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TND6319/D

PTC IGBT Driver Reference Design

Introduction

This document is the entry point to the reference documentation of PTC heater discrete IGBT driver board evaluation platform, version 1.0.1.

The evaluation platform is for thermal performance evaluation that provides developers with the tools and test data needed to build applications that drive PTC based on high current isolated driver and IGBT from On Semiconductor.

This documentation focuses on the output voltage and current adjustment through high side and low side IGBT, and would help user to setup different variables, such as voltage, to get the wanted current and get the wanted test condition. Finally, it will help customer better understand isolated driver and IGBT performance by tested data and curve.

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REFERENCE DESIGN

SPECIFICATION

Device Series	Application	Input Voltage	Output Power	Topology	I/O Isolation
NCV57000 / FGH40T65SP_F085 / NCV8871X / NCV2700X	PTC heater / /Auto / Industry	200 Vdc ~ 400 Vdc	1.8 kW	High/low side driver Isolated Power supply	Yes

OTHER SPECIFICATION

Output Voltage	Max 380 Vdc (Depends on IGBT)
Max Current	40 Arms
Minimum Efficiency	Depend on the PTC system
Operating Temp. Range	−10 – 125 °C
Cooling Method	Air conditioning water circulation system
Signal Level Control	GPIO / PWM
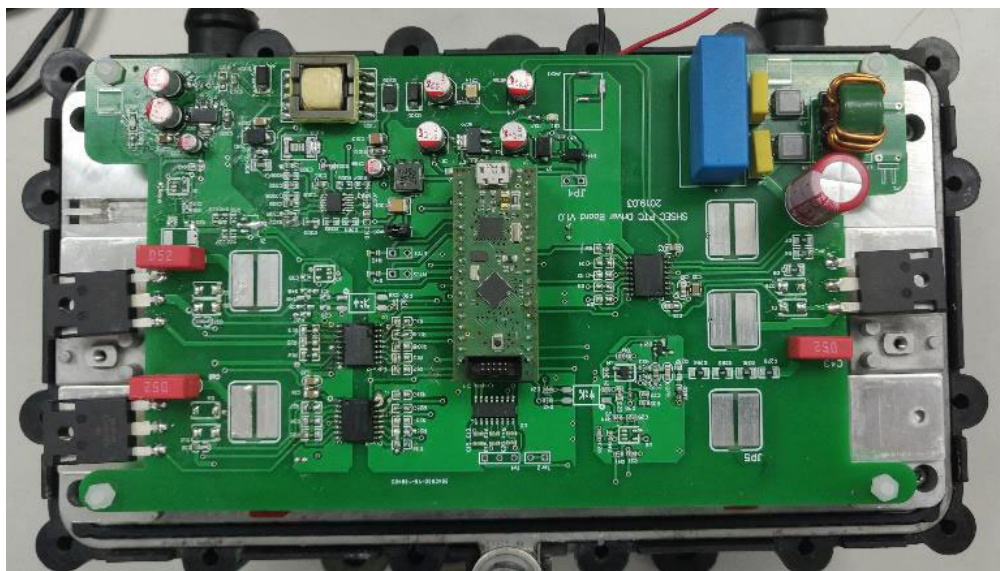
Figure 1. PTC Platform

The system diagram is in Figure 2. The key elements of the EVB are marked in the color blocks.
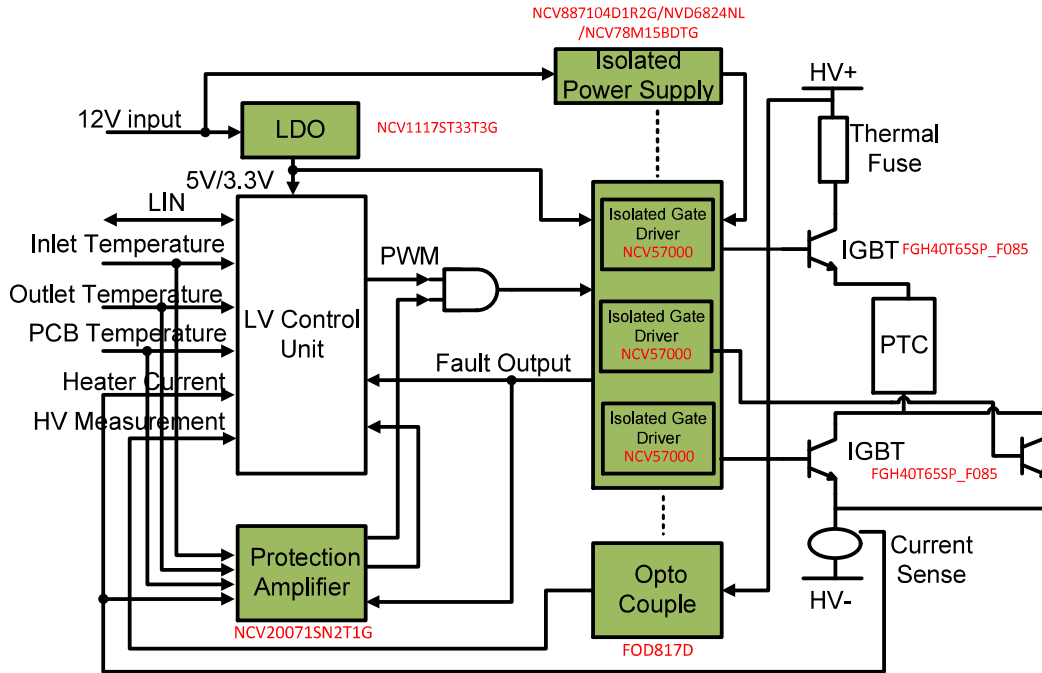
Figure 2. System Diagram of PTC Heater Driver Board
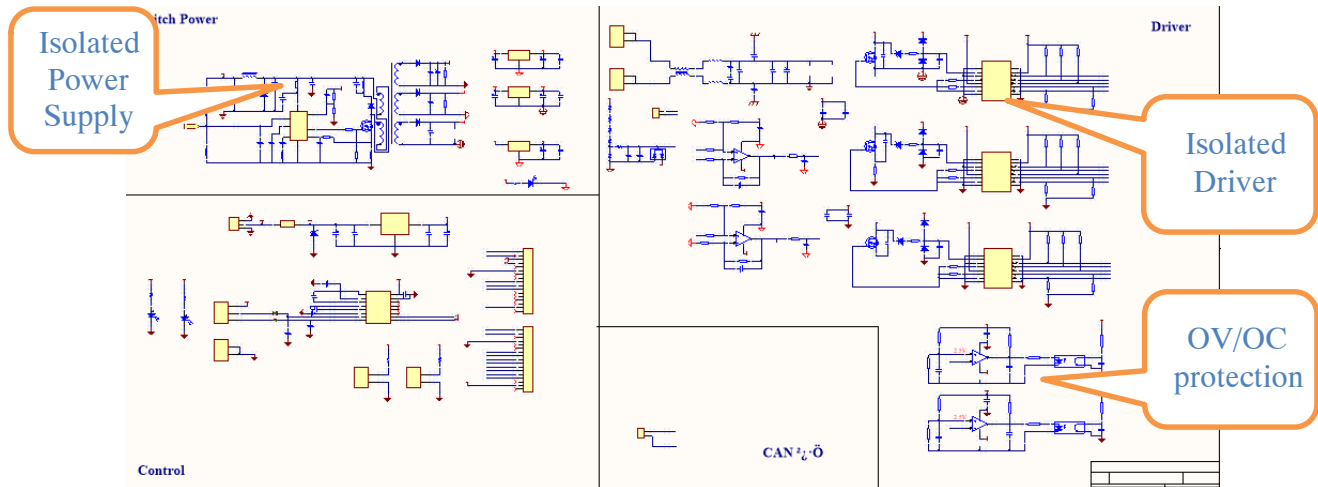
Figure 3. System Schematic Diagram of the PTC Heater Driver Board

Overview

This note will address the following topics 1) explanation of circuit 2) explanation of software and 3) thermal test result. The complete bill of materials and schematics are also included.

