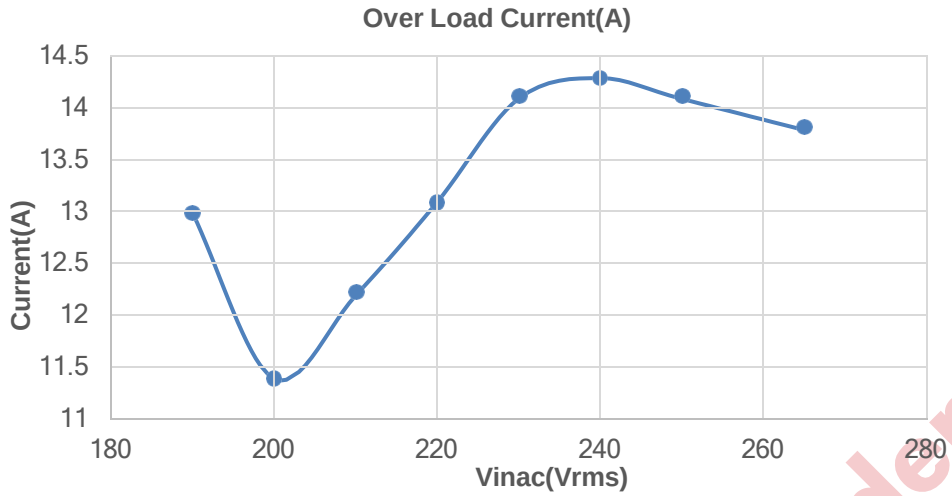
Standard: The overload current should not differ too much within the range of AC input voltage.

Result: Pass

Note: Tested at the output cap end.

Test Data:

Input Voltage	190Vac /50Hz	200Vac /50Hz	210Vac/ 50Hz	220Vac/ 50Hz	230Vac /50Hz	240Vac /50Hz	250Vac /50Hz	265Vac /50Hz
OLP (A)	13A	11.4A	12.2A	13.1A	14.1A	14.3A	14.1A	13.8A



3.2 Output Over Voltage Protection

Standard: The output over voltage should be within the voltage rating of output capacitor.

Result: Pass

Note: Tested at the output cap end with secondary side of opto-coupler for FB shorted.

Test Data:

Input Voltage	180Vac /50Hz	200Vac /50Hz	230Vac /50Hz	265Vac /50Hz	Output Capacitor Voltage Rating
OVP (V)- No Load	55.75V	55.5V	56.75V	56.75V	63V
OVP (V)- Full Load	53.75V (48V/9A)	53.25V (48V/10.5A)	53.25V (48V/10.5A)	53.75V (48V/10.5A)	

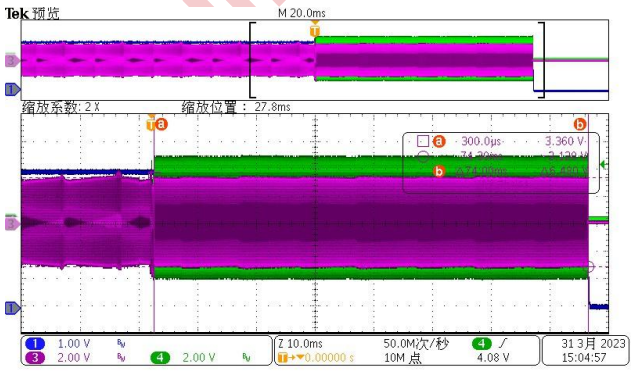
3.3 Output Short-circuit Protection

Standard: The power supply must shut down in the event of short-circuit condition and automatically return to normal operating condition once the fault condition has been removed.

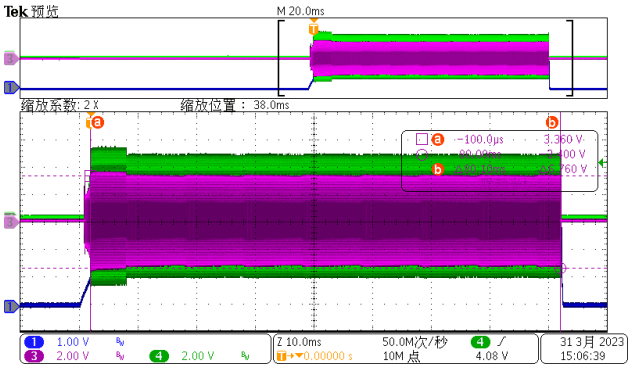
Result: Pass

Note: The short circuit protection is tested at the output cap end.

