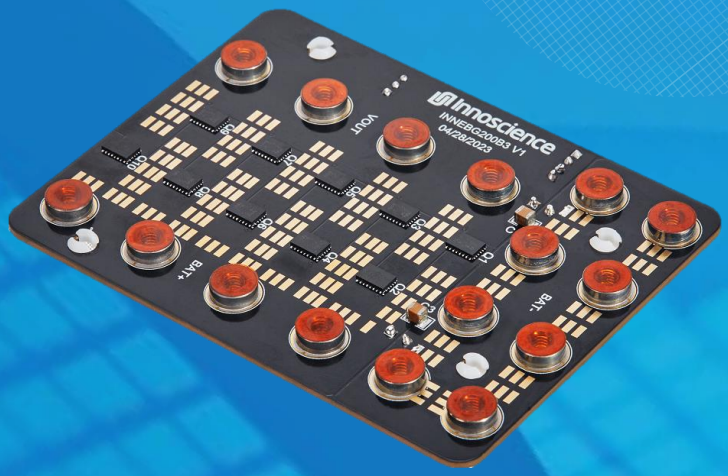
Innoscience 英诺赛科

POWER THE FUTURE

INNEBG200B3

Demo Manual

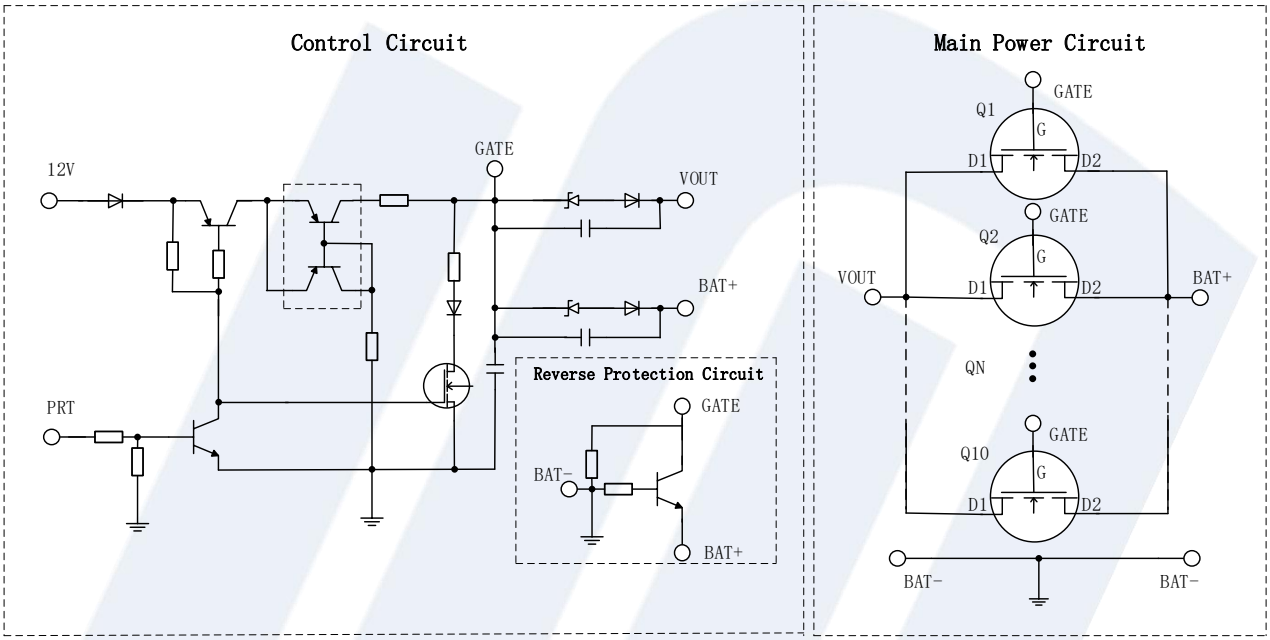
5V/200A Load Switch



5V/200A Load Switch

High Density Load switch

This Demo is a Load switch function circuit applied to the bi-directional current conduction ability, mainly used for Load switch. The switch on or off of the system can be controlled by a given PRT signal. It Adopts 10 innoscience VGaN INN040FQ012A in parallel. The max current is 200A.Input voltage 0.5Vdc-5Vdc, Output voltage0.5Vdc-5Vdc.



Highlighted Products

- Q1 to Q10: INN040FQ012A

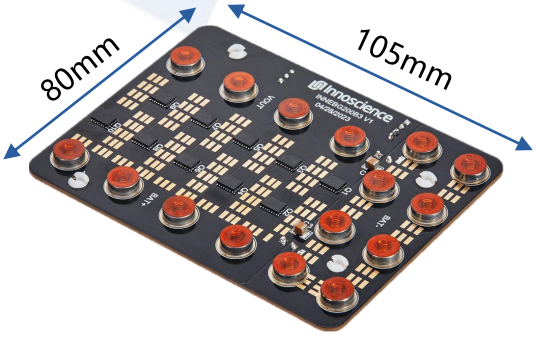
Target Applications

- Load Switch

Test Results

Content	Data	Condition
Parallel quantity	10pcs	Io=200A
Current	200A	/
Thermal	50.3℃	200A@Ta=25℃/2.5m/s airflow
	83.1℃	200A@Ta=25℃/ no airflow

Photos



List of Content

1. Overview

1.1. Description

This Demo is a Load switch function circuit applied to the bi-directional current conduction ability, mainly used for Load switch. The switch on or off of the system can be controlled by a given PRT signal. It Adopts 10 innoscience VGaN INN040FQ012A in parallel. The max current is 200A.Input voltage 0.5Vdc-5Vdc, Output voltage0.5Vdc-5Vdc. The demo size is : L105mm*D80mm*H18mm.

1.2. Features

■ Main features and Advantages

> Small size: L105mm*D80mm*H18mm

> High current capability: 200A

> Simple structure and convenient control: PRT (low: off; high: on)

> Low temperature rise: 25.3℃ (200A@Ta=25℃/2.5m/s airflow/10pcs in parallel)

■ Protection Function

> Battery reverse connection protection function

1.3. Applications

■ Load switch

2. Parameters

Table 1 Electrical characteristics (Ta=25℃)

Symbol	Parameter	Conditions	Min	Nom	Max	Units
System Specifications						
VOUT	Input voltage		0	5	5.5	Vdc
VBAT+	Output voltage		0	5	5.5	Vdc
IO	Current of load				200	A
12V	Auxiliary supply voltage	fixed value 12V	12	/	15	V
PRT	Control Signals	Low: off; high: on	3.3	/	5	V

