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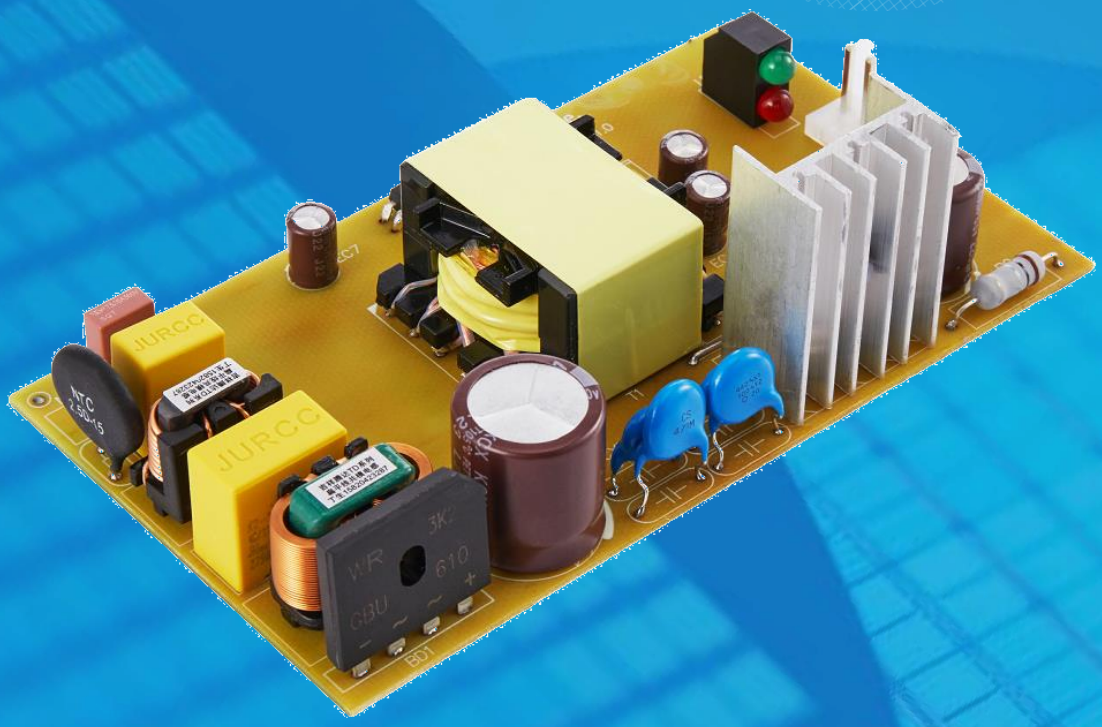
INNDAD120B4

120W E-Bike Charger Demo Manual



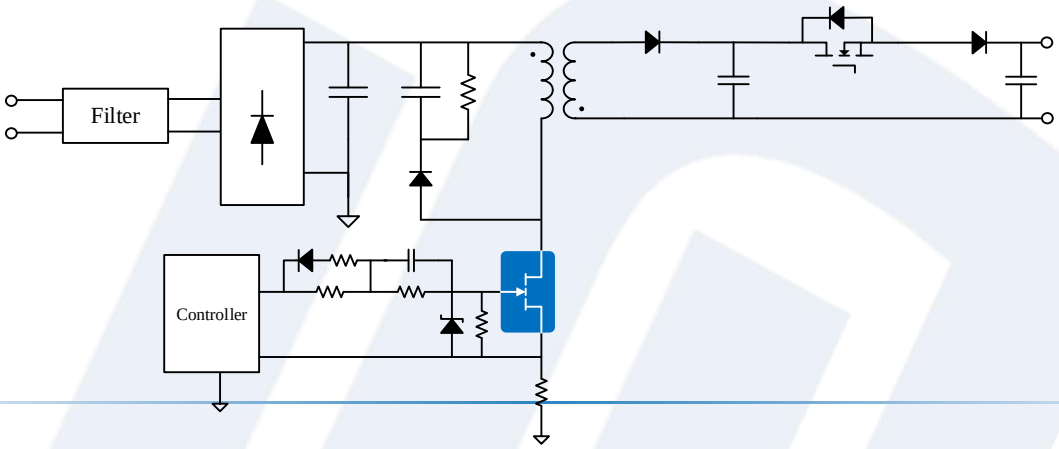
120W E-Bike Charger

介绍

120W电动自行车充电器评估板是一款高效、可靠、无风扇且低成本的交流/直流电源供应器。原边GaN功率器件靠本体自然散热，没有增加散热片。其应用主要面向电动自行车。

输入电压范围：165Vac-275Vac，输出电压范围：55V-60V，输出最大电流：1.8A。

峰值效率：91.8%。



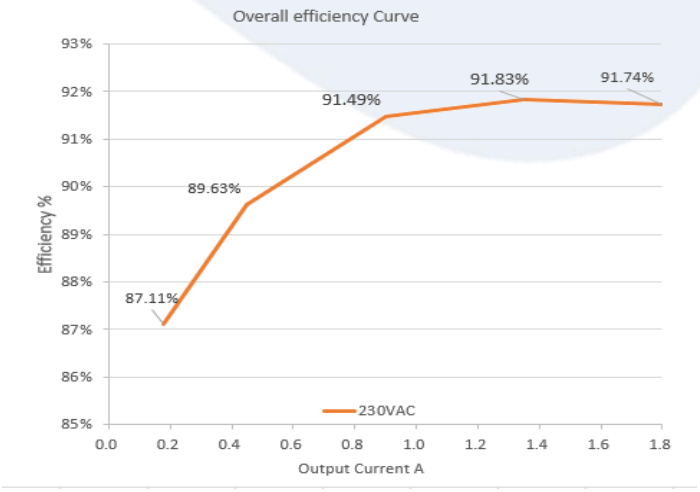
重点器件

- INN700TK350B

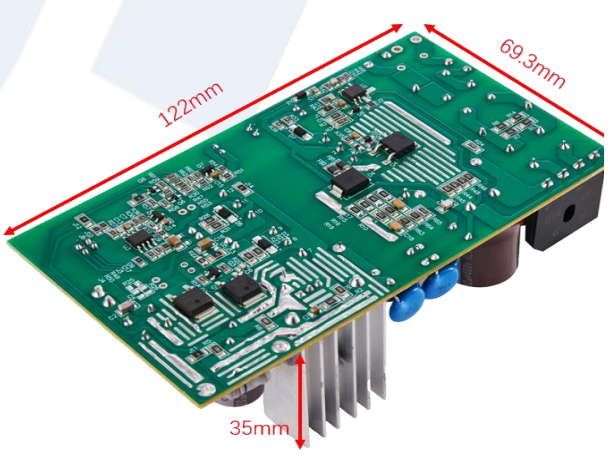
应用场景

- 电动自行车充电器

测试数据



实物图



目录

1. 概述

1.1. 引言

120W电动自行车充电器评估板是一款高效、无风扇且低成本的交流/直流电源供应器。具体参数为输入电压165Vac-275Vac，输出电压55V-60V，最大输出电流1.8A，峰值效率高达91.8%。该评估板采用单层PCB设计，单面SMT，加工简单且成本低廉。

QR由Innoscience增强型GaN场效应晶体管INN700TK350B和一个变压器组成。第三代半导体GaN晶体管由于高电子迁移率和小寄生结电容的优势，特别在高频应用中表现更为突出。