CIRCUIT DESCRIPTION

1) PTC driver board is made of a set of components that are isolated to provide a reliable working condition based on high−low power system.

- High−current single channel IGBT driver with internal galvanic isolation, designed for high system efficiency and reliability in high power applications
- Two phases output, flexible switch frequency: 100 Hz~16 kHz
- Low Saturation Voltage using Trench IGBT with Field stop Technology

- Below 500 V battery system
- Key components support AEC−Q100/101
- Rail−to−rail output operation, 3 MHz bandwidth high speed Op−Amp
- Adjustable output non−synchronous boost controller which drives an external N−channel MOSFET
- Easy for customer to qualify and evaluate whole performance
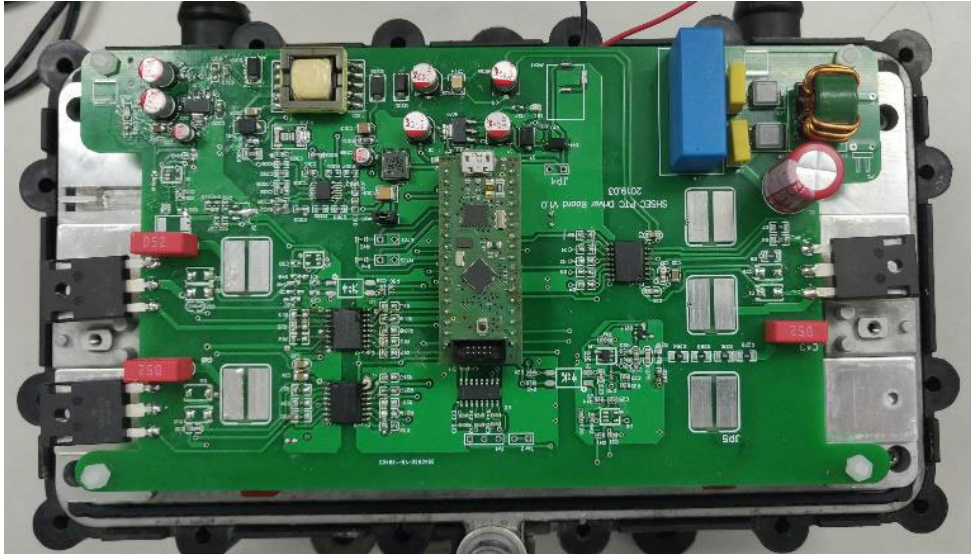
Figure 4. Driver Board

PTC Heater Module
- Input Max Power 1200 W
- Appearance Size 242 mm × 132 mm × 65 mm
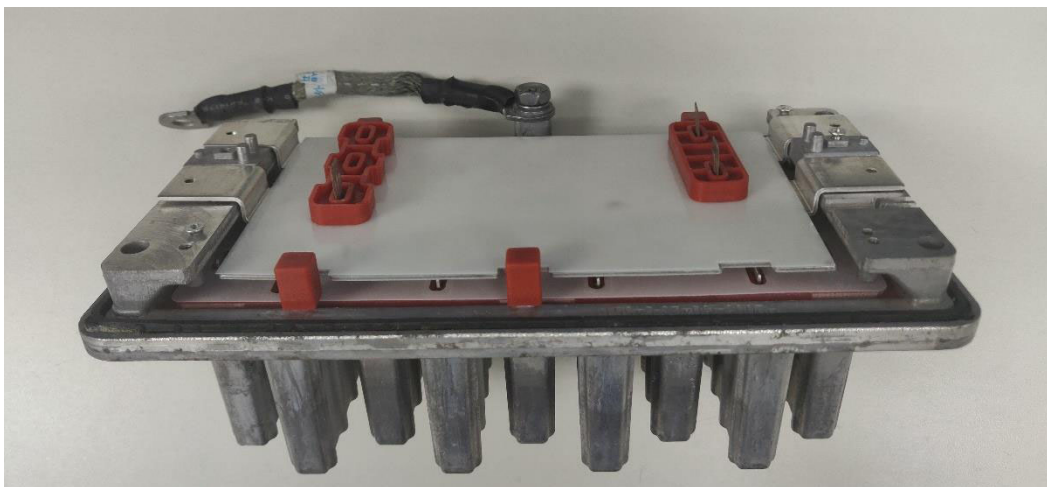
Figure 5. PTC Heater

1.2 kW DC Source

- Voltage output range: 0 – 600V
- Current output range: 0 – 8A
- Accurate Voltage and Current Measurement

Figure 6. DC Source

Isolated High Current and High Efficiency IGBT Gate Driver NCV57000

- High Current Output(+4/−6 A) at IGBT Miller Plateau Voltages
- Short Propagation Delays with Accurate Matching
- DESAT with Soft Turn Off
- Active Miller Clamp and Negative Gate Voltage
- 5 kV Galvanic Isolation
- AEC qualified
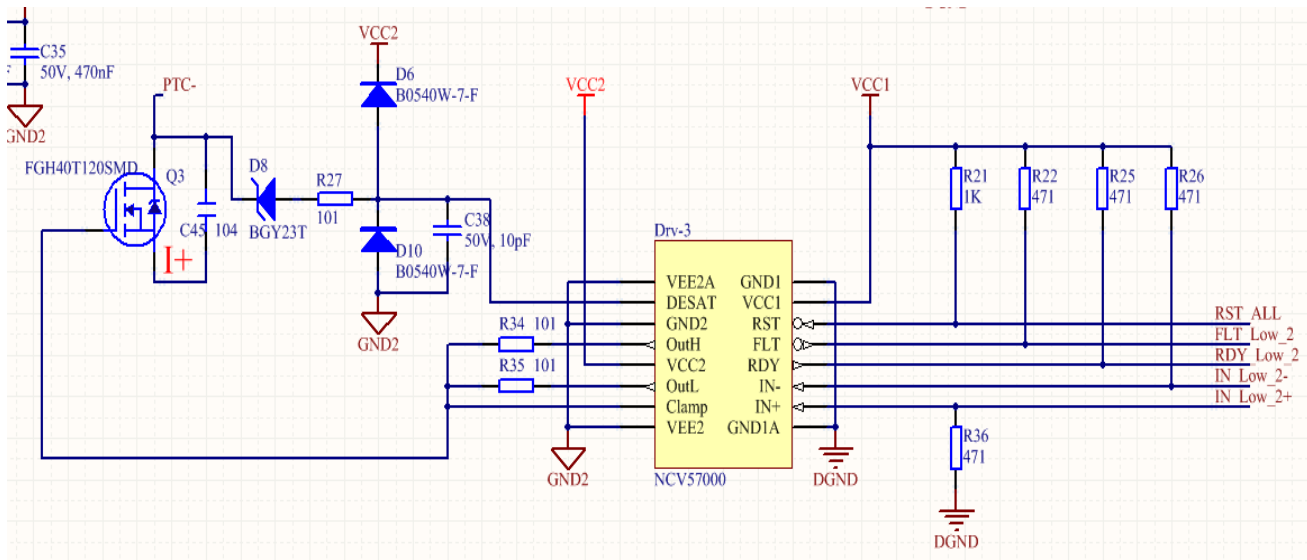
Figure 7. NCV57000 Driver Diagram
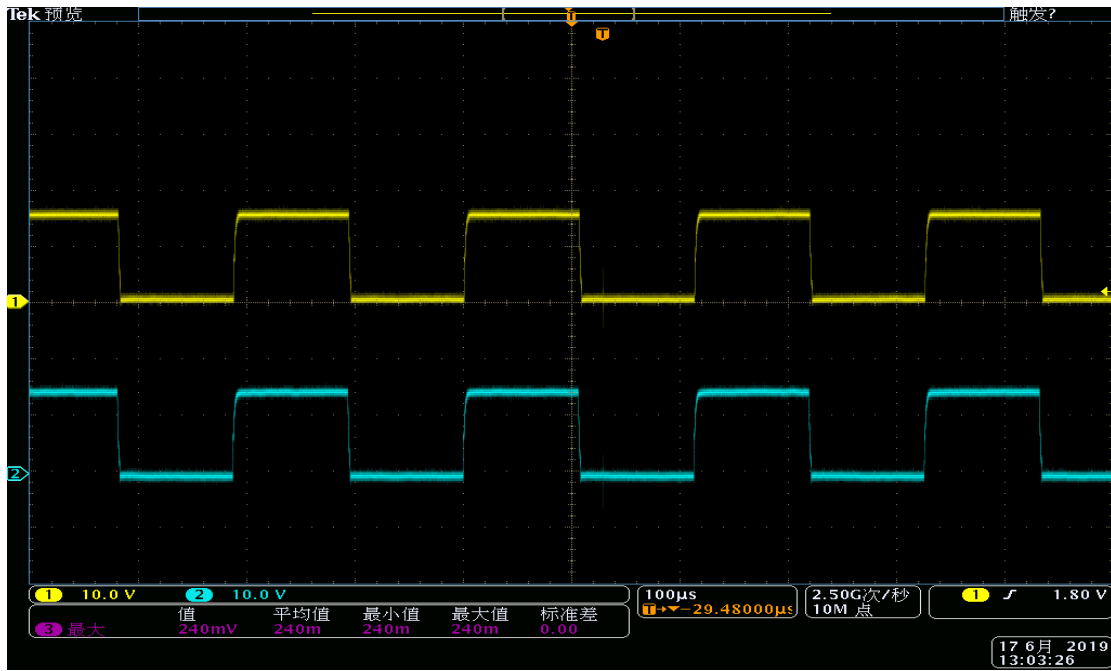
Figure 8. Input Waveform and Output Waveform