3. Demo Solutions

3.1. Topology

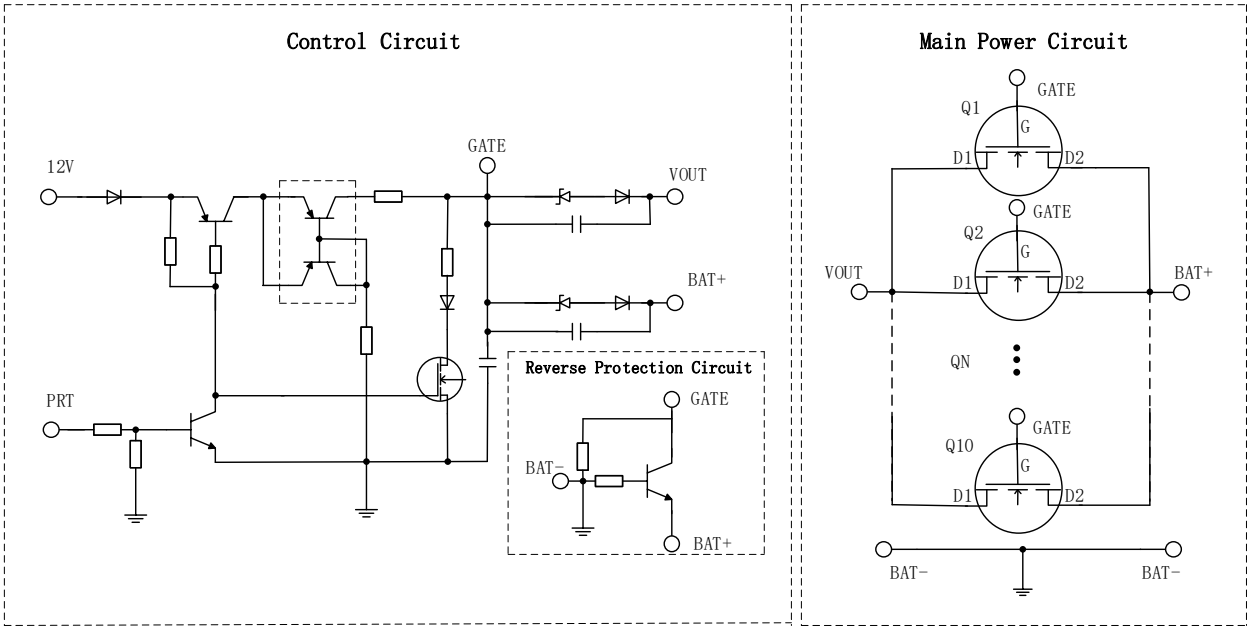


Figure 1 5V200A Load Switch topology

The control circuit is mainly realized to provide stable control voltage to the driver, and realize the stable control of the circuit. MCU can be used to control the opening and closing of the circuit through PRT pin.

BAT+/BAT- has anti-reverse connection function. If reverse connection, cannot be opened by PRT.

The main power circuit adopts 10 INN040FQ012A in parallel, which can achieve a maximum rated current capacity of 200A.

3.2. Value of InnoGaN

- Greater current capacity with a smaller size: FCQFN 6mm X 4mm
- Simpler and more reliable control circuit.
- Faster switching speed.
- Lower temperature rise.

3.3. Highlighted Products

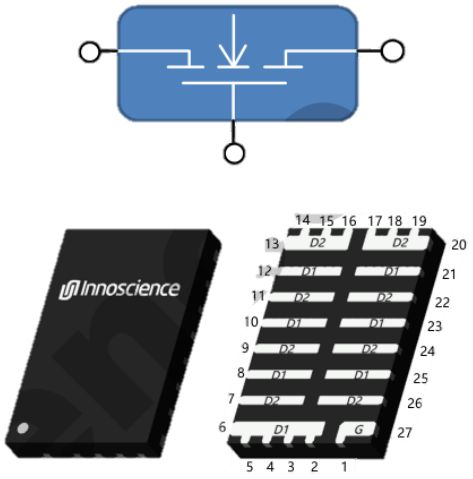


Figure 2 InnoGaN device INN040FQ012A

VGaN: INN040FQ012A

40V Bi-directional GaN Enhancement-mode Power Transistor

Key performance parameters at Tj=25℃

Parameter	Value	Unit
$V_{DD,max}$	40	V
$R_{DD(on),max}$@V_G=5V	1.2	mΩ
$Q_{G,typ}$@V_{DD}=20V	60	nC
$I_{D,DC}$	100	A

4. Hardware Implementation

4.1. Hardware Introduction

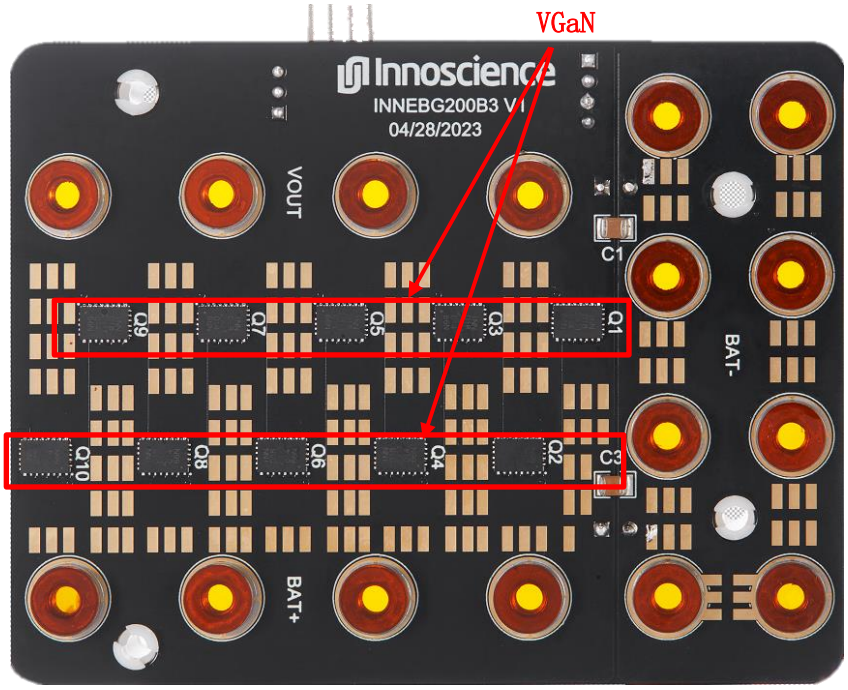


Figure 3 5V200A Load Switch (top)

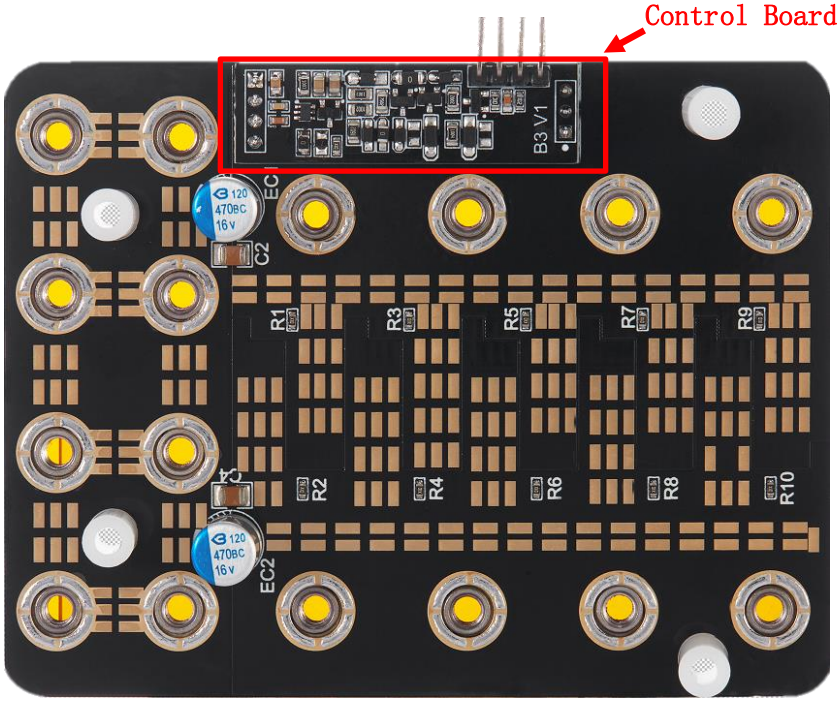


Figure 4 5V200A Load Switch (bottom)