1.2. 特色

- **主要优势**
  - > 高效率：91.7%(230Vac)
  - > PCBA 尺寸：122*69.3*40mm
  - > 高可靠性 (无风)
  - > 易于制造、成本低
- **保护功能**
  - > 逐周期过流保护
  - > 输入欠压保护
  - > 输出过压保护
  - > 输出短路保护
  - > 过功率保护

1.3. 应用

- **电动自行车充电器**

2. 参数

表 1 电气参数（Ta=25℃）

Symbol	Parameters	Test Conditions	Min	Nom	Max	Units
系统规格						
VIN	输入电压		165	230	275	Vac
F_AC	输入频率			50		Hz
Fsw,QR		Vin=230Vac，Full load	110	112	123	kHz
Output	输出电压	Io<0.6A		55		V
		0.6A≦Io≦1.8A		59		V
POUT	输出功率			106		W
Demo性能						
Pstandby	空载功耗	230Vac			0.5	W
Vripple	输出电压纹波	Full load		500		mV
Eff,pk	峰值效率	Vin=230Vac		91.8		%
Eff	满载效率	Vin=230Vac		91.7		%

3. 应用方案

3.1. 方框图

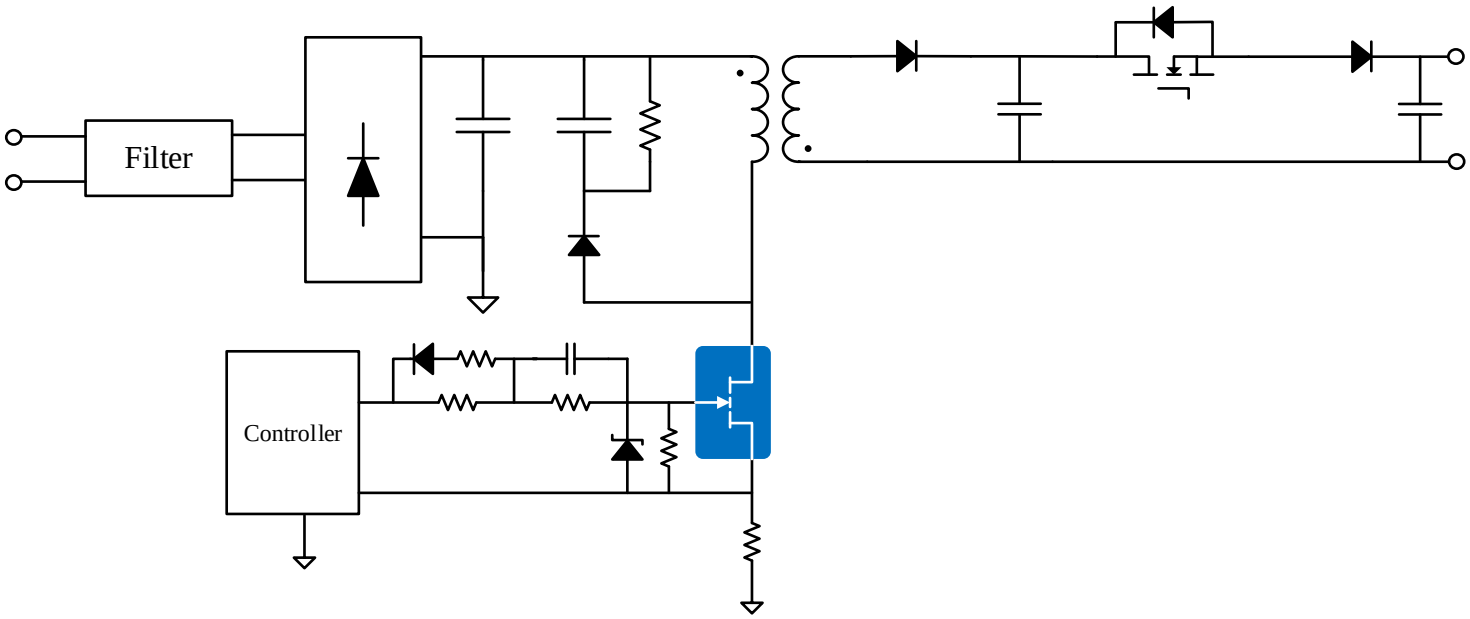


图 1 INNDAD120B4 系统框图

3.2. INN700TK350B器件介绍

INN700TK350B是Innoscience推出的一款700V硅基氮化镓增强功率晶体管，采用TO-252封装。与具有相同导通电阻的Si-MOSFET器件相比，INN700TK350B具有诸如较低的Qg和Coss、零反向恢复电荷等优势，可以降低系统的开关和驱动损耗。

表 2 INN700TK350B关键性能参数(Tj=25℃)

Parameter	Value	Unit
Vds,max	700	V
Rds(on), max@Vg=6V	350	mΩ
Qg, typ@Vds=400V	1.5	nC
Id, pulse	10	A
Qoss@Vds=400V	13	nC
Qrr@Vds=400V	0	nC