Test Condition: 180Vac/50Hz，48V/9A Output Short

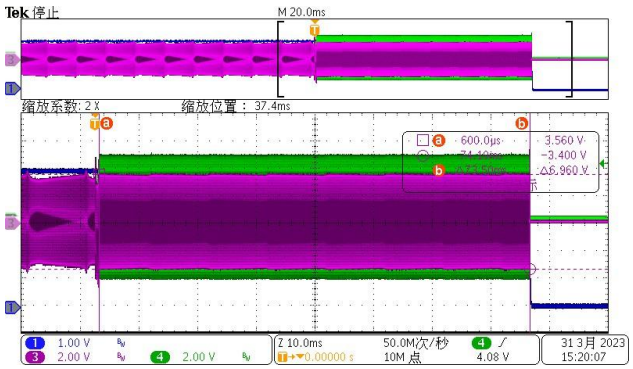


(CH1-VSS , CH3-VDEM, CH4-VCS)
Comments: Protection Enter

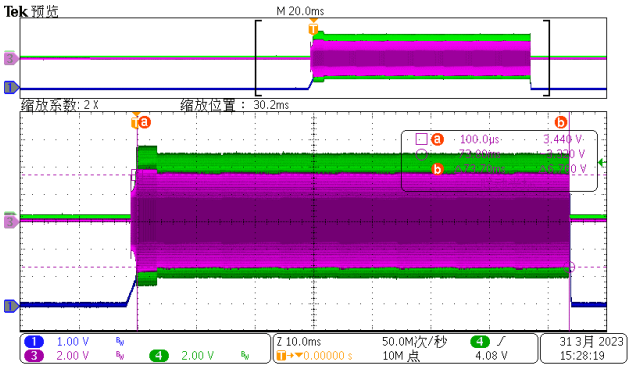


(CH1-VSS , CH3-VDEM, CH4-VCS)
Comments: Restart automatically at short condition

Test Condition: 200Vac/50Hz，48V/10.5A Output Short

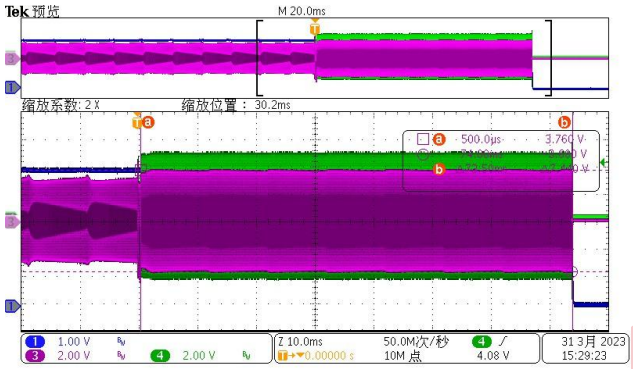


(CH1-VSS , CH3-VDEM, CH4-VCS)
Comments: Protection Enter

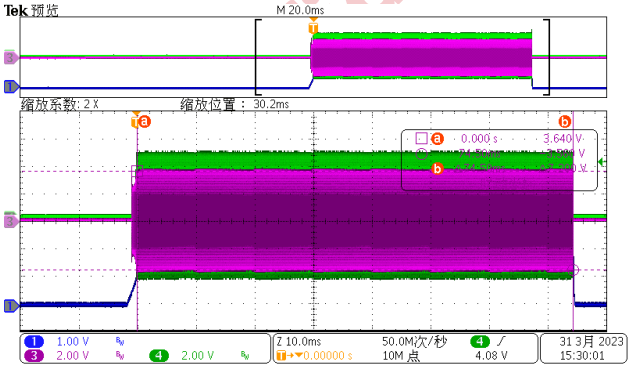


(CH1-VSS , CH3-VDEM, CH4-VCS)
Comments: Restart automatically at short condition

Test Condition: 230Vac/50Hz，48V/10.5A Output Short

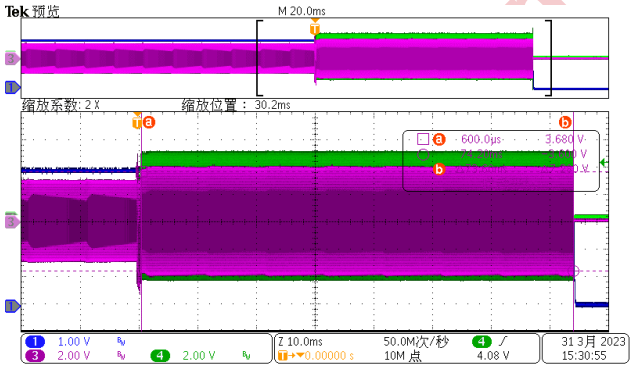


(CH1-VSS , CH3-VDEM, CH4-VCS)
Comments: Protection Enter

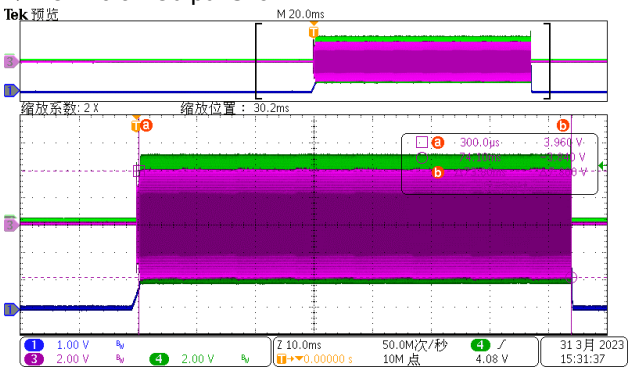


(CH1-VSS , CH3-VDEM, CH4-VCS)
Comments: Restart automatically at short condition

Test Condition: 265Vac/50Hz，48V/10.5A Output Short



(CH1-VSS , CH3-VDEM, CH4-VCS)
Comments: Protection Enter



(CH1-VSS , CH3-VDEM, CH4-VCS)
Comments: Restart automatically at short condition

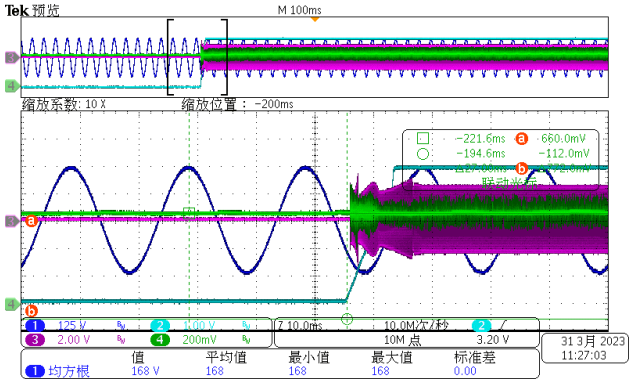
3.4 Input Brown-out Protection

Standard: The power supply should shut down when the input voltage is lower than the Brown-out protection value and return to normal operating condition when the input in the range of normal operating voltage

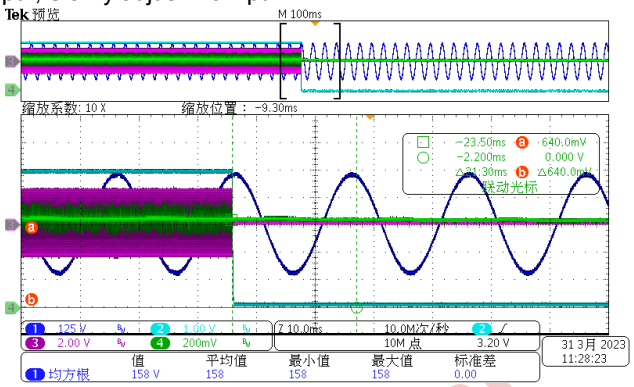
Result: Pass

Waveforms:

Test Condition: 48V/1A Output, Slowly adjust the input



(CH1-Vinac, CH2-VSS, CH3-VDEM, CH4-VBR)
Comments: 157Vac Protection recovery



(CH1-Vinac, CH2-VSS, CH3-VDEM, CH4-VBR)
Comments: 154Vac Protection enter

4 Reliability Requirements

4.1 Device Maximum Rating Test

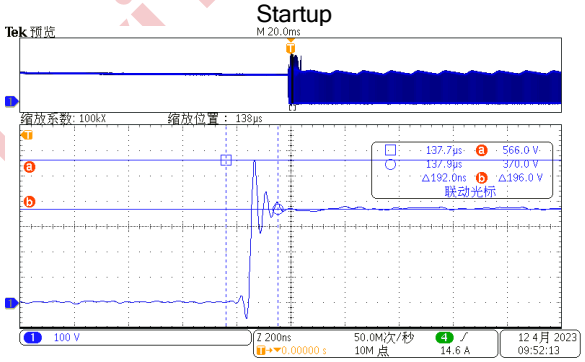
Standard: MOSFET and Diode<95% Rating

Result: Pass

Component	Rating	200Vac 50Hz/10.5A				265Vac 50Hz/10.5A				Result
		Startup	Steady	Short	Short Start	Startup	Steady	Short	Short Start	
MOSFET H	650V	464	280	454	470	566	362	496	570	PASS
MOSFET L	650V	504	276	414	408	508	374	538	528	PASS
Resonant Current		20.2	9.2	21.2	23	22.2	6.28	24	24	PASS
Resonant Capacitor Voltage	630V	344	280	368	320	396	234	436	440	PASS
DIODE1 (D9&D12)	150V	100	103.2	101.2	33.2	105.2	105.6	103.6	52.8	PASS
DIODE2 (D2&D6)	150V	104.8	104	102.4	32.8	106	106	109.2	65.2	PASS

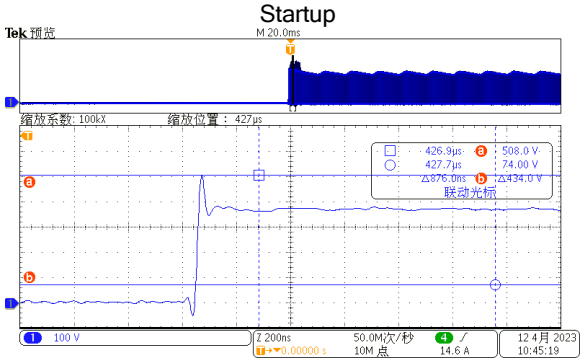
Waveforms:

Test Condition: 265Vac/50Hz Input,48V/10.5A Output, Startup



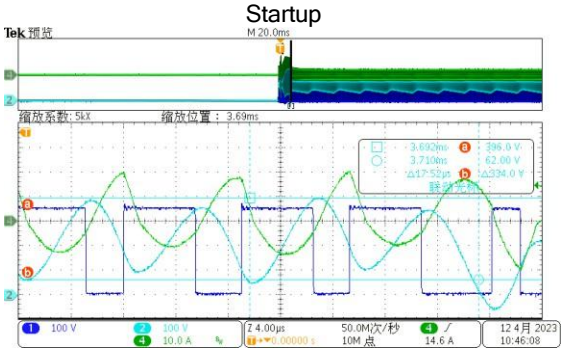
(CH1-VDrain_H)
Comments: VDrain_H_peak=566V

Test Condition: 265Vac/50Hz Input,48V/10.5A Output, Startup



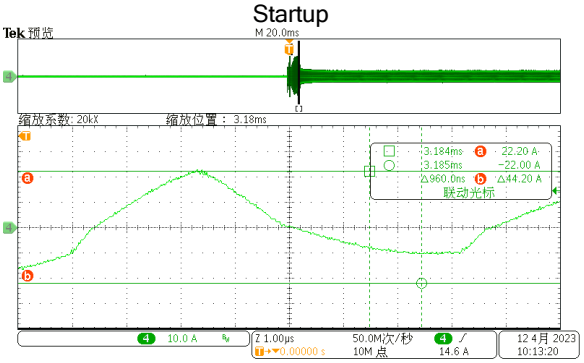
(CH1-VDrain_L)
Comments: VDrain_L_peak=508V