4.2. Design Considerations

4.2.1. InnoGaN Driver Circuit Design

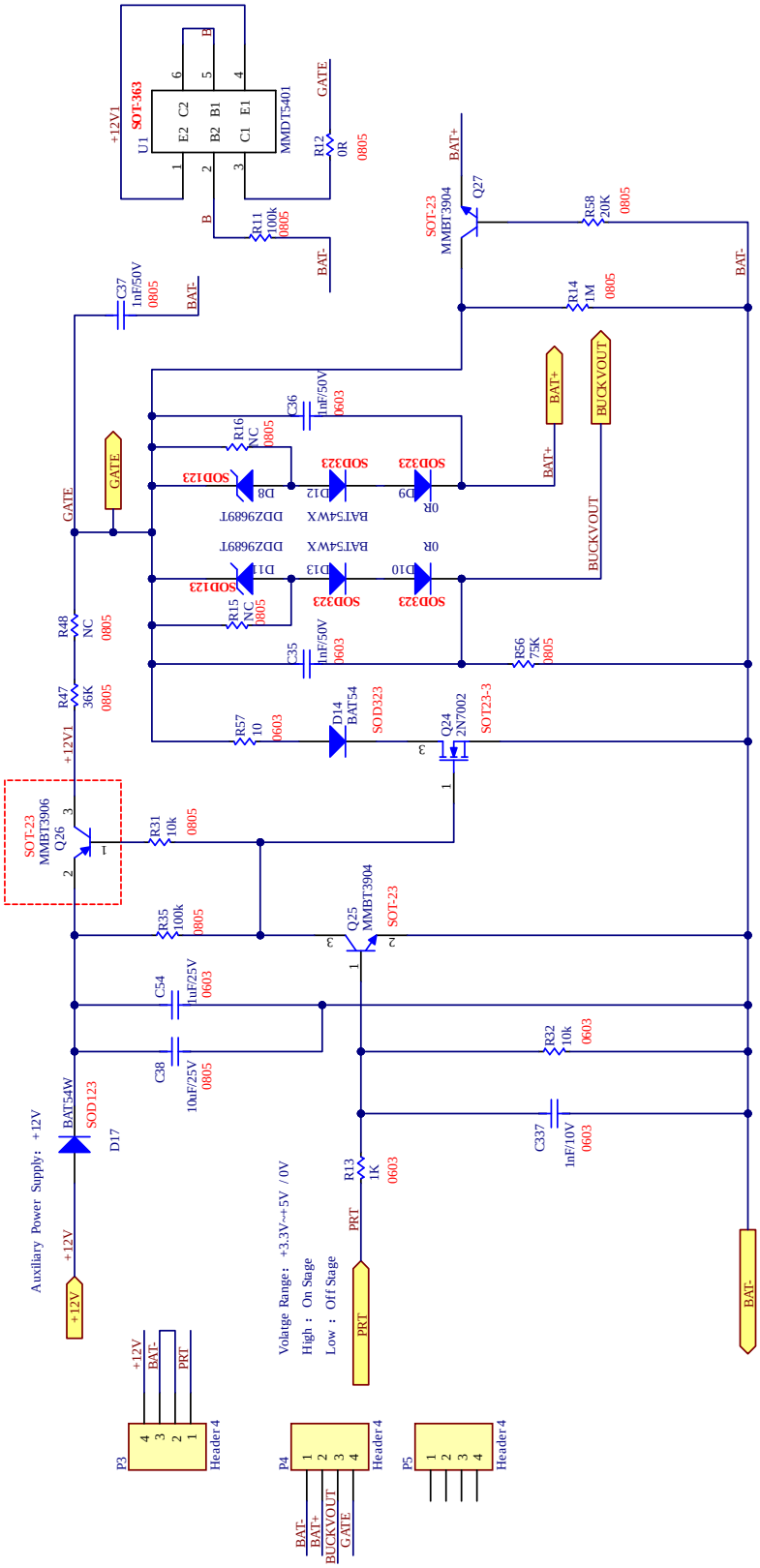


Figure 5 Control Board circuit

Recommended drive circuit as figure 5. The key device parameters are listed in the following table:

DDZ9689	Zener Diode, DDZ9689Q-7, sod-123	D8, D11	2
BAT54WX	Diode, BAT54WX, sod-123	D12, D13, D14, D17	4
MMDT5401	MMDT5401, SOT-363	U1	1

The VGaN power layout is interleaved. The regulator of the control circuit is greatly affected by temperature, so it is best to stay as far away from the pipe as possible (Figure 4).

4.2.2. InnoGaN Thermal Design

For high current and heat dissipation, at least four layers of power boards are recommended. Perforated as much as 0.2mm between layers (Figure 6).2 oz is recommended for copper.

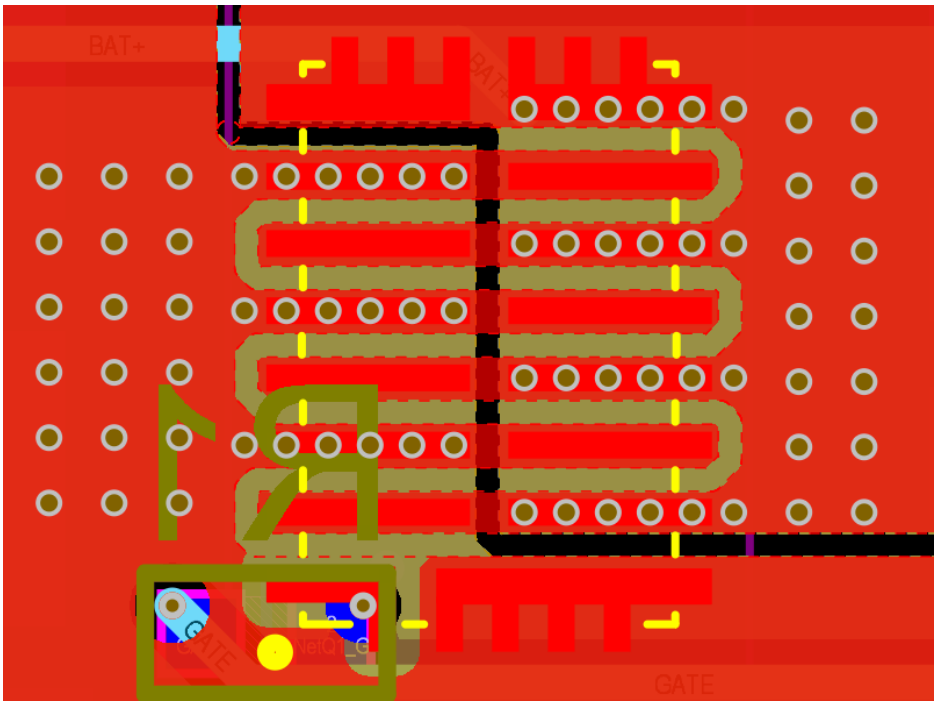


Figure 6 Layout recommended

5. Testing & Results

5.1. Test Setup

INN040FQ012A is designed mainly for load switch. Demo board adopts MCU control solution by PRT. The PRT PIN as shown in Figure 7. The system needs to provide a stable 12V DC voltage at the 12V PIN to GND.

measurement setup:

a) With power off, connect the input power supply, 12V auxiliary power supply, load, control signals, digital multimeter and oscilloscope according to figure 7 correctly.

b) Turn on the 12V auxiliary power supply.

c) Turn on input power supply to required value, make sure that input voltage does not exceed 5.5V.

d) Input a stable high voltage(3.3V) to the PRT.

e) Turn on the load make sure that current does not exceed 200A.