4. 硬件原理

4.1. PCBA实物图

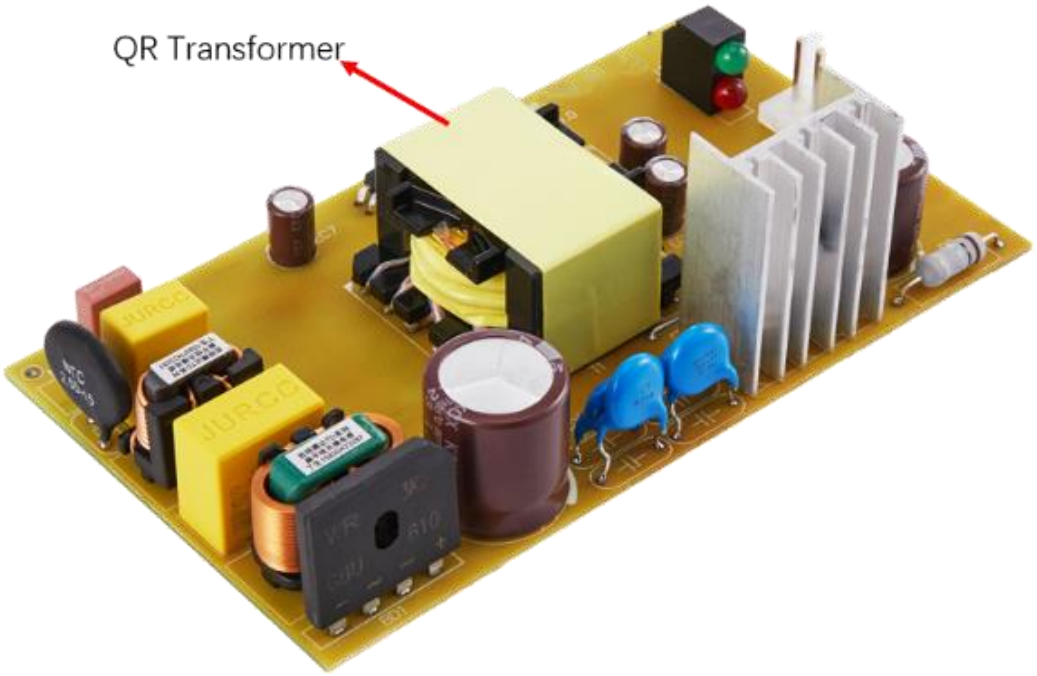


图 2 INNDAD120B4顶层视图

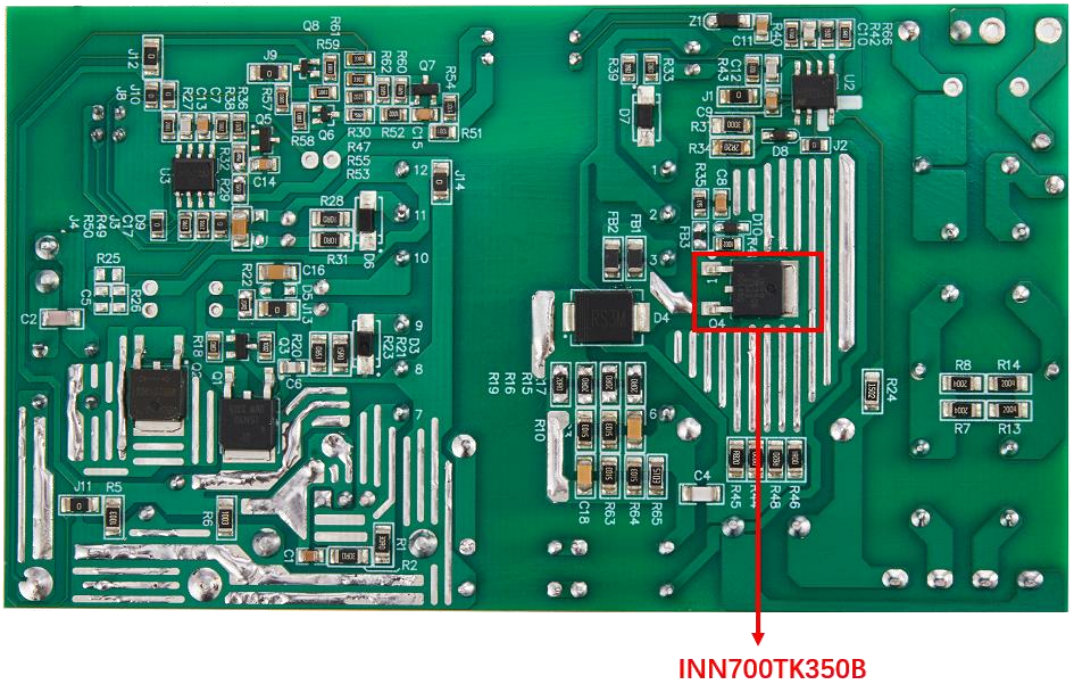
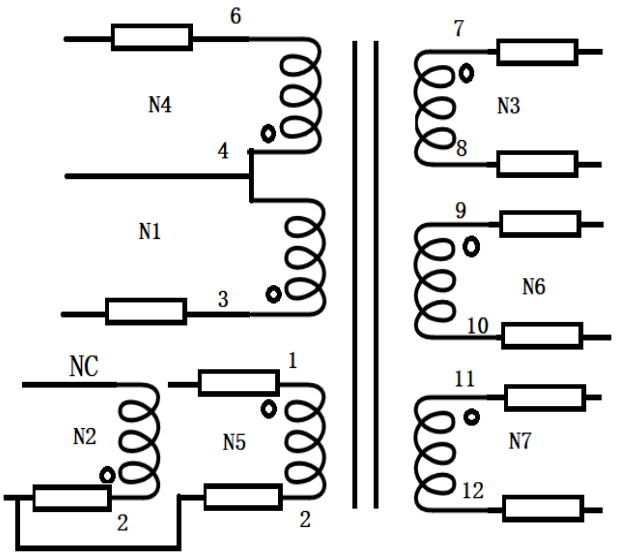


图 3 INNDAD120B4底层视图

4.2. 设计考虑因素

4.2.1. QR 变压器

电气图



结构图

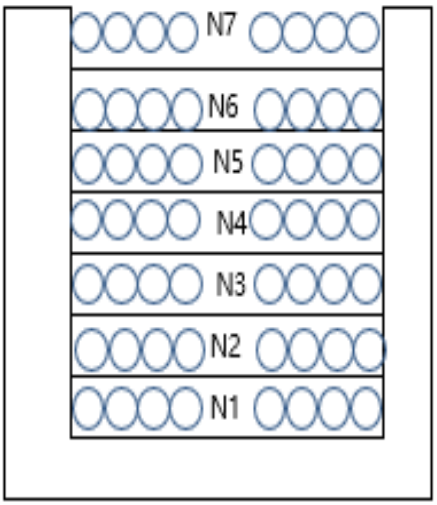


表 3 磁芯

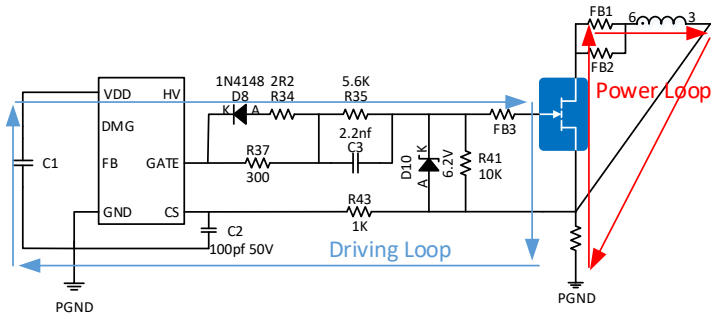
No.	Name	Core Size/Material	Vendor
1	Core	PQ3220	
2	Bobbin	Bobbin：PQ3220 (6+6PIN)	
3	Material	PC44	A-CORE/TDG/

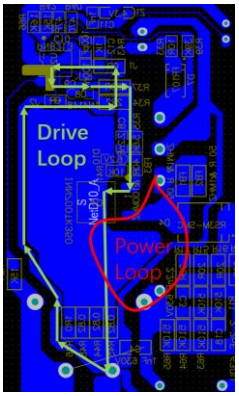
表 4 参数

No.	Winding	Turns	Inductance	Test Case
1	N1	14	330uH±5%	1V/100KHz
2	N2	20		/
3	N3	9	/	/
4	N4	9	/	/
5	N5	3	/	/
6	N6	2	/	/
7	N7	2		
Short 7-8,9-10,11-12			L3-6_max=3.3uH	

4.2.2. Layout

■ **单管**





a) 将CBYPASS置于IC附近

b) 将驱动回路放置在靠近InnoGaN的位置

a) CBUS、Transforme、InnoGaN电路环路应尽量减小。

图 4 单开关布局建议

4.2.3. 热设计指导

120W 电动自行车充电器评估板采用单层 PCB 设计。底部焊接了一个 To-252 封装的 INN700TK350B 器件，没有散热器用于功率散热。因此，请尽量保留足够的 PCB 面辅助散热。如下图所示，PCB 面积约为 385 mm²（30.6mm * 12.6mm）。

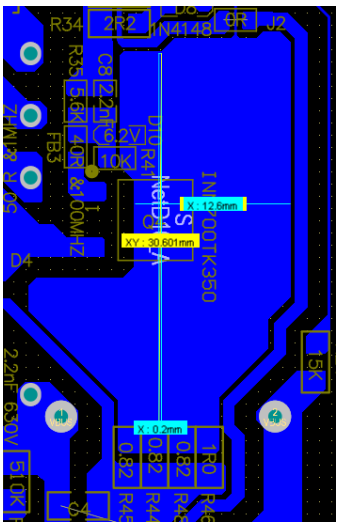


图 5 PCB INN700TK350B的散热面积

5. 测试指南

5.1. 测试环境

- 输入功率计: ZLG PA310
- 输出负载: ITECH IT8732
- 示波器: Tektronix MSO44 500MHz
- 输入交流电: eec EAB-120