Test Condition: 265Vac/50Hz Input,48V/10.5A Output, Startup



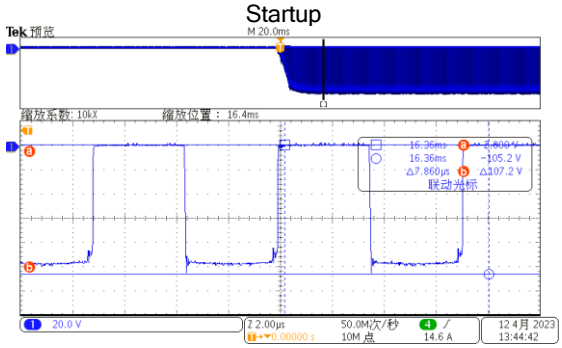
(CH2-VCr)
Comments: VCr_peak=396V

Test Condition: 265Vac/50Hz Input,48V/10.5A Output, Startup



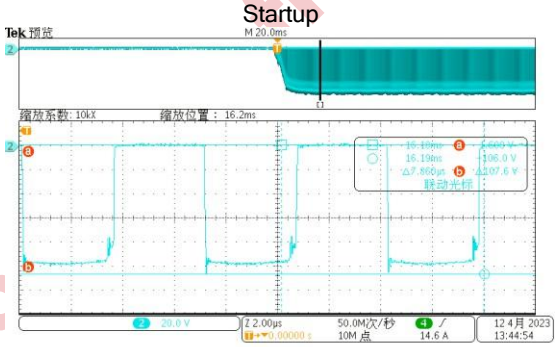
(CH4-Ir)
Comments: Ir_peak=22.2A

Test Condition: 265Vac/50Hz Input,48V/10.5A Output, Startup



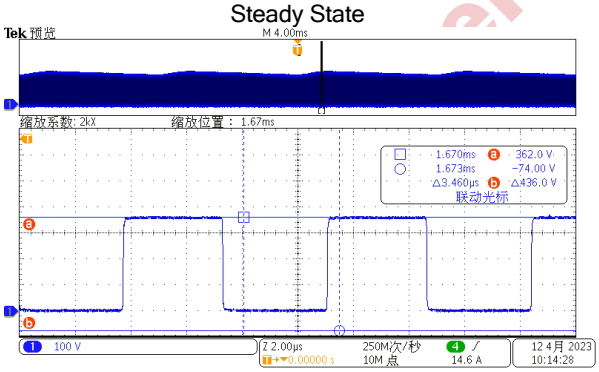
(CH1-VDiode1)
Comments: VDiode1=105.2V

Test Condition: 265Vac/50Hz Input,48V/10.5A Output, Startup



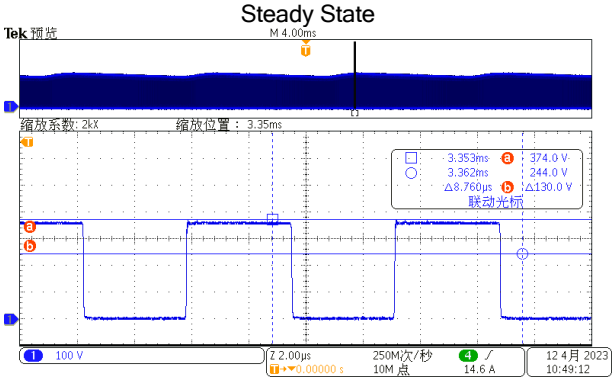
(CH2-VDiode2)
Comments: VDiode2=106V

Test Condition: 265Vac/50Hz Input,48V/10.5A Output, Steady State



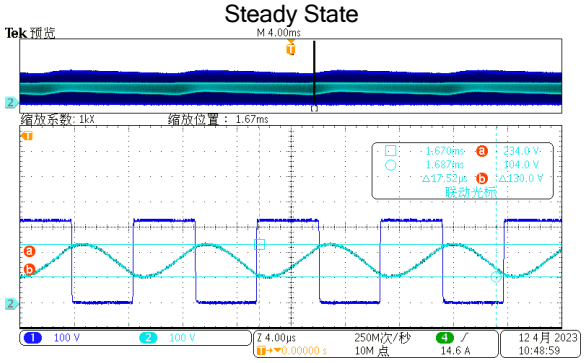
(CH1-VDrain_H)
Comments: VDrain_H_peak=362V

Test Condition: 265Vac/50Hz Input,48V/10.5A Output, Steady State



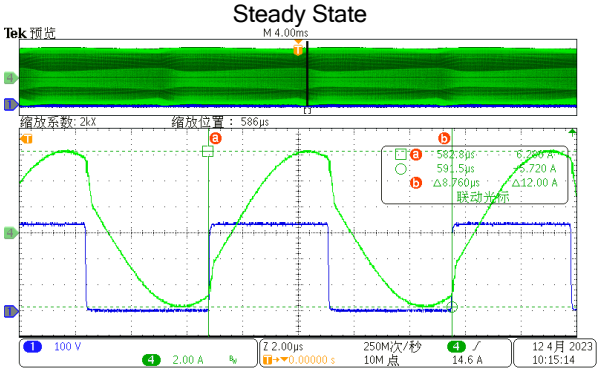
(CH2-VDrain_L)
Comments: VDrain_L_peak=374V