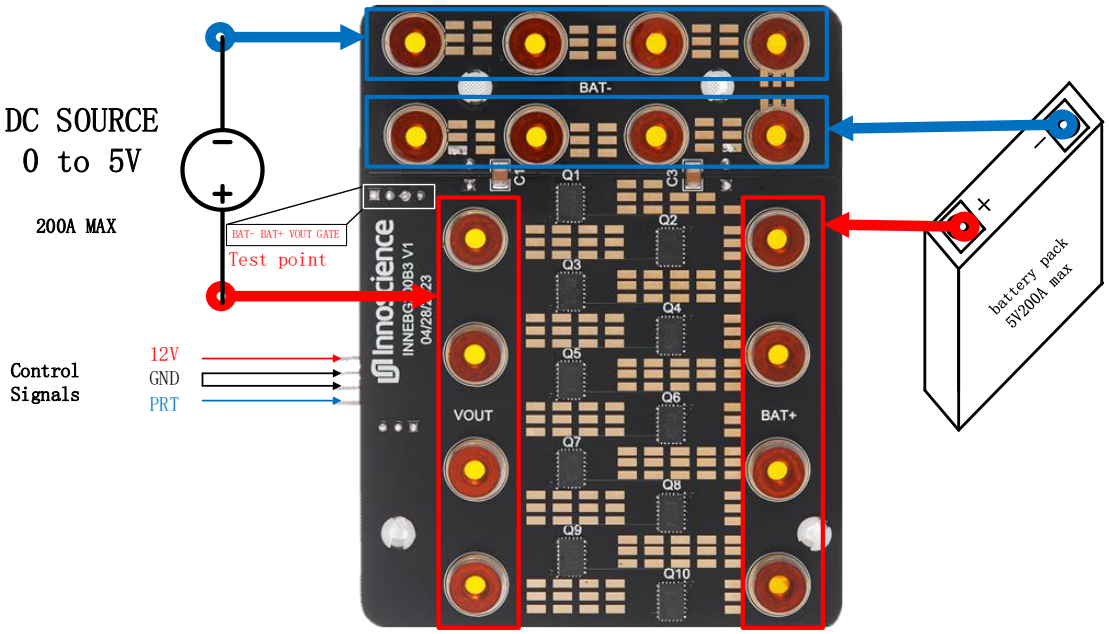
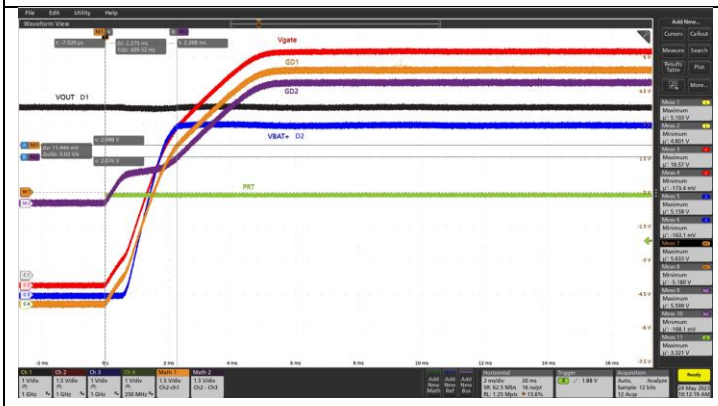


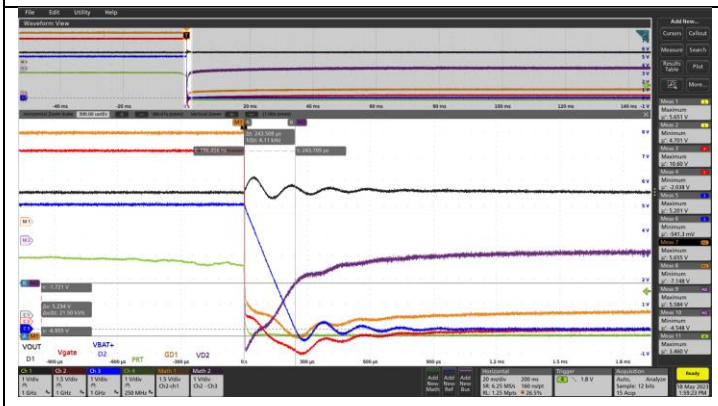
Figure 7 wiring diagram

5.2. Test Results

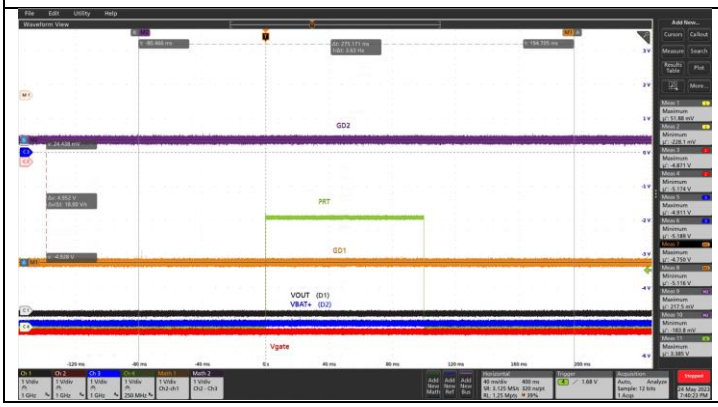
5.2.1. Load switch turn on

Waveform	Result
	**Test Condition:** VOUT=5V Auxiliary Power=12V Io=0A PRT Control Signal: 0V → 3.3V No Airflow **Test Result:** The opening process is normal with a stable opening delay of 2.275ms from the PRT control signal to Vo (BAT+).

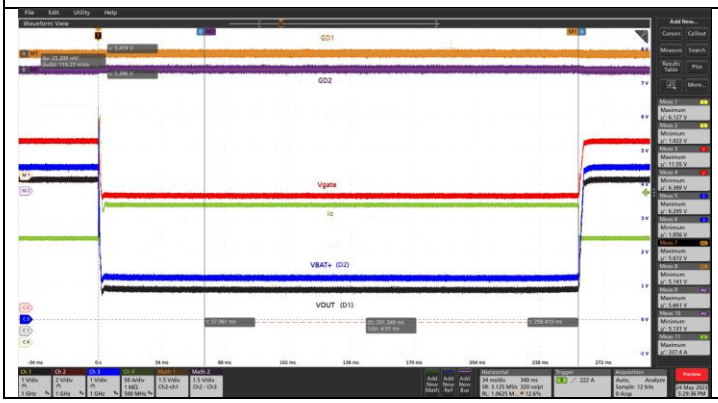
5.2.2. Load switch turn off

Waveform	Result
	**Test Condition:** VOUT=5V Auxiliary Power=12V PRT Control Signal: 3.3V→ 0V Io=10A No Airflow **Test Result:** The shutdown process is normal and Vgate drops to Vo(BAT+)=0 with a shutdown delay of about 243.509us