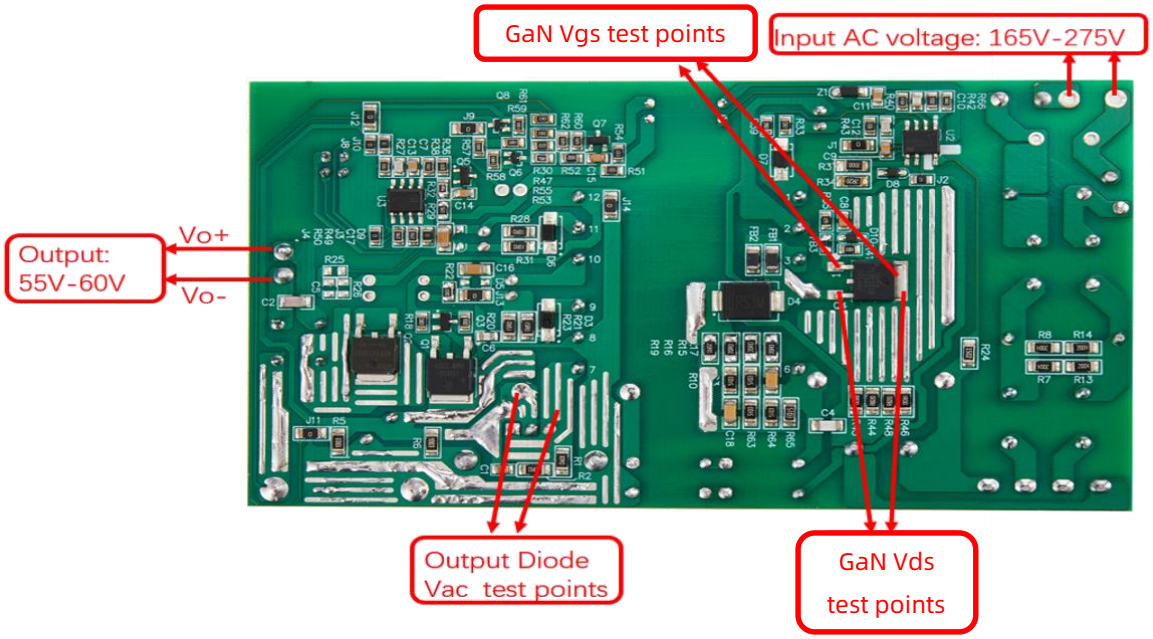


图 6 测试点

图 7 测试环境

5.2. 测试结果

5.2.1. 效率

表 5 整体效率

Vin（V）	100%load η (%)	75%load η (%)	50%load η (%)	25%load η (%)	10%load η (%)	Average η (%)
165Vac	91.10	91.58	91.58	90.45	88.19	91.18