Non−Synchronous Boost Controller, Automotive Grade NCV887100D1R2G

- Peak Current Mode Control with Internal Slope Compensation
- 1.2 V 2% Reference voltage
- Wide Input Voltage Range of 3.2 V to 40 Vdc, 45 V Load Dump

- Input under−voltage lockout (UVLO)
- Internal Soft−Start
- Low quiescent current in sleep mode
- Cycle−by−cycle current limit protection
- Hiccup−mode short−circuit protection (SCP)
- Thermal shutdown (TSD)
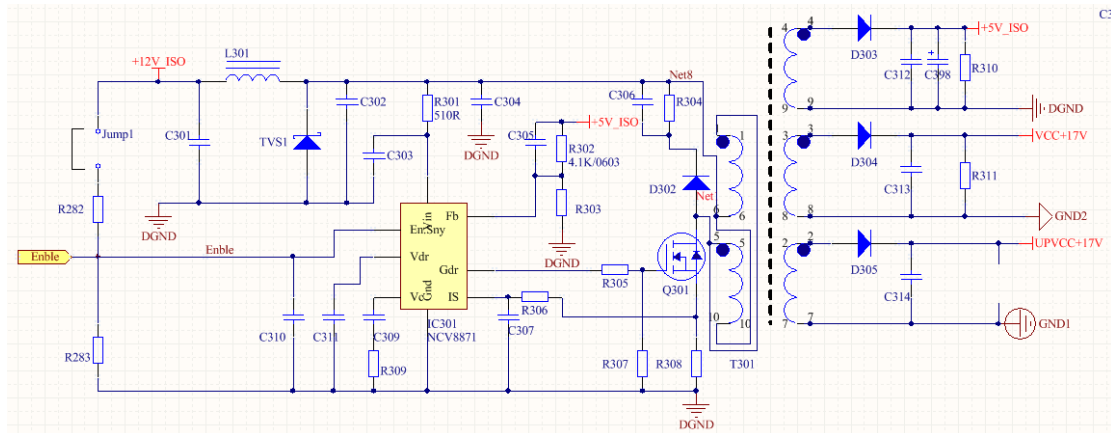
Figure 9. NCV8871 Boost Diagram
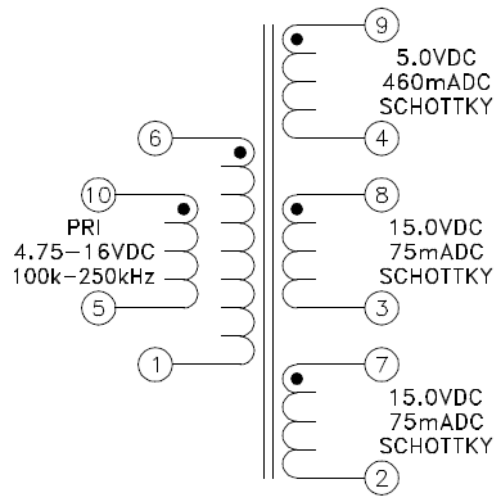
Figure 10. Transform Input/Output Capability
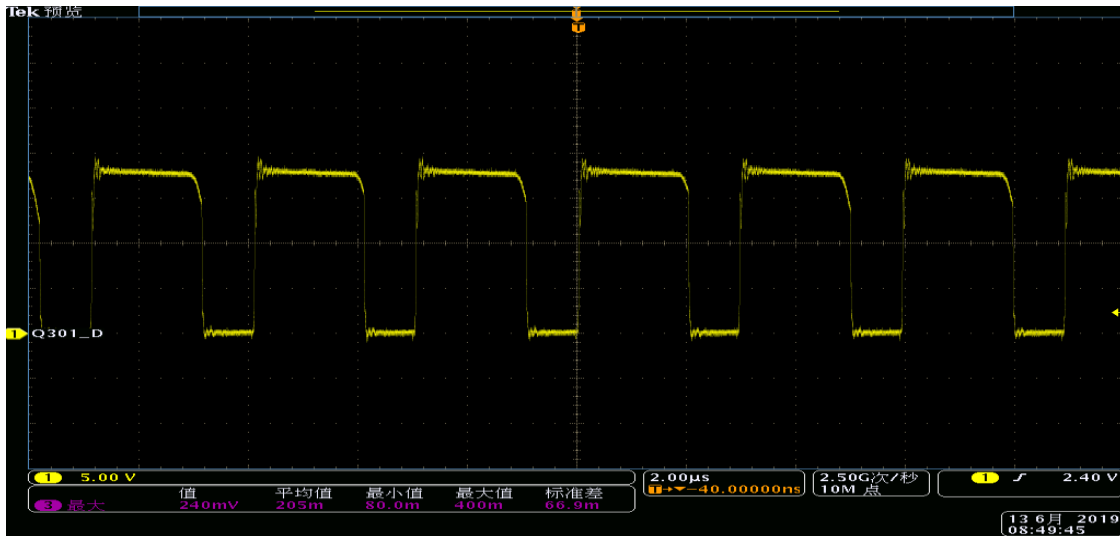
Figure 11. Drain−Source Voltage of Mos