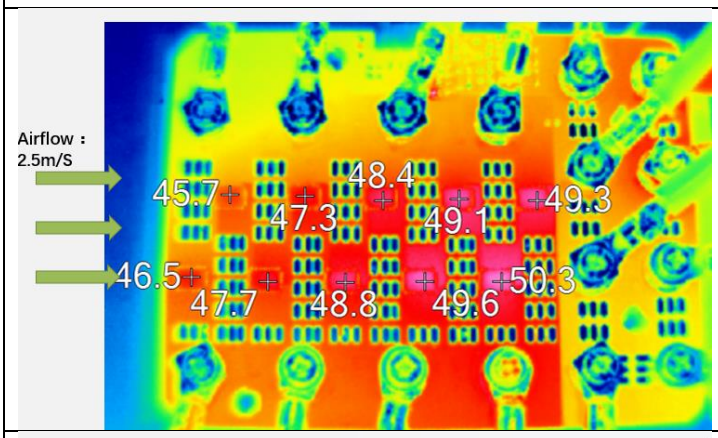
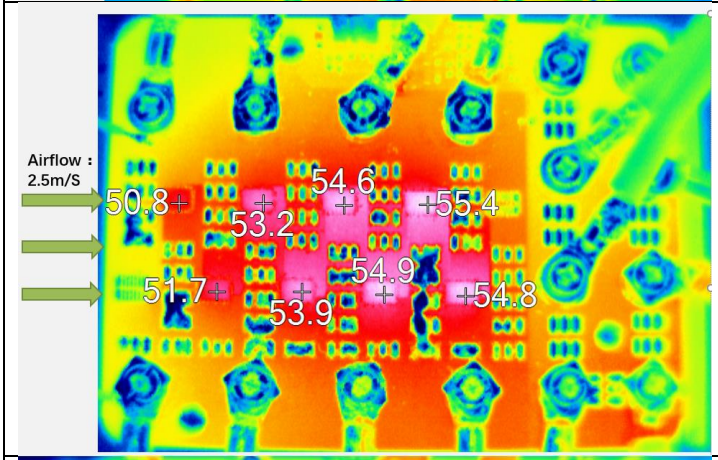
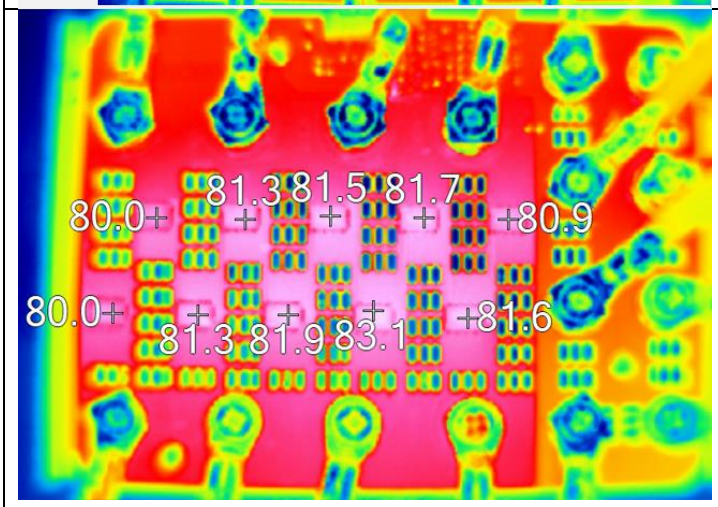
5.2.3. Reverse Protection

Waveform	Result
	**Test Condition:** VOUT=0V VBAT+=-5V Auxiliary Power Supply:12V PRT Control Signal: 0V→3.3V→ 0V No Airflow **Test Result:** The reverse protection circuit works and the VGaN keeps off.

5.2.4. Load short circuit

Waveform	Result
	**Test Condition:** VOUT=5V Auxiliary Power:12V PRT Control Signal :3.3V Io=150A(CC=200A) Load short circuit and recoverd No Airflow **Test Result:** The system keeps on normally.

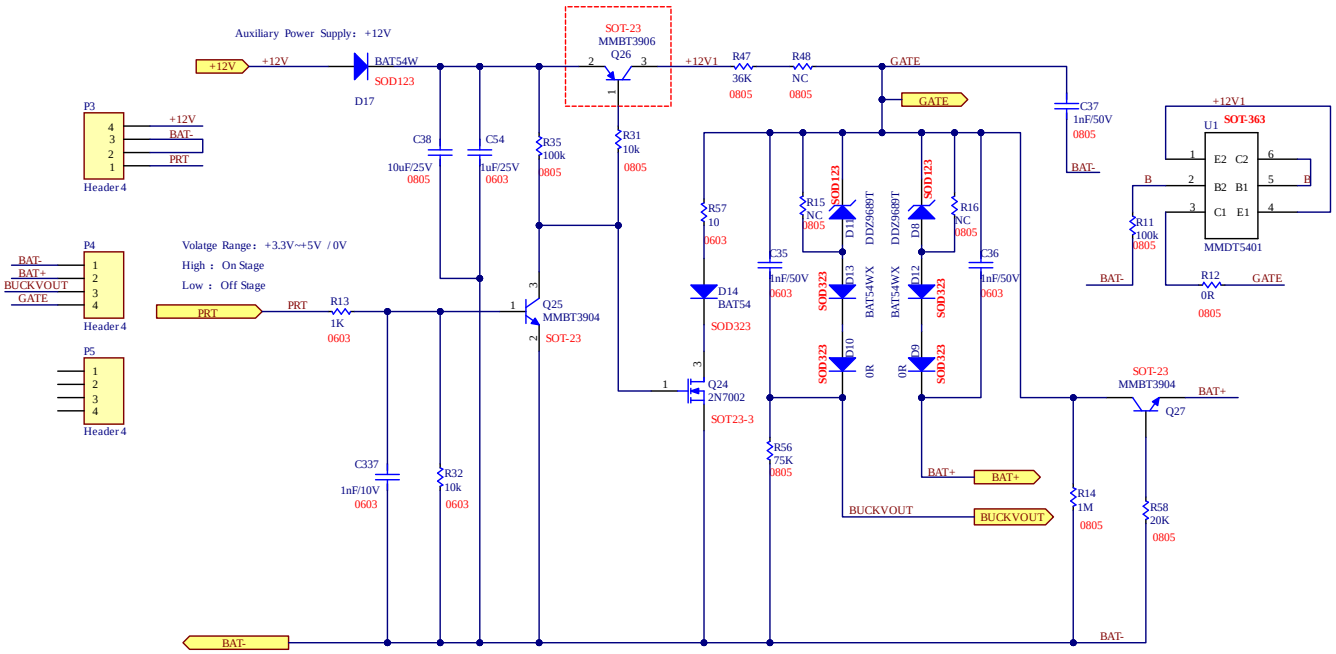
5.2.5. Thermal Test

Thermal	Result
	Test Condition: Vin=5V, Io=200A, Airflow:2.5m/s TA=25℃ INN040FQ012A in parallel: 10pcs **Test Result:** T_min:45.7℃ T_max: 50.3℃
	Test Condition: Vin=5V, Io=200A, Airflow:2.5m/s TA=25℃ INN040FQ012A in parallel: 8pcs **Test Result:** T_min:50.8℃ T_max: 55.4℃
	Test Condition: Vin=5V, Io=200A, Airflow:0m/s TA=25℃ INN040FQ012A in parallel: 10pcs **Test Result:** T_min:80.0℃ T_max: 83.1℃