230Vac	91.74	91.83	91.49	89.63	87.11	91.17
275Vac	91.73	91.59	91.02	88.67	85.90	90.75

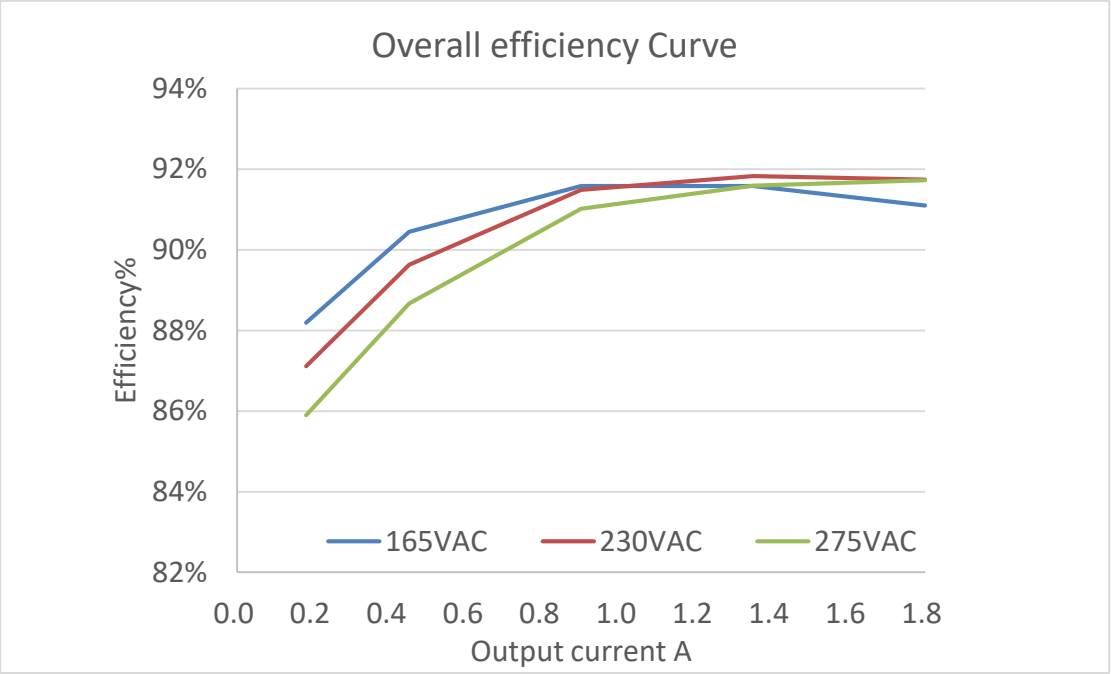
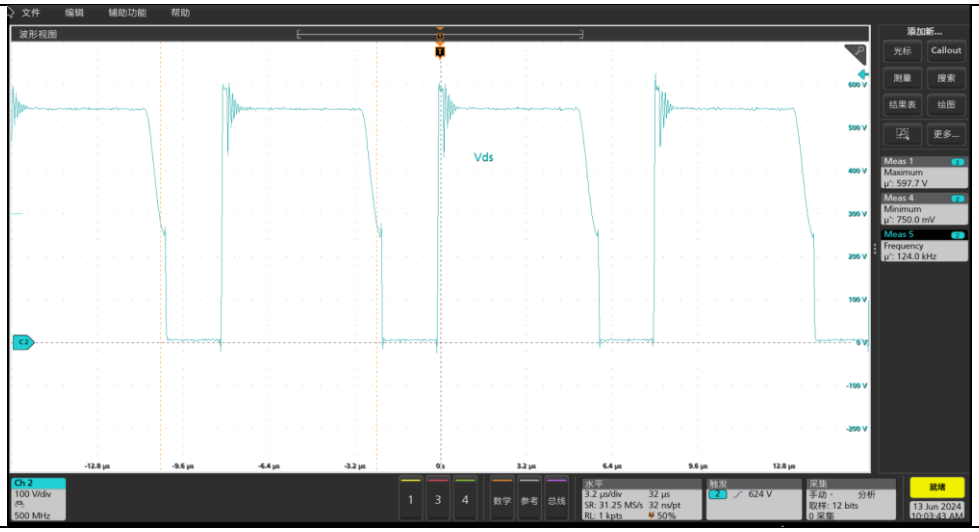
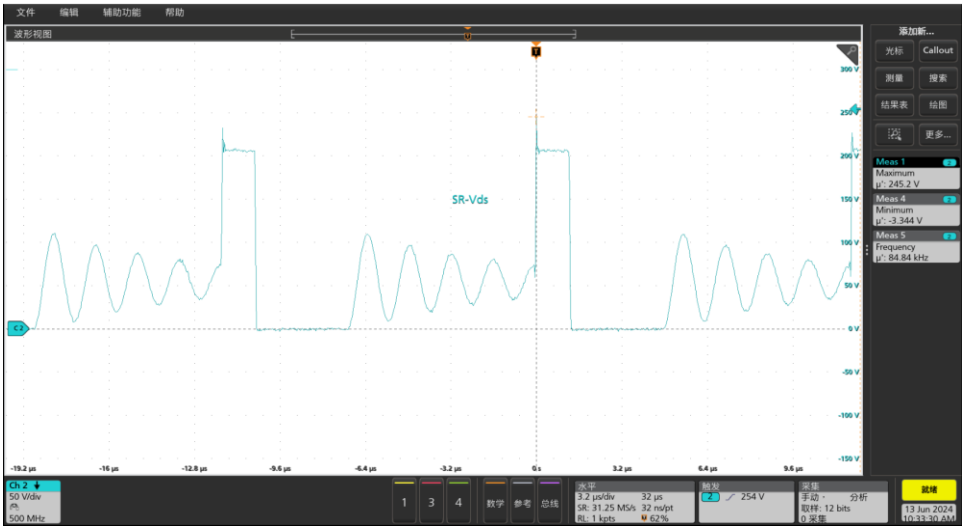
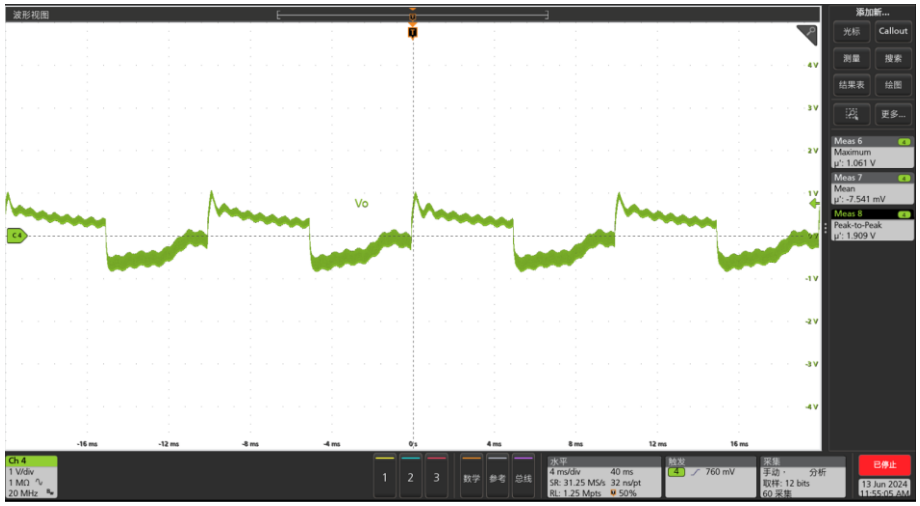