Operational Amplifier NCV20071SN2T1G
- QR Frequency Jittering to Reduces EMI Signature
- New Quiet−Skip Technology Ensures Operation Outside Audible Range
- Integrated HV Startup with Brownout Protection Provides an efficient power−on source and protects ageists drops in input mains voltage
- Valley Switching Operation with Valley Lockout. Maximizing the efficiency over the entire power range

- Integrated X2 Capacitor Discharge Capability Eliminates the need for a X2 resistors
- NTC Compatible Fault Pin Extra protection against high temperature or other fault conditions
- High Drive Capability: −500 mA / +800 mA Enables faster switching of primary−side MOSFET
- Latch input for OVP and OTP implementations Simple implementation of required protection functions
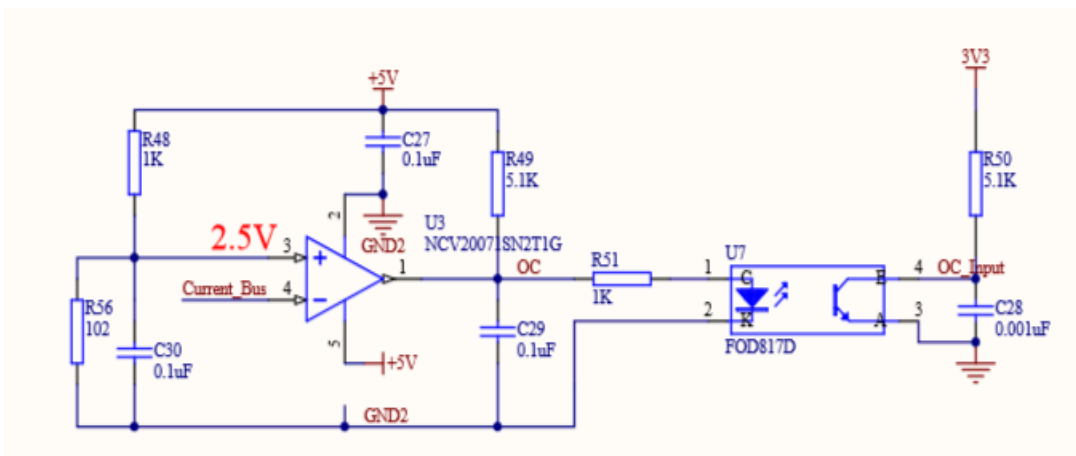
Figure 12. Operational Amplifier

2) Another key element of the evaluation board is to simulate and realize the driver algorithm. At least it needs 3 GPIOs or PWM port to driver one high side IGBT and two low side IGBT.

Figure 13. First Step: Define GPIOs, PWM Output and ADC Input

Figure 14. Second Step: Detect Heatsink Temperature by Reading ADC Data

TEST RESULT

3) Thermal results
- Input Max Voltage: 100 Vdc ~ 320 Vdc
- Switching frequency: 16 kHz
- Control battery input: 12 Vdc
- Tj: ≤ 150°C

- Ta: 25°C
- Output Power: 1.2 kW
- Heater water container volume: 3 L
- Water pump model: DKB80A−12
  12 VDC, 30 L/Min, 80 W

Figure 15. Pump

Figure 16. Multiple Temperature Data Recorder
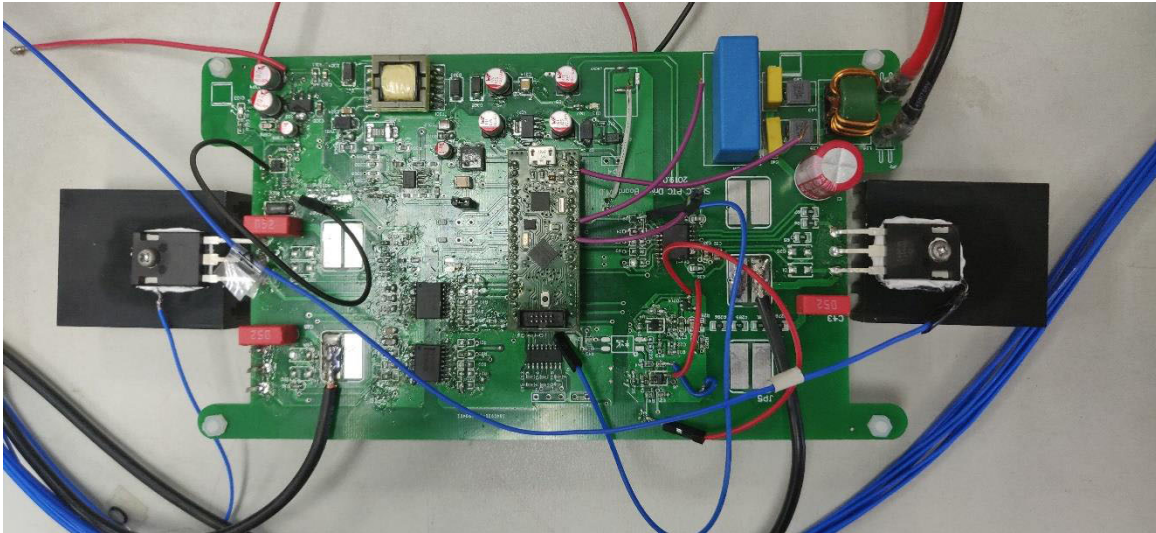
Figure 17. Key Temperature Detect Point: High Side IGBT / Low Side IGBT / PTC Heatsink
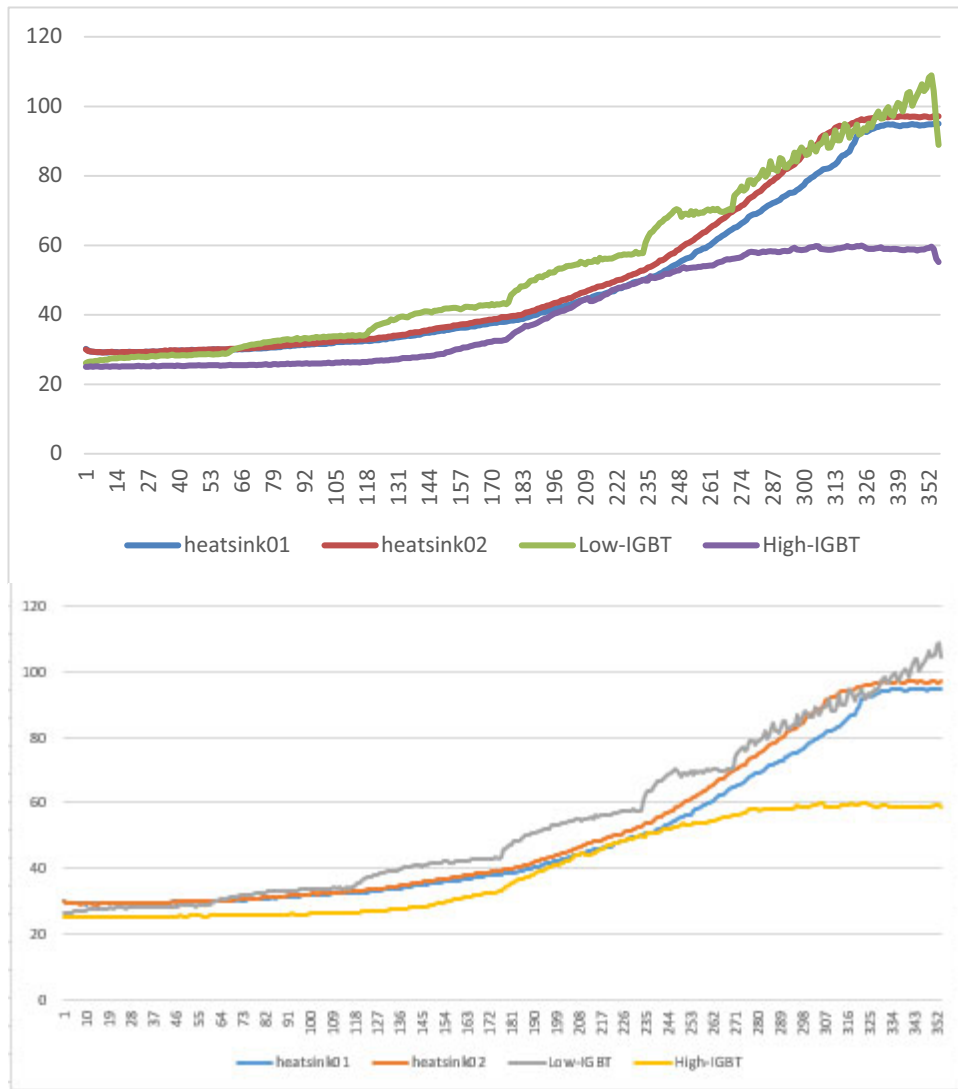
Figure 18. Temperature Waveform from Low Power to High Power