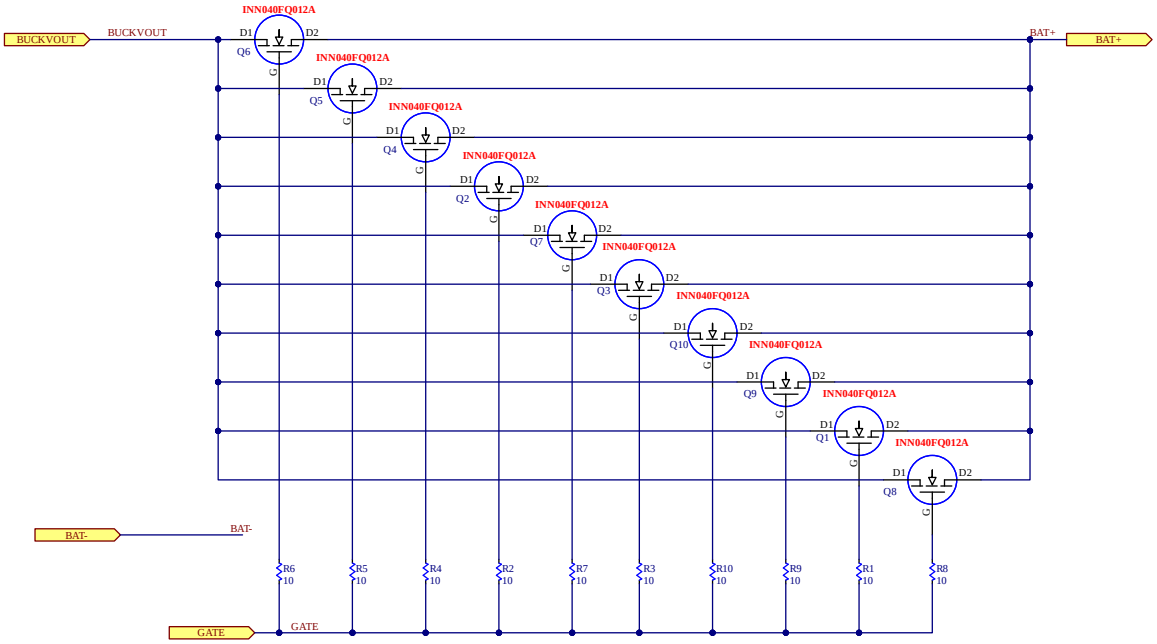
Appendix

Appendix A. Schematics

Driver Control Circuit:



Main Power Circuit:



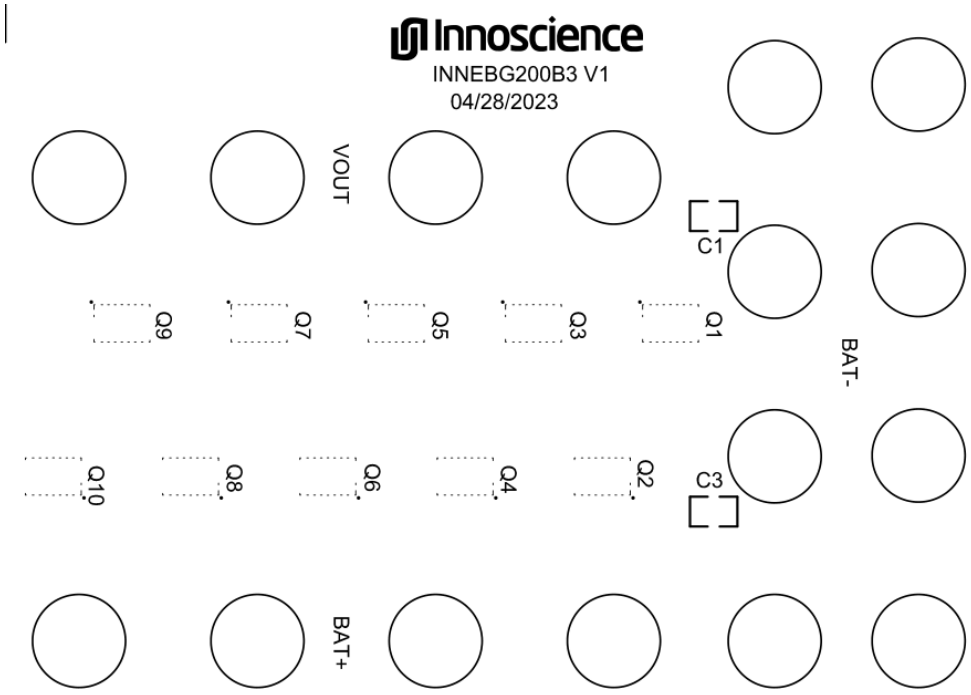
Appendix B. BOM

Comment	Description	Designator	Quantity
22uF/25V	'22uF/25V,X7R,25V,1210	C1, C2, C3, C4	4
100pF/50V	100pF/50V,0603	C35, C36	2
1nF/50V	1nF,X7R,50V,±10% ,0603	C37	1
10uF/25V	10uF/25V,0805	C38	1
1uF/25V	1uF/25V,0603	C54	1
1nF/10V	1nF/10V,0603	C337	1
DDZ9689	Zener Diode, DDZ9689Q-7, sod-123	D8, D11	2
BAT54WX	Default Diode, BAT54WX, sod-123	D12, D13, D14, D17	4
0R	resistance,0R,1206,1%	D9, D10	2
470uF/16V	470uF/16V, EC8*11.5*3.5	EC1, EC2	2
M40*30	SMTSOM430BTR, SMD	J1,J2,J3,J4,J5,J6,J7,J8,J9, J10,J11,J12,J13,J14,J15,J16	16
Header 3	Header, 3X1Pin, HDR2.54,	P5	1
Header 4	Header, 4X1Pin, HDR2.54,90°	P3	1
Header 4	Header, 4X1Pin, HDR2.54,	P4	1
Innoscience GaN	INN040FQ012A, Innoscience, FCQFN 6*4	Q1, Q2, Q3, Q4, Q5, Q6, Q7, Q8, Q9, Q10	10
2N7002	N-Channel MOSFET, SOT23-3L	Q24	1
MMBT3904	NPN Bipolar Transistor, SOT23-3L	Q25, Q27	2
MMBT3906	MMBT3906, SOT-23, PNP, -40V, SOT23-3L	Q26	1
10	resistance,10R,0603,1%	R1, R2, R3, R4, R5, R6, R7, R8, R9, R10, R57	11
36k	resistance, 10K,0805,1%	R47	2
0R	resistance, 0R,0805,1%	R12	1
1K	resistance,0K,0603,1%	R13	1
1M	resistance,1M,0805,1%	R14	1
NC	resistance, 0805,1%	R15, R16	2
75k	resistance, 75k,0805,1%	R56	3
10k	resistance,10K,0805,1%	R31	1
10k	resistance,10K,0603,1%	R32	1