图 8 总效率曲线

5.2.2. 开关波形

	**测试条件** Vin=275Vac/50Hz Vout=60V 满载 **结果** Vds_max=598V
	**测试条件** Vin=275Vac/50Hz Vout=60V 轻载到满载 **结果** Vds_max_SR=245V

5.2.3. 动态性能



测试条件

Vin=90Vac/60Hz

Vout=60V

33%(0.6A) ~100%(1.8A) load

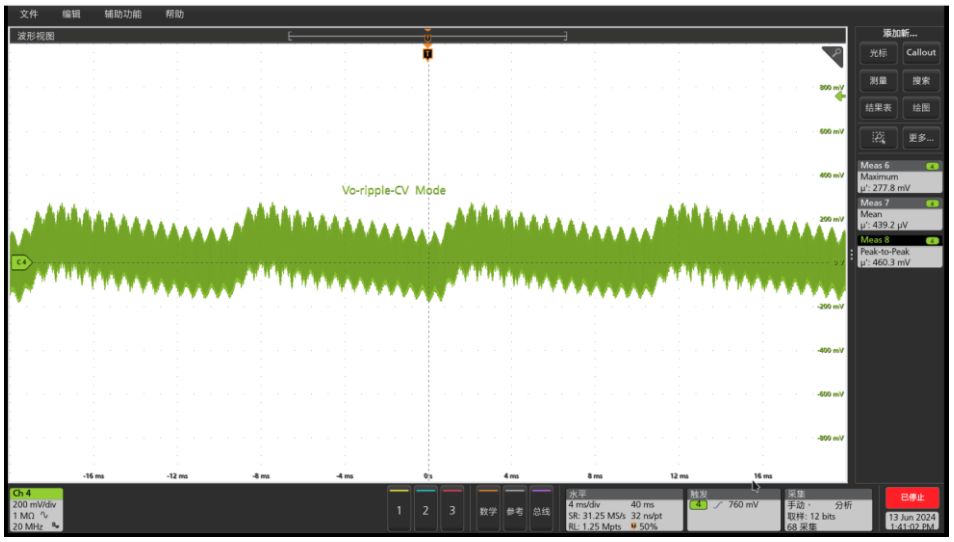
0.25A/us

T1=T2=5ms

结果

Vpp<5%

5.2.4. 输出纹波



测试条件

Vin=165Vac/50Hz

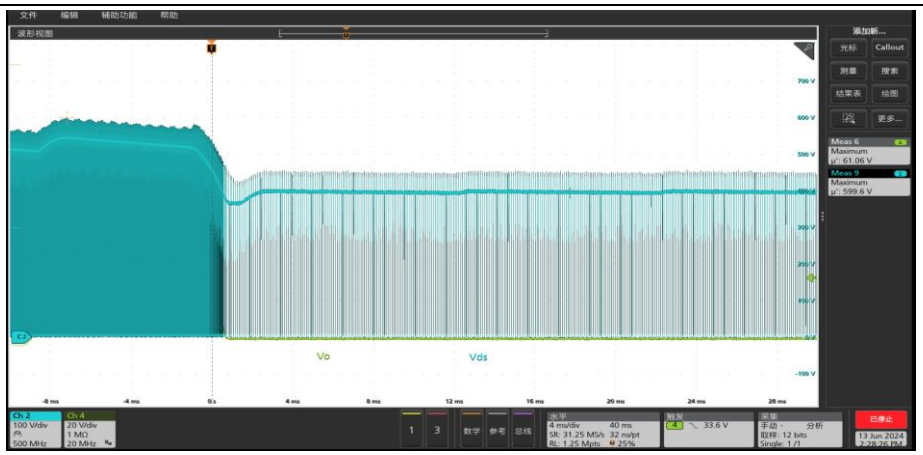
Vout=60V

满载 CV

结果

Vo_ripple=460 mV < 600mV

5.2.5. 短路测试



测试条件

Vin=275Vac/50Hz

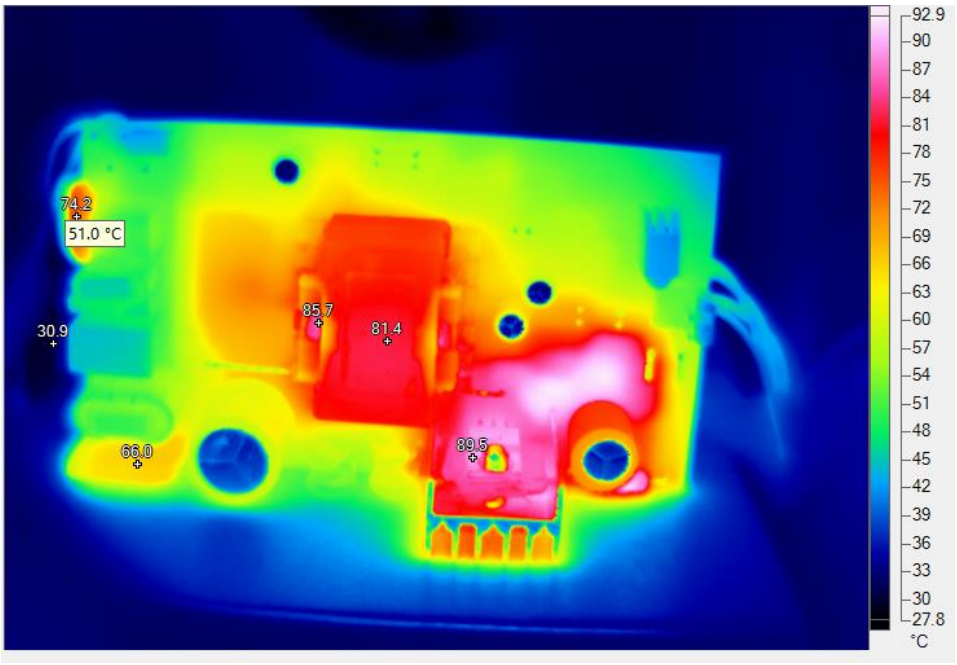
Vout=60V

满载

结果

Vds_max_QR=599.6V

5.2.6. 热性能



顶部

测试条件

Vin=165Vac/50Hz

Vout=60V

满载

环境温度31°C

运行1小时

结果

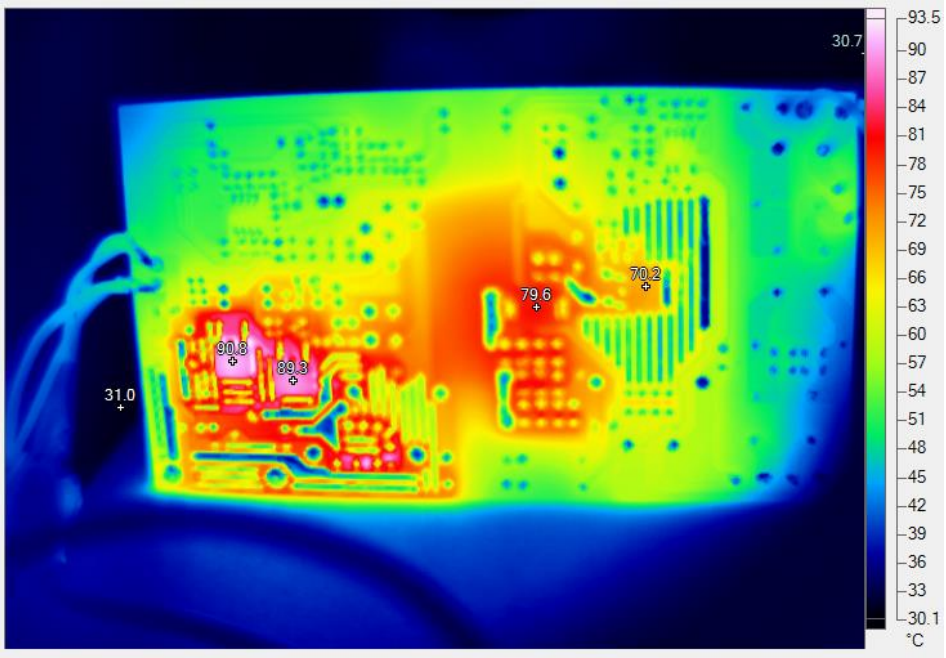
变压器线圈:85.7℃

磁芯：81.4℃

争流二极管:89.5℃

热敏电阻:74.2℃

整流桥:66℃



底部

测试条件

Vin=165Vac/50Hz

Vout=60V

满载

环境温度 31°C

运行1小时

结果

GaN：70.2℃

吸收二极管：79.6℃

背对背二极管:90.8℃

背对背MOSFET:89.3℃

测试条件

将PCBA安装进机箱并测试组件的温度。

机箱内部使用半灌胶进行散热。

Devices	Unit:℃	Equivalent to 55 ℃
输出整流二极管	93.07	122.07
变压器线圈	80.52	109.52
变压器磁芯	89.91	118.91
整流桥	87.13	116.13
反向输出MOSFET	96.4	125.4
GaN(INN700TK350B)	86.8	115.8
吸收电路二极管	92.07	121.07
反向输出二极管	90.32	119.32
机箱顶部	51.16	80.16
机箱底部	61.9	
机箱底部	60.2	

测试条件

Vin=165Vac/50Hz

Vout=60V

满载

环境温度26°C

运行3小时

结果

通过

Devices	Unit：℃	Equivalent to 55 ℃
输出整流二极管	91.6	119.6
变压器线圈	79.96	107.96
变压器磁芯	90.72	118.72
整流桥	71.42	99.42
反向输出MOSFET	95.2	123.2
GaN(INN700TK350B)	81.28	109.28
吸收电路二极管	89.44	117.44
反向输出二极管	89.21	117.21
机箱顶部	49.86	
机箱底部	60.2	