	heatsink01	heatsink02	Low-IGBT	High-IGBT					
1	heatsink01	heatsink02	Low-IGBT	High-IGBT	31	29.4	29.4	28	25.2
2	30.2	30	26.1	25	32	29.4	29.4	28.1	25.1
3	29.7	29.6	26.4	25	33	29.6	29.5	28.3	25.2
4	29.4	29.5	26.5	25.1	34	29.6	29.6	28.3	25.3
5	29.4	29.4	26.5	25	35	29.5	29.7	28.3	25.3
6	29.3	29.3	26.7	25.1	36	29.5	29.6	28.2	25.3
7	29.2	29.3	26.7	25.1	37	29.7	29.7	28.4	25.3
8	29.2	29.3	27	25	38	29.5	29.7	28.5	25.3
9	29.2	29.1	26.9	25	39	29.7	29.7	28.3	25.2
10	29.2	29.2	27.1	25.1	40	29.5	29.7	28.3	25.4
11	29.1	29.3	27.1	25.1	41	29.7	29.6	28.3	25.3
12	29.3	29.3	27.3	25	42	29.7	29.7	28.4	25.2
13	29.3	29.4	27.4	25.1	43	29.5	29.7	28.4	25.2
14	29.3	29.1	27.4	25.1	44	29.7	29.7	28.3	25.3
15	29.3	29.2	27.4	25.1	45	29.7	29.7	28.4	25.4
16	29.1	29.1	27.6	25	46	29.9	29.8	28.4	25.4
17	29.2	29.3	27.6	25.1	47	29.8	29.7	28.5	25.4
18	29.3	29.3	27.5	25.1	48	29.7	29.8	28.5	25.4
19	29.2	29.3	27.6	25.1	49	29.8	29.9	28.6	25.5
20	29.4	29.3	27.6	25.1	50	29.8	29.9	28.6	25.4
21	29.3	29.3	27.9	25.1	51	29.9	29.9	28.6	25.4
22	29.3	29.3	27.8	25.1	52	29.8	29.9	28.6	25.4
23	29.3	29.2	27.9	25.2	53	29.9	30	28.7	25.5
24	29.3	29.3	28	25.3	54	29.9	30	28.6	25.5
25	29.3	29.3	27.9	25.1	55	30.1	30	28.5	25.5
26	29.3	29.3	27.9	25.2	56	30	30	28.6	25.5
27	29.4	29.4	27.8	25.1	57	30	30.1	28.6	25.5
28	29.4	29.3	27.9	25.1	58	30	30	28.7	25.3
29	29.4	29.4	28.1	25.1	59	30	30	28.9	25.4
30	29.5	29.5	28.1	25.4	60	30	30	28.7	25.4

61	30	30.1	28.9	25.5	91	31.2	31.5	32.8	26
62	30	30.2	29.4	25.6	92	31.4	31.7	33.1	25.9
63	29.9	30.2	29.9	25.5	93	31.2	31.7	33.3	26
64	30	30.2	30.1	25.5	94	31.4	31.8	33.2	26.1
65	30	30.1	30.4	25.5	95	31.4	31.8	33.1	25.9
66	30.1	30.2	30.5	25.5	96	31.5	31.9	33.3	26
67	30	30.3	30.7	25.5	97	31.5	31.8	33.4	26
68	30.1	30.3	30.9	25.5	98	31.7	31.8	33.6	26
69	30.1	30.3	31	25.5	99	31.6	32	33.4	26
70	30.1	30.3	31.2	25.6	100	31.6	32	33.5	26
71	30.2	30.5	31.4	25.6	101	31.6	32.1	33.7	26.1
72	30.4	30.4	31.4	25.6	102	31.6	32.2	33.5	26.1
73	30.3	30.6	31.6	25.5	103	31.9	32.2	33.7	26.2
74	30.3	30.5	31.7	25.6	104	31.8	32.1	33.7	26.1
75	30.3	30.7	31.7	25.6	105	31.9	32.2	33.8	26.1
76	30.4	30.7	32	25.7	106	32.1	32.5	33.8	26.2
77	30.4	30.7	32	25.8	107	32.1	32.5	33.8	26.2
78	30.5	30.7	32.1	25.6	108	32.1	32.7	34	26.2
79	30.6	30.8	32.2	25.6	109	32.1	32.6	33.8	26.4
80	30.6	30.8	32.4	25.8	110	32.2	32.6	33.8	26.2
81	30.6	30.9	32.5	25.8	111	32.2	32.7	34.1	26.4
82	30.7	31	32.6	25.7	112	32.2	32.6	34	26.2
83	30.7	31	32.5	25.8	113	32.3	32.7	34.2	26.3
84	30.9	31.1	32.8	25.8	114	32.2	32.8	33.9	26.3
85	30.9	31.2	32.9	25.8	115	32.3	32.7	34	26.3
86	31	31.3	33	26	116	32.3	32.9	34.2	26.2
87	30.9	31.2	32.8	25.8	117	32.3	32.9	34	26.4
88	31.1	31.4	32.8	25.9	118	32.5	32.9	34.1	26.4
89	31.1	31.5	33.1	25.9	119	32.5	32.9	34.4	26.4
90	31.2	31.5	33.3	26	120	32.4	33.1	35.5	26.5
121	32.5	33.1	35.8	26.5	151	35.4	36.4	41.7	28.7
122	32.7	33.1	36.4	26.7	152	35.6	36.5	41.8	29.2
123	32.7	33.2	36.9	26.8	153	35.6	36.6	41.8	29.3
124	32.7	33.4	37.1	26.8	154	35.8	36.6	41.9	29.5
125	32.9	33.4	37.4	26.9	155	35.9	36.9	42	29.7
126	33	33.5	37.6	26.8	156	36.1	36.9	42	30
127	32.9	33.5	37.8	26.9	157	36.2	37	41.8	30.1
128	33.2	33.7	37.9	26.9	158	36.3	37.2	41.5	30.2
129	33.2	33.7	38.7	27.1	159	36.3	37.3	41.9	30.6
130	33.2	34	38.4	27.1	160	36.3	37.3	42.3	30.6
131	33.5	34	38.7	27.2	161	36.4	37.4	42.3	30.7
132	33.5	34.1	39.1	27.2	162	36.7	37.6	42.2	30.9
133	33.6	34.2	39.4	27.3	163	36.7	37.7	42.2	31.1
134	33.7	34.3	39.5	27.5	164	36.7	37.9	42	31.3
135	33.8	34.3	39.3	27.5	165	36.9	38	42.4	31.4
136	34	34.4	39.2	27.5	166	36.9	38	42.7	31.5
137	33.9	34.8	39.8	27.5	167	37.2	38.2	42.6	31.8
138	34	34.8	40	27.7	168	37.2	38.3	42.7	31.7
139	34.1	35	40.3	27.7	169	37.3	38.4	42.8	32
140	34.3	35	40.4	27.7	170	37.5	38.6	42.6	32.1
141	34.3	35	40.5	27.9	171	37.6	38.6	43.1	32.2
142	34.5	35.3	40.7	28	172	37.7	38.8	42.7	32.5
143	34.7	35.5	41	28	173	37.7	38.8	43	32.5
144	34.8	35.4	41	28.1	174	37.9	39	42.9	32.5
145	34.8	35.7	40.9	28.1	175	37.9	39.3	43.1	32.5
146	35	35.7	40.6	28.2	176	37.9	39.3	43.4	32.7
147	35	35.9	41.2	28.3	177	38	39.3	43	32.8
148	35.2	36.1	41.2	28.5	178	38.2	39.4	43.6	33.3
149	35.3	36.2	41.4	28.6	179	38.3	39.6	45.7	33.9
150	35.5	36.3	41.4	28.7	180	38.3	39.7	46.2	34.5
181	38.5	39.7	47	35.1	211	44.7	47	55.3	44.8
182	38.5	39.9	47.2	35.4	212	44.8	47.2	55.2	43.9
183	38.8	39.9	48.2	35.8	213	45.2	47.5	55.3	43.9
184	38.8	40.2	48.2	36.2	214	45.4	47.6	55.8	44.2
185	39.1	40.6	48.4	36.8	215	45.7	48.1	55.3	44.6
186	39.2	40.7	48.8	36.7	216	45.8	48.2	56.4	44.8
187	39.5	40.9	49.7	36.9	217	45.8	48.3	55.9	45.3
188	39.8	41.2	49.9	37.1	218	46.1	48.5	56.2	45.8
189	39.9	41.3	49.9	37.4	219	46.3	48.9	56.1	46
190	40.1	41.7	50.8	37.7	220	46.5	48.9	56.2	46.4
191	40.6	41.9	51	38.1	221	46.7	49.3	56.2	47.1
192	40.7	42.2	50.8	38.5	222	46.8	49.5	56.5	47.3
193	40.7	42.3	51.4	38.9	223	47.4	49.9	56.8	47.5
194	41.1	42.6	51.5	39	224	47.6	50	57.1	47.8
195	41.2	42.7	52.2	39.5	225	47.6	50.1	57.1	47.8
196	41.4	43	52.1	39.9	226	48.1	50.5	57.4	48.2
197	41.7	43.4	52.2	40.3	227	48.3	50.8	57.3	48.2
198	41.8	43.5	53	40.5	228	48.6	51.2	57.4	48.4
199	42.1	43.7	53.3	40.8	229	48.9	51.4	57.3	48.8
200	42.4	44.1	53.2	41.1	230	49.3	51.7	57.5	48.8
201	42.5	44.3	53.5	41.2	231	49.5	51.9	58.1	49.1
202	42.6	44.4	53.9	41.5	232	49.6	52.2	57.6	49.4
203	42.8	44.8	54.1	41.8	233	49.7	52.7	57.8	49.7
204	43	44.8	54.1	42	234	50	52.7	57.8	50
205	43.3	45.2	54.3	42.5	235	50.2	53.1	60.8	49.8
206	43.6	45.6	54.4	42.9	236	50.6	53.6	62.3	49.8
207	43.8	45.9	54.5	43.4	237	50.7	53.8	63.6	51.1
208	44.1	46.2	55.3	43.8	238	50.9	54.1	63.9	50.7
209	44.2	46.4	54.9	44.2	239	51.1	54.5	64.9	50.6
210	44.5	46.6	54.5	44.4	240	51.4	54.9	65.5	50.8