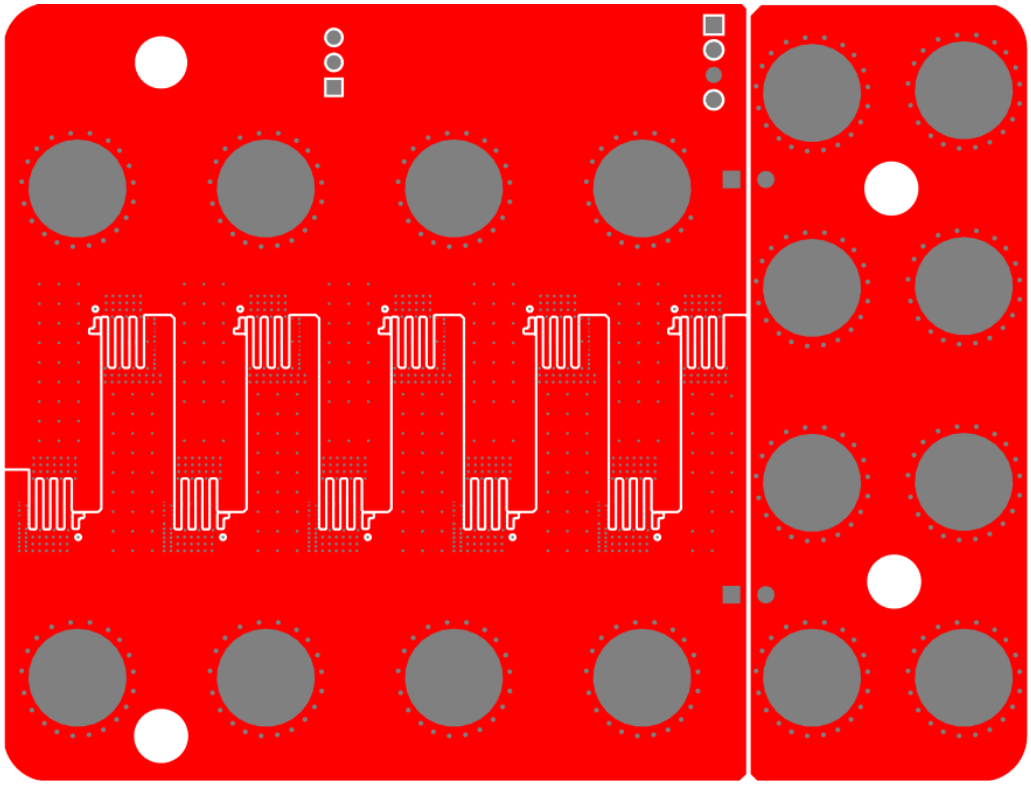
100k	resistance,100K,0805,1%	R35,R11	2
20K	resistance,20K,0805,1%	R58	1
MMDT5401	MMDT5401, SOT-363	U1	1