测试条件

Vin=275Vac/50Hz

Vout=60V

满载

环境温度27°C

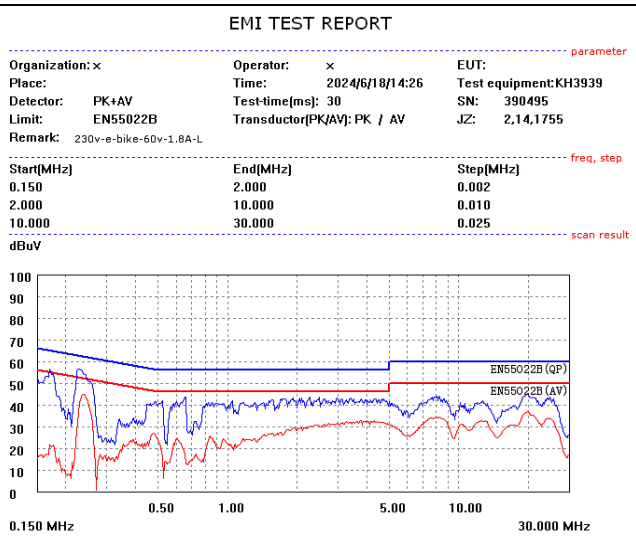
运行3小时

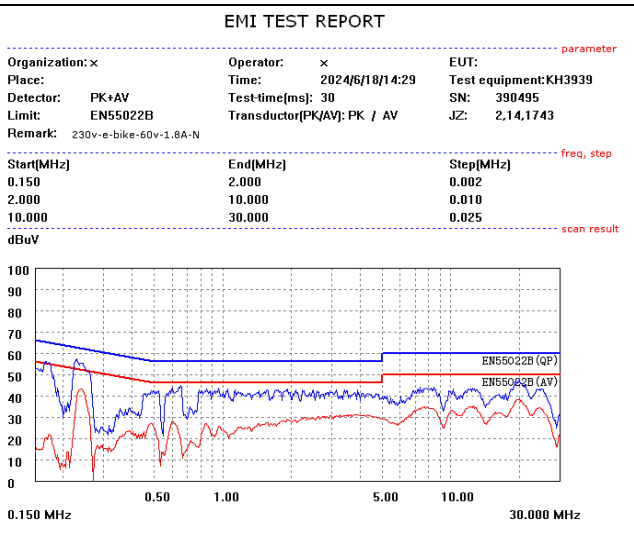
结果

通过

5.2.7. EMI

L	N
230V	





附录

附件 A. 原理图

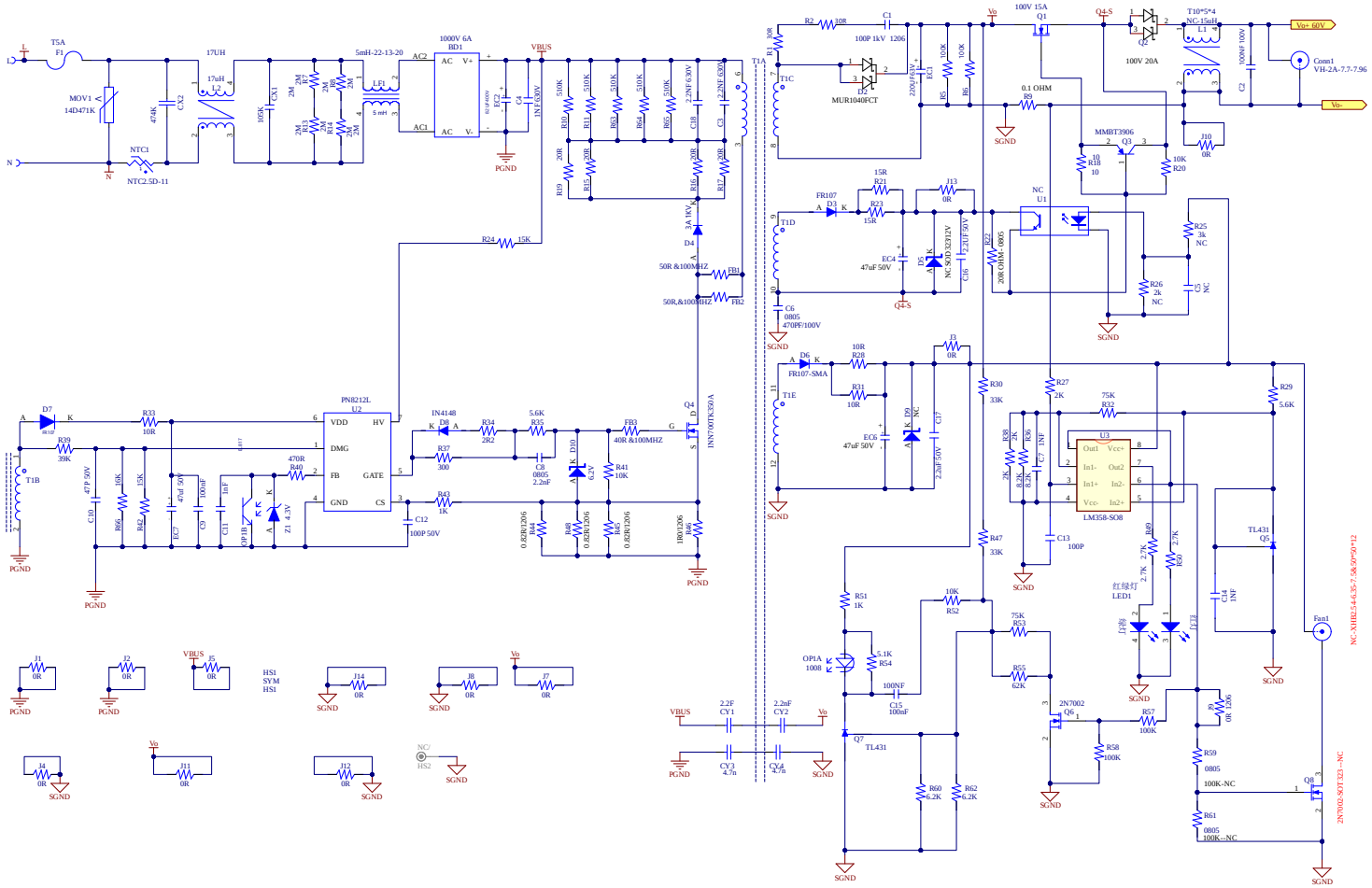


图 9 原理图

附件 B. BOM

表 6 BOM

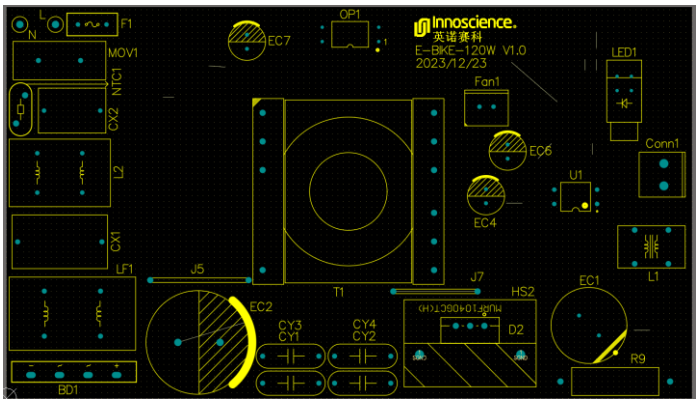
Comment	Description	Designator	Footprint	Quantity
WRGBU610	Rectifier Bridge World 1KV/6A	BD1	GBU_4P-L22.0-W3.5-P5.08	1
100P 1KV	Capacitor X7R 10%	C1	C1206R	1
100NF 100V	Capacitor X7R 10%	C2	C1206R	1
2.2NF 630V	Capacitor X7R 10%	C3,'C18	C1206R	2
1NF 630V	Capacitor X7R 10%	C4	C1206R	1
100P 100V	Capacitor X7R 10%	C6,	C0805R	1
2.2N 50V	Capacitor X7R 10%	C8	C0805R	1
1NF 50V	Capacitor X7R, 10%	C7, C11, C14	C0805R	3
100nF 50V	Capacitor X7R, 10%	C9, C15	C0805R	2
47P 50V	Capacitor X7R, 10%	C10	C0805R	1
100P 50V	Capacitor X7R, 10%	C12'C13	C0805R	2
2.2UF 50V	Capacitor X7R, 10%	C16, C17	C1206R	2
105K X2	JURCC yellow X2 105K MPX/MKP 275VAC305VAC	CX1	17*9.5*6.5 PIN=15mm	1
474K X2	JURCC yellow X2 474K MPX/MKP 275VAC305VAC	CX2	12*8*15 PIN=10mm	1
2.2nF Y2	AJC 222M 400VAC	CY1, CY2	pitch 7.5mm	2
4.7n Y2	KNSCHA JT 472M 400VAC	CY3, CY4	pitch 7.5mm;	2
220UF 63V	Aluminum electrolytic capacitor Yongming LK '220UF 63V	EC1	EC 13*26.5*5	1
82 UF 400V	Aluminum electrolytic capacitor Yongming KCX 82UF 400V	EC2	EC18*35.5*7.5	1
47UF 50V	Aluminum electrolytic capacitor Yongming LK 47UF 50V	EC4, EC7,'EC6	EC6.3*11.2*2.5	3
MUR1040FCT	YFW fast recovery/High efficiency diode/Voltage: 400V	D2	TO-220	1