Test Condition: 265Vac/50Hz Input,48V/10.5A Output, Steady State



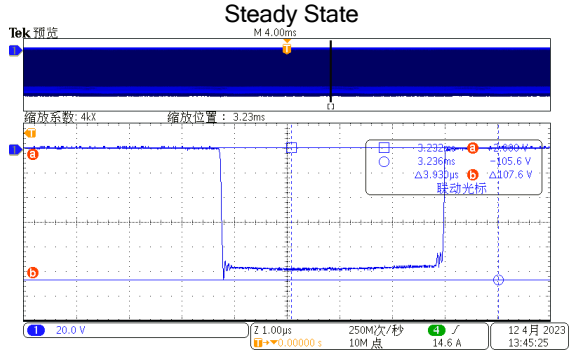
(CH3-VCr)
Comments: VCr_peak=234V

Test Condition: 265Vac/50Hz Input,48V/10.5A Output t, Steady State



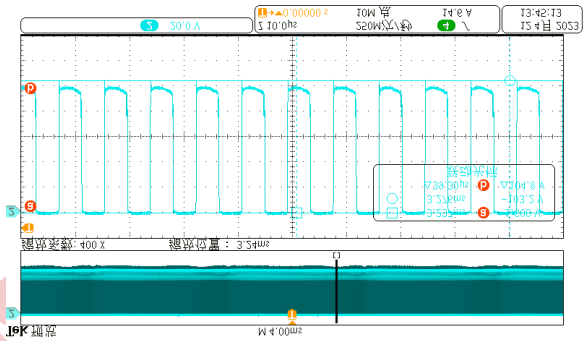
(CH4-Ir)
Comments: Ir_peak=6.28A

Test Condition: 265Vac/50Hz Input,48V/10.5A Output, Steady State



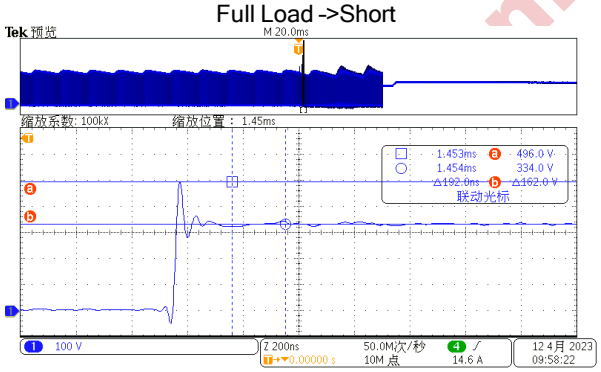
(CH1-VDiode1)
Comments: VDiode1=105.6V

Test Condition: 265Vac/50Hz Input,48V/10.5A Output, Steady State



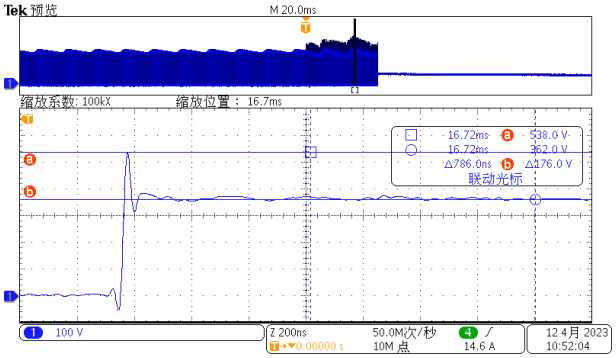
(CH2-VDiode2)
Comments: VDiode2=106V

Test Condition: 265Vac/50Hz Input,48V/10.5A Output, Full Load ->Short



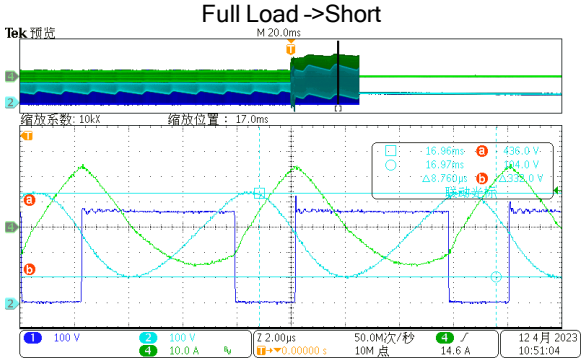
(CH1-VDrain_H)
Comments: VDrain_H_peak=496V

Test Condition: 265Vac/50Hz Input,48V/10.5A Output, Full Load ->Short



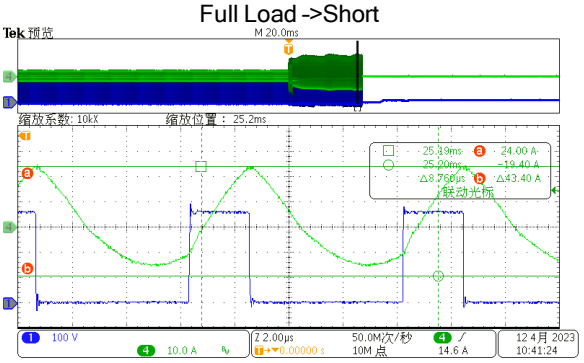
(CH2-VDrain_L)
Comments: VDrain_L_peak=538V