Appendix C. PCB Layouts

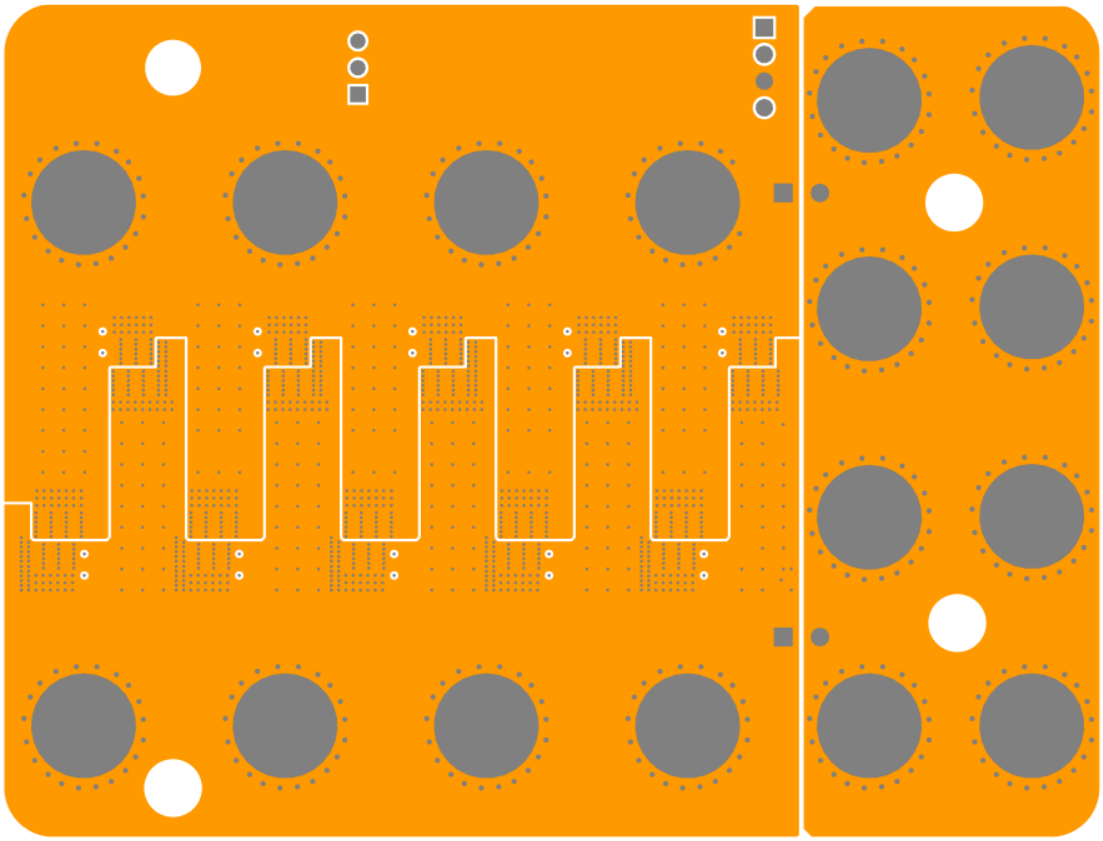
Main Board



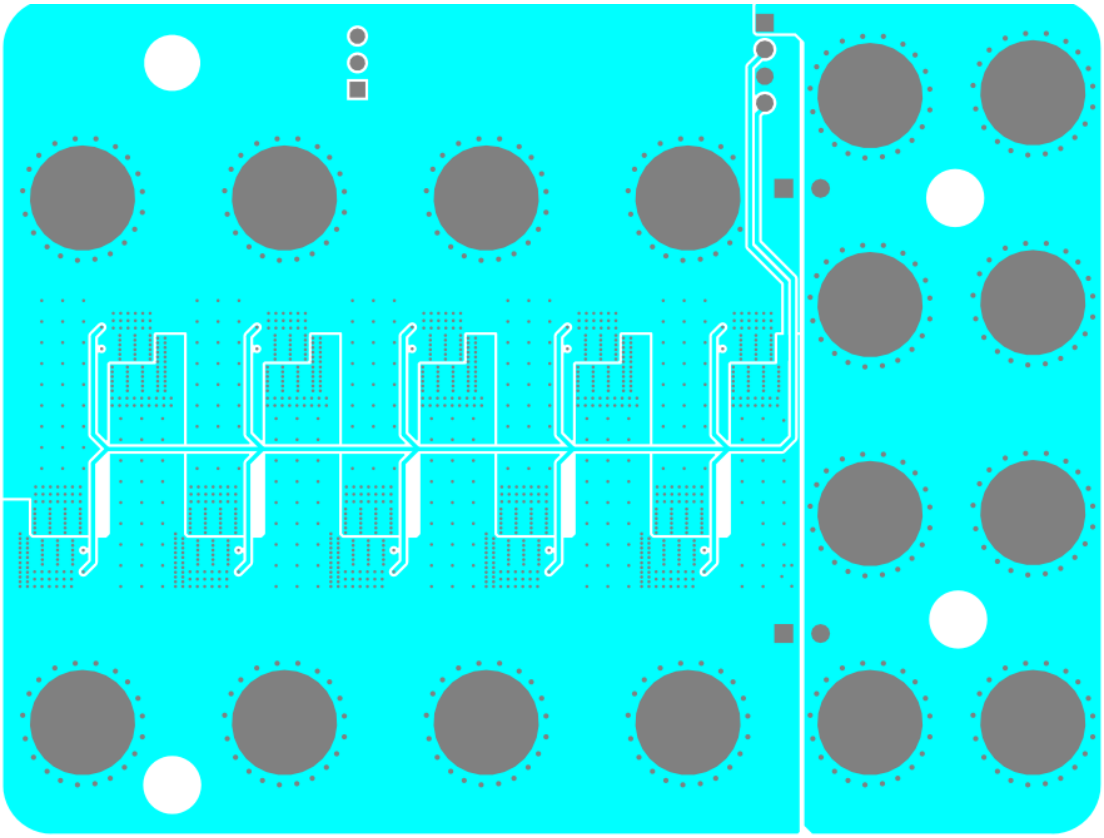
Top overlay



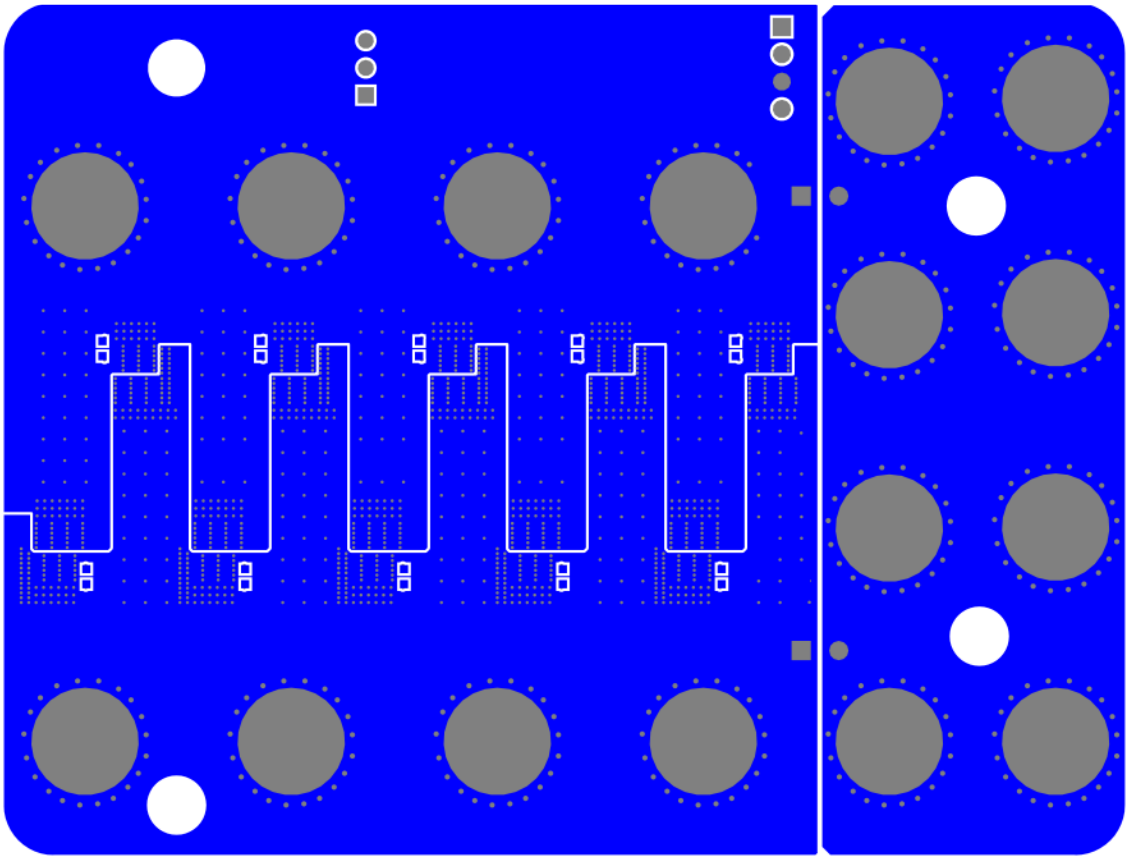
Top layer



Mid layer 1



Mid layer 2



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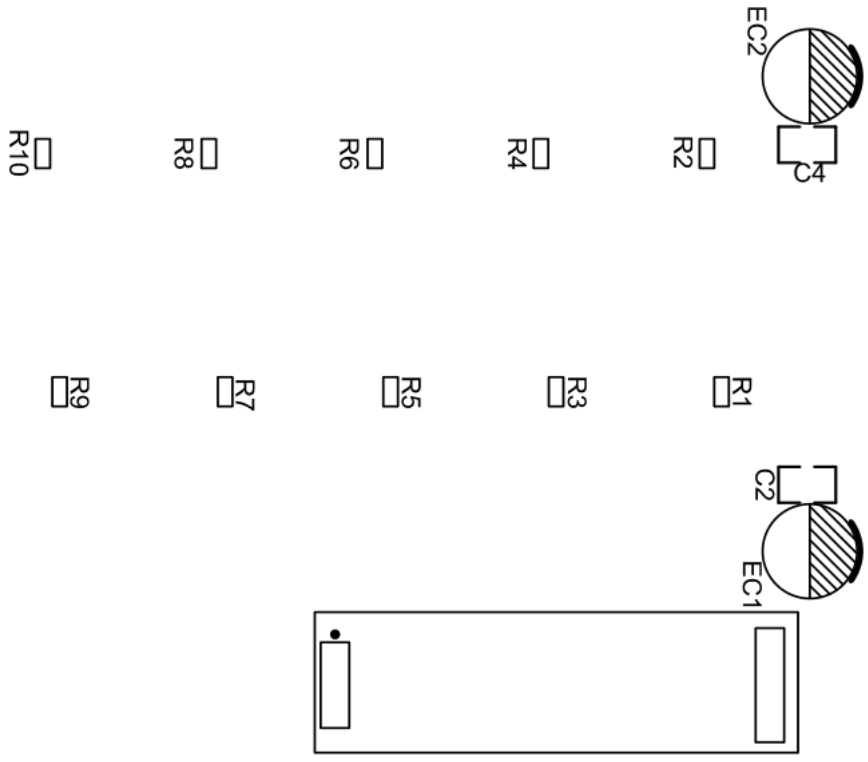
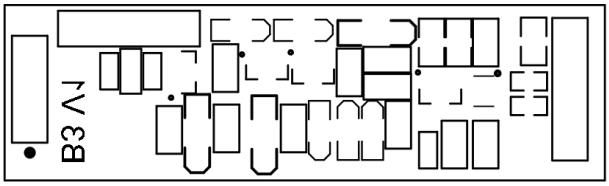


Bottom overlay

Control Board

A/N



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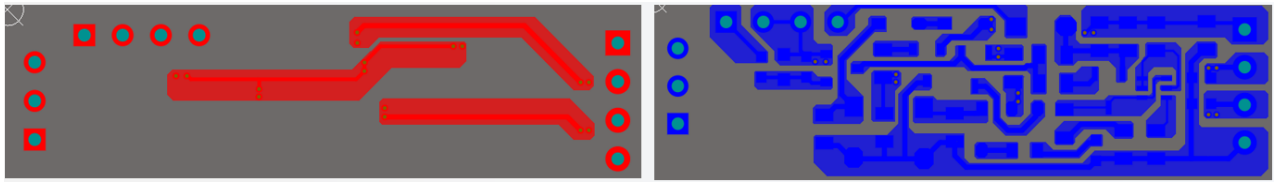
Bottom overlay



Top Layer

Bottom layer

Revision History

Date	Author	Versions	Description	Check
2023/05/30	Xinwei Li	1.0	First edition	AE Team
2023/07/31	Xinwei Li	1.1	Update figure of cover page and 3.1 Topology, key device of bom	AE Team
2023/08/03	Xinwei Li	1.2	Update thermal test	AE Team

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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