	Current: 5A tube installation 10A VF=1.15V			
FR107	VDSS 1KV if=1A, tr=500 n s	D6 D7 D3	SMA	3
RS3M	3A 1KV GOODWORK	D4	SMC	1
IN4148	SOD323_SMD 1N4148	D8	SOD-323	1
BZT52C6V2S	6.2V Zener diode	D10	SOD-323	1
BZT52C4V3S	4.3V Zener diode	Z1	SOD-123	1
SQT3.15M	300VAC 3.15APlastic sealed square slow break Fuse	F1	FUSED-4X8-	1
50R &100MHZ	SMD Bead 50Ω@100MHz	FB1，'FB2	R1206	2
40R &100MHZ	SMD Bead 40Ω@100MHz	FB3	R0805	1
0R	0R,±1%,	J1, J9, J11, J12, J13, J14	R1206	6
0R	0R,±1%	J2, J3, J4, J8, J10	R0805	5
0R	Φ1.0mm*15	J5	JUMP_DIP_17.5	1
0R	Φ1.0mm*15	J7	JUMP_DIP_15	1
LT-10X13-SCH	LT-10X13-short	L1	LF 12*7.5*12	1
17UH	CM Inductor Lucky Tenda TD1212NY-17UH vertical	L2	L 18*12*16.5	1
5mH	'CM Inductor Lucky Tenda达TD1515-5mH vertical	LF1	8*10	1
红绿灯	Typical RED GaAs LED	LED1	14.3*6.2*12.4 (L*W*H)	1
NTC2.5D-15	NTC Resistor/ 2.5Ω 2.5D-15 / Dip P=7.5mm	NTC1	2.5D-15	1
OPTO EL817(C)-G	Optocoupler EVERLIGHT EL817(C)-G	OP1	DIP-4	1
15N10	N-mosfet 100V 15A Rdson=95 mohm &Vgs=10V	Q1	TO-252	1
MBR20100DT	Schottky Rectifiers 100V 20A VF=0.85V	Q2	TO-252	1
MMBT3906	PNP Bipolar Transistor	Q3	SOT-23B_N	1

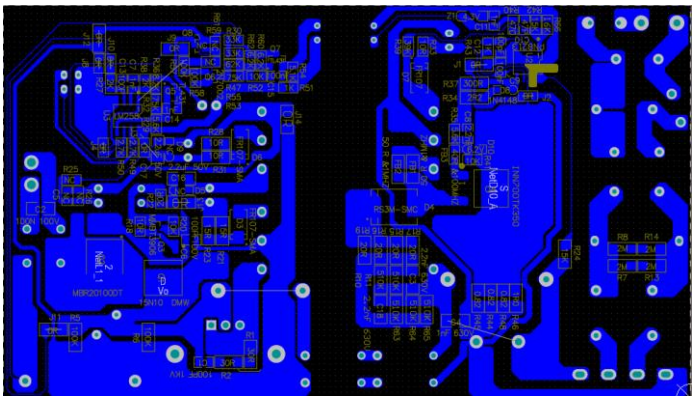
	MMBT3906			
INN700TK350B	GaN,700V/350 mΩ Innoscience	Q4	TO-252	1
TL431	ADJUSTABLE PRECISION SHUNT REGULATORS	Q5, Q7	SOT23	2
2N7002	N-Channel MOSFET 2N7002	Q6	SOT323	1
30R	Resistor 1%	R1, R2	R1206	2
100K	Resistor 1%	R5, R6	R1206	2
2M	Resistor 1%	R7, R8, R13, R14	R1206	4
0.1R	0.1R 1W DIP	R9	RES-TH_BD5.0-L15.5-P19.50-D0.7	1
510K	Resistor 1%	R10, R11, R63, R64, R65	R1206	5
20R	Resistor 1%	R15, R16, R17, R19	R1206	4
10	Resistor 1%	R18	R0805	1
10K	Resistor 1%	R20, R41, R52	R0805	3
15R	Resistor 1%	R21, R23	R1206	2
20R	Resistor 1%	R22	R0805	1
15K	Resistor 1%	R24	R1206	1
2K	Resistor 1%	R27, R38	R0805	2
10R	Resistor 1%	R28, R31	R1206	2
5.6K	Resistor 1%	R29, R35	R0805	2
33K	Resistor 1%	R30, R47	R0805	2
75K	Resistor 1%	R32, R53	R0805	2
10R	Resistor 1%	R33	R0805	1
2R2	Resistor 1%	R34	R1206	1
8.2K	Resistor 1%	R36	R0805	1
300	Resistor 1%	R37	R1206	1
39K	Resistor 1%	R39	R0805	1
470R	Resistor 1%	R40	R0805	1
15K	Resistor 1%	R42	R0805	1
1K	Resistor 1%	R43, R51	R0805	2
0.82R	Resistor 1%	R44, R45, R48	R1206	3
1R	Resistor 1%	R46	R1206	1
2.7K	Resistor 1%	R49, R50	R0805	2

5.1K	Resistor 1%	R54	R0805	1
62K	Resistor 1%	R55	R0805	1
100K	Resistor 1%	R57, R58	R0805	2
6.2K	Resistor 1%	R60, R62	R0805	2
16K	Resistor 1%	R66	R0805	1
PQ3220	Transformer: PQ3220 Lm=330uH 23:3:9:2:2	T1	34*33*25.1(L*W*H)	1
PN8212L-SOP7	Chipown PN8212L-SOP7 QR PWM IC	U2	SOP7	1
LM258-SO8	Low-power dual operational amplifiers ST	U3	SO8	1
VH-2A-7.7-7.96	Output connector	Conn1	7.7*7.96*13.3 (L*W*H)	1
HS1	Heatsink	HS1	26.3mm（L） *15.4mm (W)*35mm(H)	1
NC	connect to one fan	Fan1	50mm*50mm*12mm (L*W*H)	1
NC	VCR 14D471KA	MOV1	MOV 16.5*6.8*21.5	1
NC	N-Channel MOSFET	Q8	SOT323	1
NC	Resistor 1%	R25, R26	R0805	2
NC	Resistor 1%	R59, R61	R0805	2
NC	4-Pin Phototransistor Optocoupler	U1	DIP-4	1
NC	Capacitor X7R 10%	C5	C0805R	1
NC	Zener diode/BZT52-B12S,12V ZENER, SOD-323, PANJIT	D5 D9	SOD-323	2

附件 C. PCB Layouts



(a) 顶层 Layout



(b) 底层 Layout

历史版本

日期	版本	备注	作者
2024/6/27	1.0	第一版	AE团队

Note:
There is a dangerous voltage on the demo board, and exposure to high voltage may lead to safety problems such as injury or death.
Proper operating and safety procedures must be adhered to and used only for laboratory evaluation demonstrations and not directly to end-user equipment.

Reminder:
This product contains parts that are susceptible to electrostatic discharge (ESD). When using this product, be sure to follow antistatic procedures.

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