Test Condition: 265Vac/50Hz Input,48V/10.5A Output, Full Load ->Short



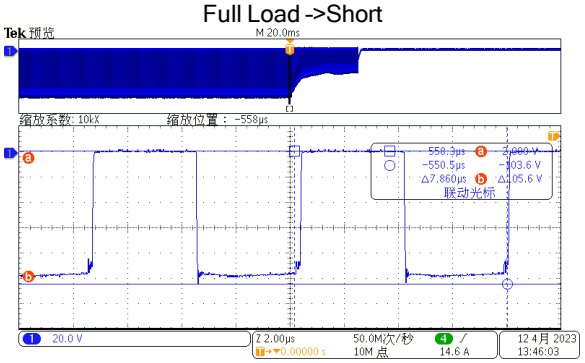
(CH2-VCr)
Comments: VCr_peak=436V

Test Condition: 265Vac/50Hz Input,48V/10.5A Output t, Full Load ->Short



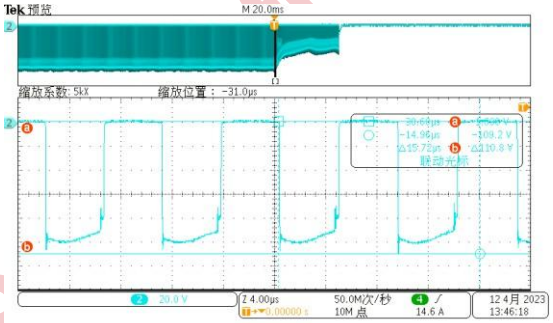
(CH4-Ir)
Comments: Ir_peak=24A

Test Condition: 265Vac/50Hz Input,48V/10.5A Output, Full Load ->Short



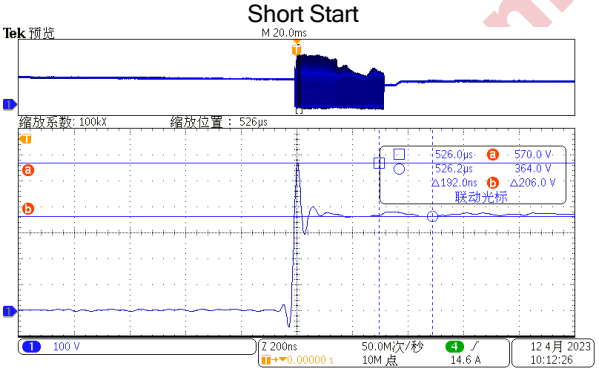
(CH1-VDiode1)
Comments: VDiode1=103.6V

Test Condition: 265Vac/50Hz Input,48V/10.5A Output, Full Load ->Short



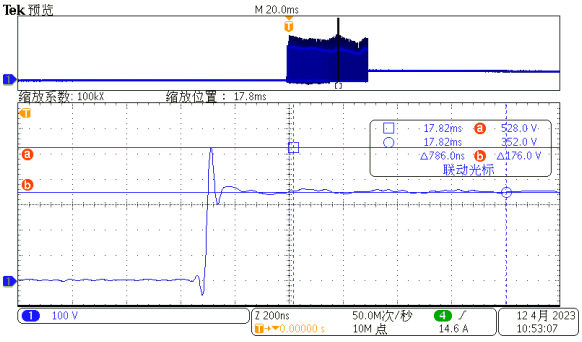
(CH2-VDiode2)
Comments: VDiode2=109.2V

Test Condition: 265Vac/50Hz Input,48V/10.5A Output, Short Start



(CH1-VDrain_H)
Comments: VDrain_H_peak=570V

Test Condition: 265Vac/50Hz Input,48V/10.5A Output, Short Start



(CH1-VDrain_L)
Comments: VDrain_peak=528V

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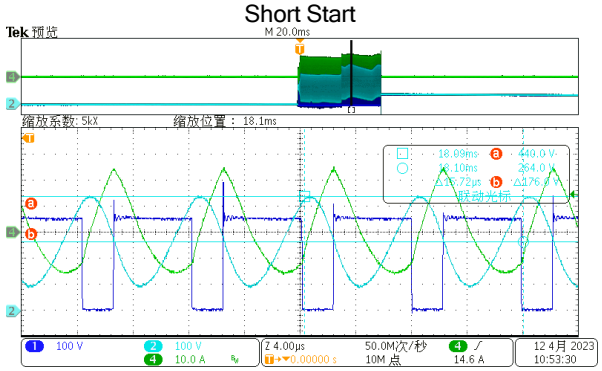
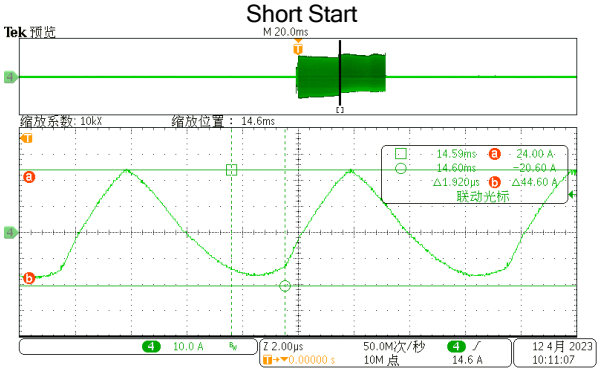
Tel: +86-18681585060 E-mail: wyq@cokinic.com
www.cokinsemi.com

Test Condition: 265Vac/50Hz Input,48V/10.5A Output, Short Start



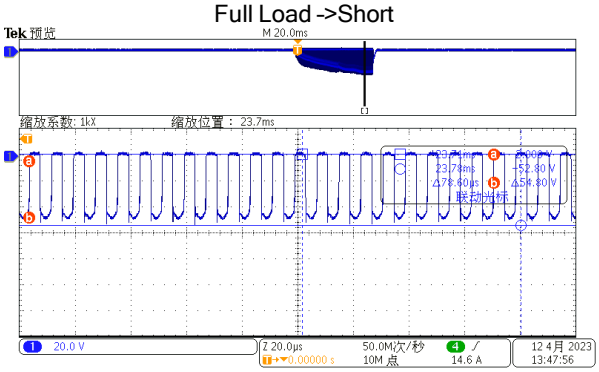
(CH3-VCr)
Comments: VDiode_peak=440V

Test Condition: 265Vac/50Hz Input,48V/10.5A Output , Short Start



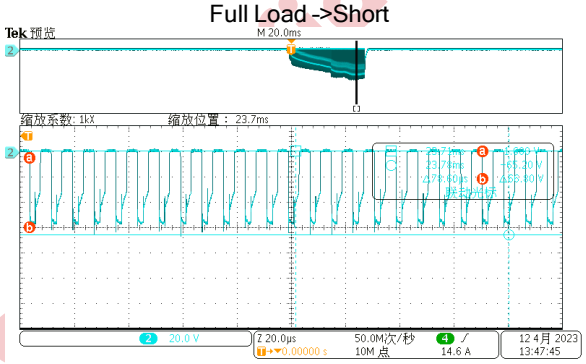
(CH4-Ir)
Comments: Ir_peak=24A

Test Condition: 265Vac/50Hz Input,48V/10.5A Output, Full Load ->Short



(CH1-VDiode1)
Comments: VDiode1=52.8V

Test Condition: 265Vac/50Hz Input,48V/10.5A Output, Full Load ->Short



(CH2-VDiode2)
Comments: VDiode2=65.2V

4.2 Bmax Test

Standard: Steady-state rated load: Bmax≤0.32T;

Transient and its peak load: Bmax≤0.38T.

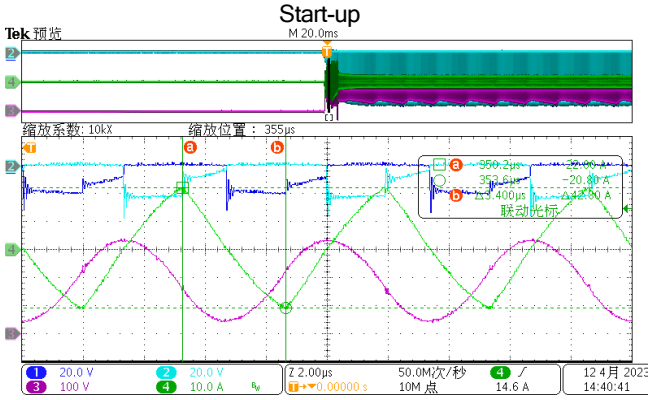
Result: Pass

Note: The turn numbers of the transform is 14, and the sectional area is 175mm², Lp is 120μH, Lr=20μH.

Vin	180Vac	200Vac	230Vac	265Vac	Bmax-limit(T)	Result
Output	**48V/9A**	**48V/10.5A**	**48V/10.5A**	**48V/10.5A**		
Start-up	0.163T	0.18T	0.17T	0.18T	0.32	**PASS**
Steady	0.22T	0.21T	0.21T	0.14T	0.38	**PASS**
Short	0.18T	0.185T	0.188T	0.2T	0.38	**PASS**
Short Start	0.186T	0.17T	0.17T	0.19T	0.38	**PASS**

Waveforms:

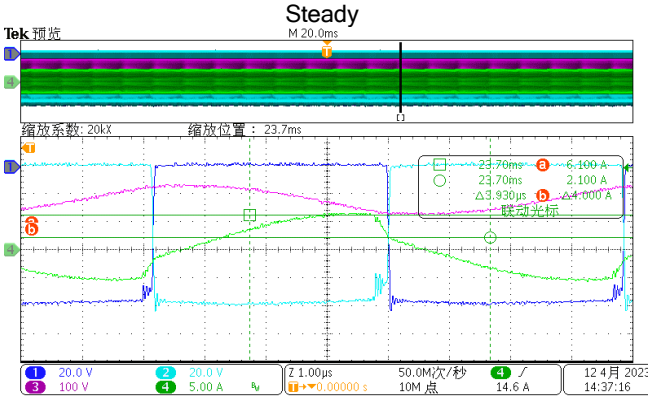
Test Condition: 265Vac/50Hz Input, 48V/10.5A Output, Start-up



(CH1-Vdiode1,CH2-Vdiode2,CH3-IL1,CH4-Vcr)

Comments:

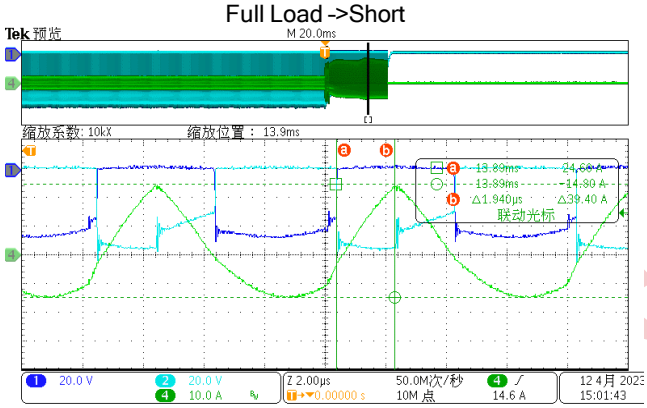
Test Condition: 265Vac/50Hz Input, 48V/10.5A Output, Steady



(CH1-Vdiode1,CH2-Vdiode2,CH3-IL1,CH4-Vcr)

Comments:

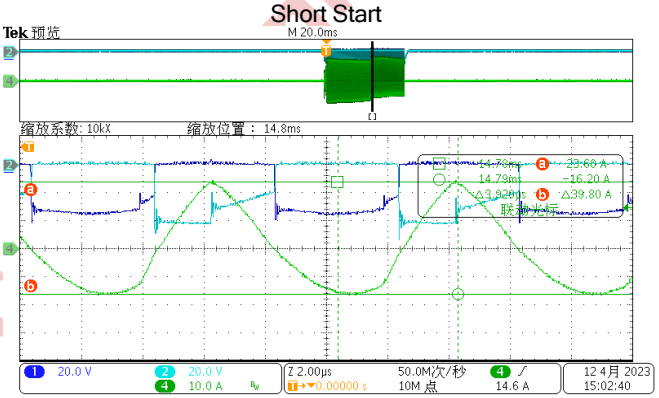
Test Condition: 265Vac/50Hz Input, 48V/10.5A Output, Full Load ->Short



(CH1-Vdiode1,CH2-Vdiode2,CH3-IL1,CH4-Vcr)

Comments:

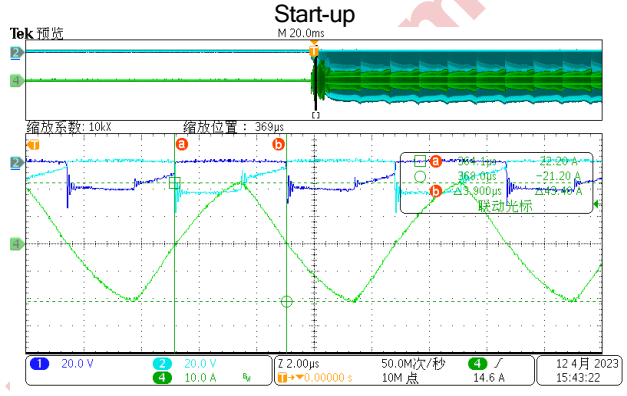
Test Condition: 265Vac/50Hz Input, 48V/10.5A Output, Short Start



(CH1-Vdiode1,CH2-Vdiode2,CH3-IL1,CH4-Vcr)

Comments:

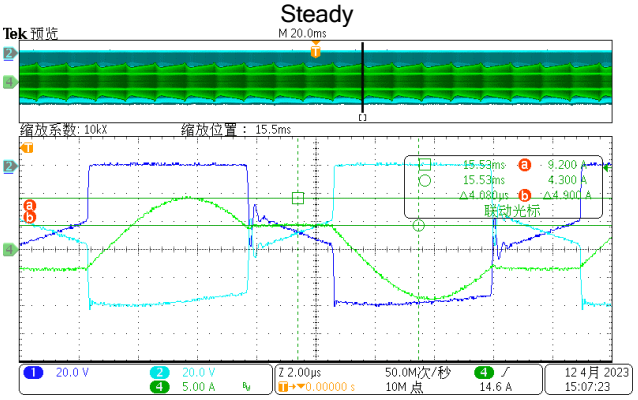
Test Condition: 200Vac/50Hz Input, 48V/10.5A Output, Start-up



(CH1-Vdiode1,CH2-Vdiode2,CH3-IL1,CH4-Vcr)

Comments:

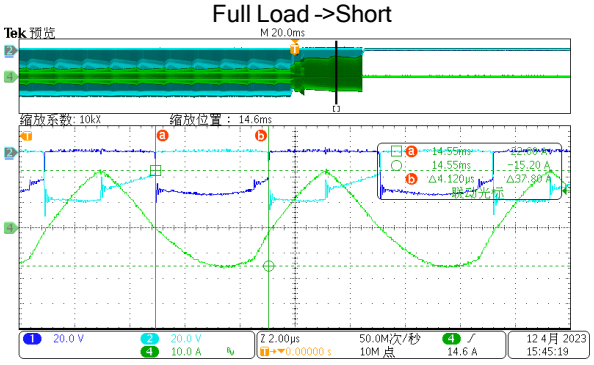
Test Condition: 200Vac/50Hz Input, 48V/10.5A Output Steady



(CH1-Vdiode1,CH2-Vdiode2,CH3-IL1,CH4-Vcr)

Comments:

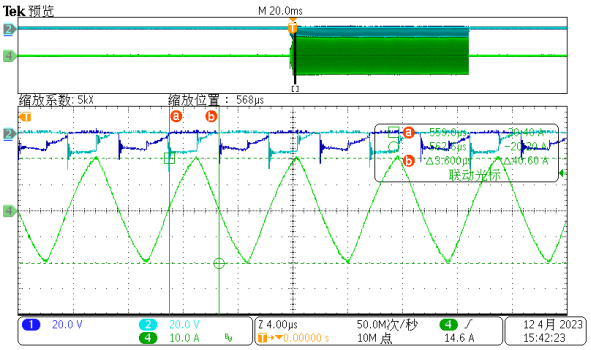
Test Condition: 200Vac/50Hz Input, 48V/10.5A Output, Full Load ->Short



(CH1-Vdiode1,CH2-Vdiode2,CH3-IL1,CH4-Vcr)

Comments:

Test Condition: 200Vac/50Hz Input, 48V/10.5A Output Short Start



(CH1-Vdiode1,CH2-Vdiode2,CH3-IL1,CH4-Vcr)

Comments:

4.3 Thermal Test

Test Condition: 230Vac/50Hz input; 48V/10.5A output; Burn-in 0.5Hour @ Open Air with no airflow, Ta is the ambient temperature.

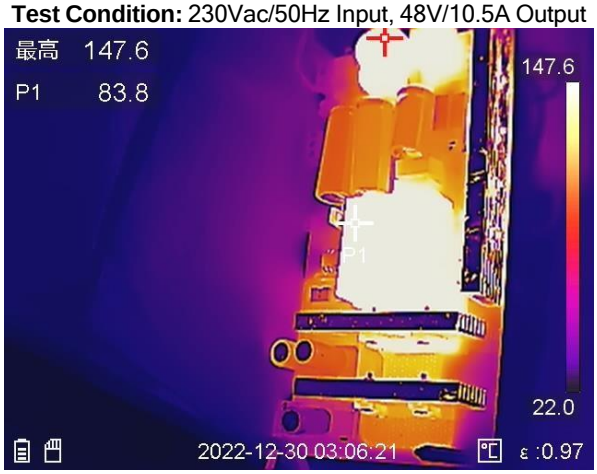
Standard: MOS, IC and Diode: Ta=25℃, Trise<90℃. Transformer, Inductor: Ta=25℃, Trise<120℃.

Result: The transformer needs additional heat dissipation measures.

Test Data:

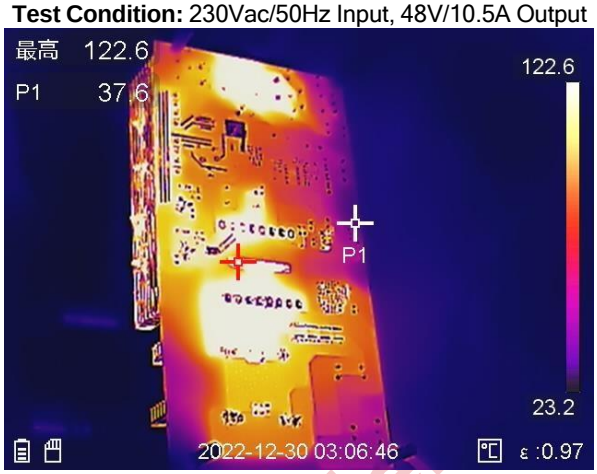
Trise(℃)	480V10.5A	
	Ta: 24℃	
Location	230V/50Hz	
	T(℃)	Trise(℃)
MOSFET H	73	49
MOSFET L	73	49
DIODE1 &2	82	58
DIODE 3 & 4	77	53
NTC1 & 2	147.6	123.6
Rectifier 1 & 2	67	42
CM1 Inductor	72	48
Transformer	135.7	111.7

Test Condition: 230Vac/50Hz Input, 48V/10.5A Output



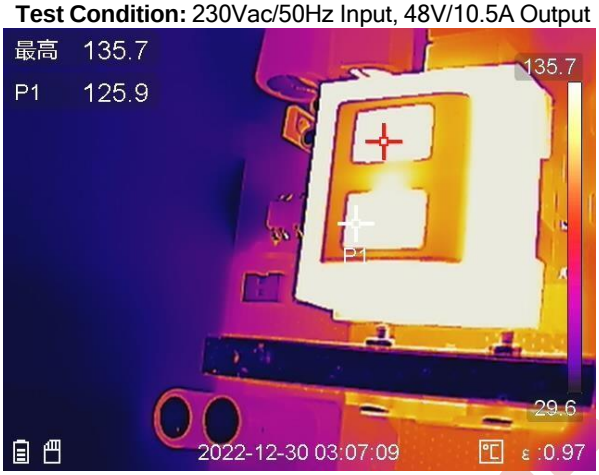
Comments: TOP Side MAX=147.6℃(NTC)

Test Condition: 230Vac/50Hz Input, 48V/10.5A Output



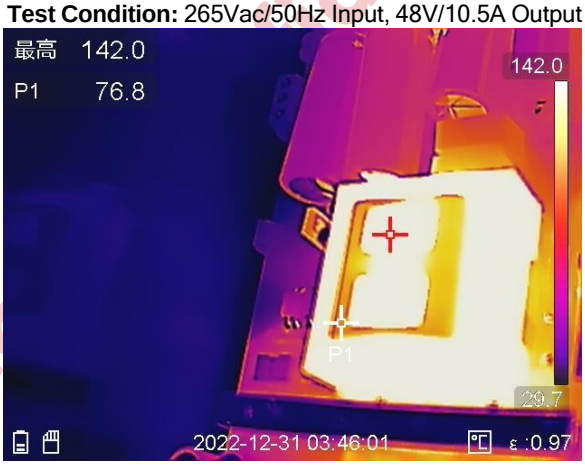
Comments: Bottom Side MAX=122.6℃

Test Condition: 230Vac/50Hz Input, 48V/10.5A Output



Comments: Transformer=135.7℃

Test Condition: 265Vac/50Hz Input, 48V/10.5A Output



Comments: Transformer=142℃

Revision History

DATE	REV	DESCRIPTION
2023/04/14	1.0	First Release

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