#					#				
241	51.9	55.6	66.4	50.9	271	64.6	69.6	70.2	56.1
242	52.1	55.6	66.8	51.2	272	65	70.1	74.3	56.2
243	52.7	56.1	67.6	51.8	273	65.2	70.5	75	56.3
244	53	56.7	67.9	51.8	274	65.7	70.8	75.6	56.4
245	53.4	57.2	68.6	51.8	275	66.3	71.4	76.9	56.7
246	53.9	57.6	69.2	52.2	276	66.7	71.7	75.7	57.1
247	54.3	57.8	70	52.4	277	67.3	72.5	76.4	57.5
248	54.5	58.5	70.4	52.7	278	68.2	73.3	78.7	57.9
249	55	58.8	70	52.8	279	68.6	73.8	78.8	58.1
250	55.5	59.4	68.2	53.3	280	68.9	74.2	77.6	58
251	55.8	60	69	53.7	281	69	74.9	78.9	57.9
252	56.2	60.4	69.1	53.2	282	69.4	75.3	79.2	57.8
253	56.4	60.7	68.7	53.4	283	69.7	75.6	80.3	57.9
254	56.6	61.1	69.8	53.5	284	70.4	76.4	81.7	58.2
255	57.3	61.5	68.7	53.6	285	70.9	77.1	79.7	58
256	58	62.1	69.7	53.6	286	71.4	77.5	80.6	58.2
257	58.4	62.6	69.1	53.8	287	71.8	78.2	84.2	58.3
258	58.6	63.1	69.5	53.8	288	72.1	78.5	82	58.2
259	59.1	63.7	69.4	54	289	72.4	79.2	81.8	58.2
260	59.1	63.8	69.9	54	290	72.7	79.6	81.4	58
261	59.7	64.5	70.3	54.1	291	73.1	80.3	85.1	58
262	60.1	65	69.9	54.2	292	73.8	80.9	84.8	58.3
263	60.7	65.6	70.5	54.2	293	74.2	81.9	82.5	58.4
264	61.2	65.9	70.1	54.5	294	74.5	82	82.4	58.3
265	61.8	66.4	70.5	55	295	75.1	82.5	83.7	58.4
266	62.2	67.1	69.7	55.2	296	75.1	82.8	84	59
267	62.7	67.5	69.6	55.4	297	75.3	83.3	86.7	59.3
268	63.1	67.9	69.7	55.7	298	75.8	84	84.1	58.8
269	63.7	68.5	70.1	56	299	76.3	84.6	87	58.7
270	64.1	69.3	70.4	55.9	300	76.8	85.5	88.2	58.6
301	77.4	86.4	87.3	58.7	331	94	96.9	97.4	59.1
302	78.4	87	86	58.8	332	94.1	97	98.5	59.2
303	78.9	87.5	86.3	59.3	333	94.4	96.8	96.5	59.4
304	79.4	87.9	89.6	59.4	334	94.4	97	96.6	59
305	79.8	87.9	88	59.5	335	94.7	96.9	98.7	59
306	80.4	88.7	87	59.8	336	94.8	96.8	99.8	59
307	80.9	89.5	89	59.7	337	94.7	97.1	97.7	58.9
308	81.3	90.9	89.1	59	338	94.8	97	97.2	59
309	81.9	91.6	90	58.9	339	94.5	96.9	99.3	59
310	82	91.8	91.7	58.8	340	94.4	96.9	101	58.9
311	82.1	92.2	88.1	58.7	341	94.3	97.1	100.6	58.7
312	82.4	92.6	88.2	58.7	342	94.5	97.1	98.5	58.6
313	82.9	92.9	89.9	58.8	343	94.5	97	100.7	58.6
314	83.3	93.8	93.1	59	344	94.5	97.1	103.8	58.9
315	84	94.2	90.2	59.1	345	94.7	96.9	104.1	58.8
316	85	94.4	90.2	59.1	346	94.9	97	100.2	58.8
317	85.9	94.2	92.3	59.3	347	94.7	97	101.7	58.8
318	86	94.1	94.9	59.4	348	94.7	96.9	103.2	58.5
319	86.6	94.4	94.2	59.8	349	94.4	96.8	104.6	58.7
320	87	94.5	90.9	59.5	350	94.5	96.9	106.3	58.8
321	88.7	95.2	92.8	59.4	351	94.5	97.1	104.4	58.8
322	89.6	95.3	92.9	59.5	352	94.7	97	105.3	59.1
323	91.5	95.7	94.7	59.8	353	94.8	96.8	108.3	59.2
324	92	95.9	91.9	59.7	354	94.8	96.8	108.9	59.6
325	92.8	96.3	92.2	59.9	355	94.9	97.2	104.4	59
326	92.8	96	93.7	59.6	356	94.8	97.1	95.4	56.1
327	92.6	96.3	93.1	59.1	357	95	97.1	88.9	55.2
328	93	96.5	95	59	358	95.2	97	84.6	54.4
329	93.4	96.6	94	59	359	95	96.8	82.4	53.8
330	93.6	96.7	95.7	59	360	95.3	96.8	79.3	53.4

Figure 19. Raw Data of Different Points

SCHEMATICS

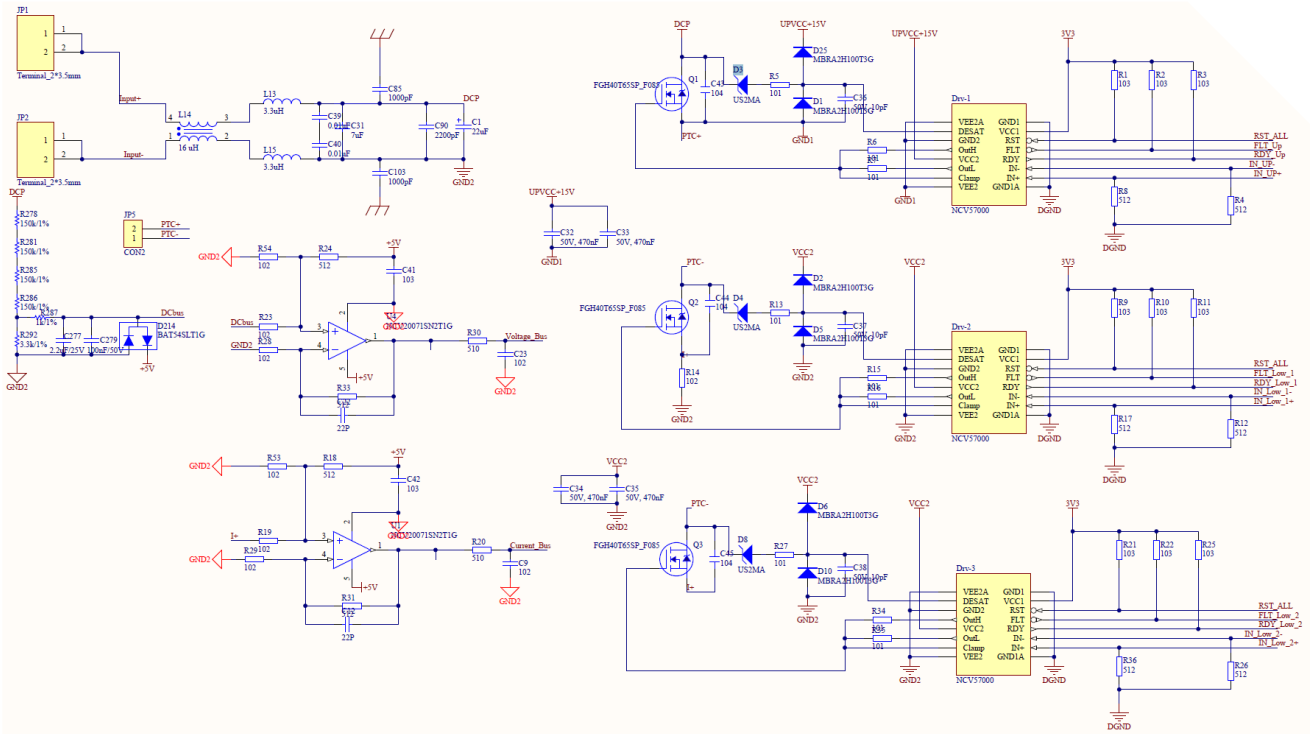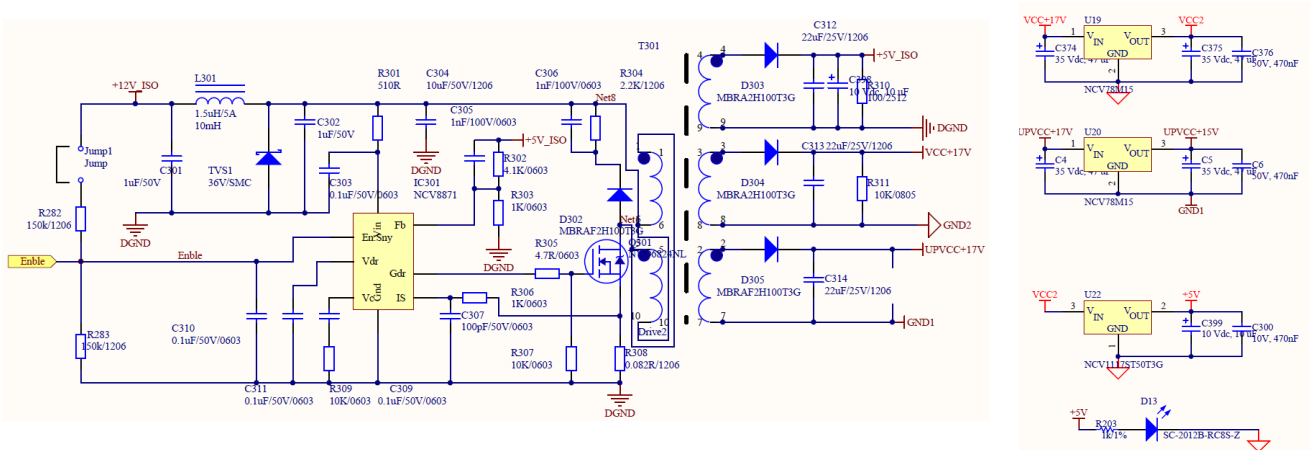**Figure 20. Schematic of Isolated Gate Drivers and PTC Power Stage**

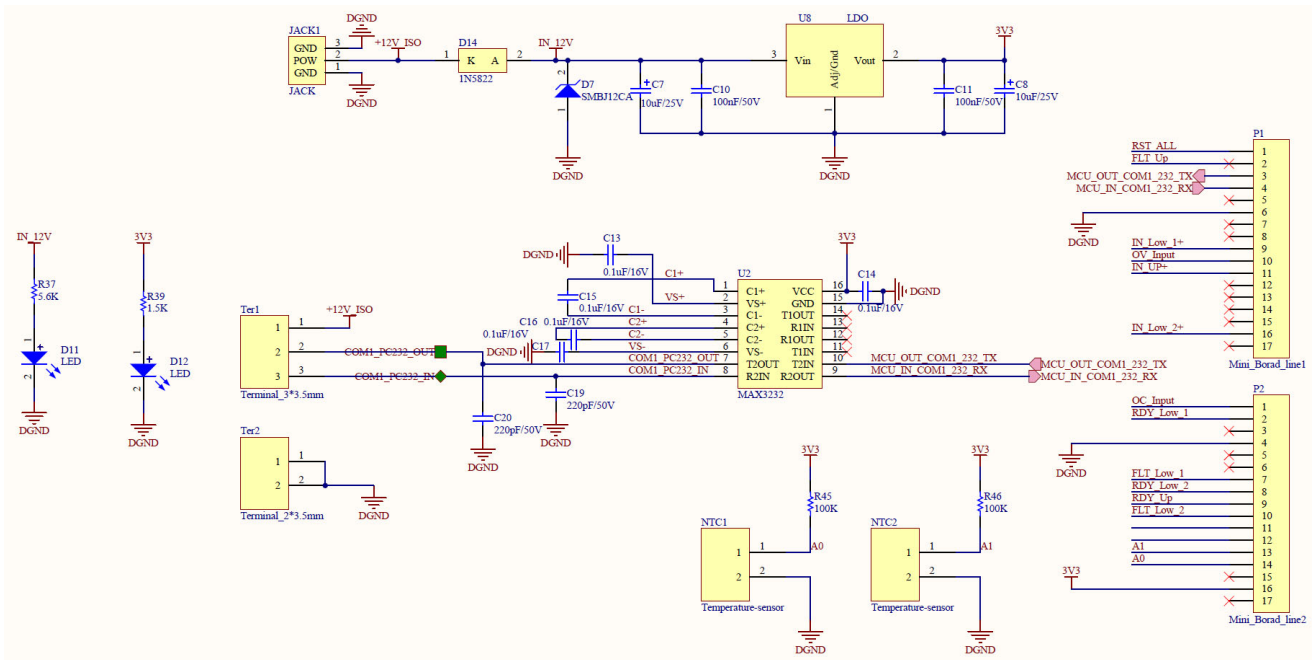**Figure 21. Schematic of Auxiliary Power Supply**
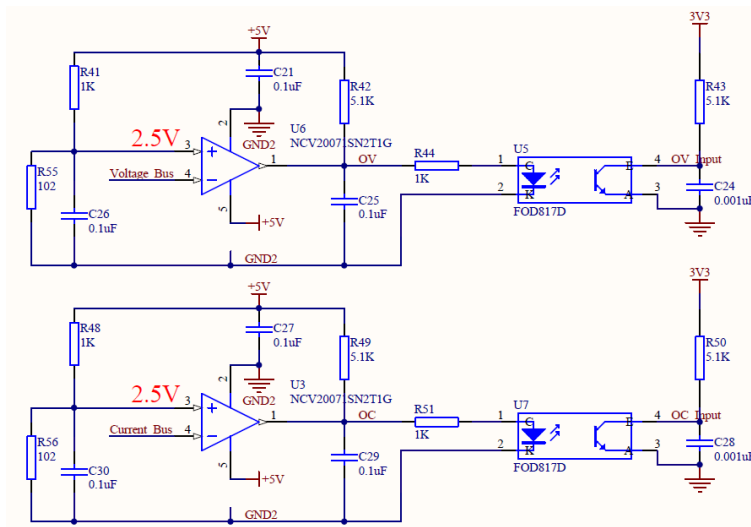
Figure 22. Schematic of the Interface Circuit

Figure 23. Schematic of Over Voltage and Over Current

BILL OF MATERIALS

Main Board Description	Manufacturer Part Number	Manufacturer	Qty.	Designator
Schottky Diode 2A 100V, SMA	MBRA2H100T3G	ON Semiconductor	10	D1, D2, D5, D6, D10, D25, D302, D303, D304, D305,
Rectifier Diode 50A 1000V, SMA	NRVUS2MA	ON Semiconductor	3	D3,D4,D8,
Schottky Diode 3A 40V, DO−214AB	SS34	ON Semiconductor	1	D14,
Schottky Diode 1A 30V, SOT−23	BAT54SLT1G	ON Semiconductor	1	D214,
IGBT 650V,40A, TO−247	FGH40T65SF−F085	ON Semiconductor	3	Q1,Q2,Q3,
MOSFET 20mΩ 100V, DPAK	NVD6824NL	ON Semiconductor	1	Q301,
IC IGBT Driver, SOIC−16 WB	NCV57000	ON Semiconductor	3	Drv−1, Drv−2, Drv−3,
IC Boost Controller, SOIC−8	NCV887104D1R2G	ON Semiconductor	1	IC301,
IC Linear Voltage Regulator, SOT−223	NCV1117ST33T3G	ON Semiconductor	1	U8
IC Operational Amplifier,TSOP−5	NCV20071SN2T1G	ON Semiconductor	4	U1, U3, U4, U6,
IC Linear Voltage Regulator, DPAK	NCV78M15BDTG	ON Semiconductor	2	U19, U20,
IC Linear Voltage Regulator, SOT−223	NCV1117ST50T3G	ON Semiconductor	1	U22,
Transient Diode 100A 5V, DO−214AA	SMBJ12CA	Littlefuse	2	D7,TVS1,
IC Photo Coupler,SOP4	FOD817D	Any	2	U5, U7,
E−Cap 450V−22uF WCAP−AT1H (13X25mm)	860241478004	WURTH	1	C1,
E−Cap 35V−47uF WCAP−ASLU(6.3X7.7mm)	865090545008	WURTH	4	C4, C5, C374, C375,
MLCC 0805−50V−470nF		Any	4	C6, C32,C33, C34,C35,C376,
E−Cap 25V−10uF AF−CAP−D (6.6X6.6mm)	865060542002	WURTH	2	C7,C8,
MLCC 0603−16V−102M		Any	4	C9,C23, C24, C28,
MLCC 0603−50V−100nF		Any	2	C10,C11,
MLCC 0603-22pF		Any	2	C12,C22,
MLCC 0603-16V−0.1uF		Any	13	C13, C14, C15, C16, C17, C19, C20, C21, C26, C25, C27, C29, C30,
W-Cap 800VDC-2uF DKMJ−P	1GLBH520D800−301	BM−CAP	1	C31
MLCC 0805-50V−10pF		Any	3	C36,C37,C38,
W-Cap 310VAC-0.01uF X2CAP	1X2H310 K310−A73	BM−CAP	2	C39,C40,
MLCC 0603−16V−103M		Any	2	C41,C42,
W−Cap 68nF CAP−HV	890303423005CS	WURTH	3	C43,C44,C45,
MLCC 1210−1000pF		Any	2	C85,C103,
MLCC 1210−2200pF		Any	1	C90,
MLCC 0805-25V−2.2uF		Any	1	C277,
MLCC 0805-50V−100nF		Any	1	C279,
MLCC 0805-10V−470nF		Any	1	C300,
MLCC 2512-50V−1uF		Any	1	C301,
MLCC 0603-50V−1uF		Any	1	C302,
MLCC 0603-50V−0.1uF		Any	4	C303, C309 ,C310, C311,
MLCC 1210-50V−10uF		Any	1	C304,
MLCC 0603-100V−1nF		Any	2	C305, C306,
MLCC 0603-50V−100pF		Any	1	C307,

BILL OF MATERIALS (continued)

Main Board Description	Manufacturer Part Number	Manufacturer	Qty.	Designator
MLCC 1206-25V−22uF		Any	3	C312, C313, C314,
E−Cap 10V−10uF WCAP−ASLU	865090240001	WURTH	2	C398, C399,
LED 0805 (Green)		Any	3	D11,D12,D13,
DC−005 (5.5*2.1mm)		YI MENG	1	JACK1,
Interface_input_power (7*7mm)	WP−THRBU	WURTH	2	JP1,JP2,
JUMPER (2*3.5mm)		Any	1	JUMP1,
Temperature−sensor (2*3.5mm)		Any	2	NTC1,NTC2,
Terminal_3*3.5mm		Any	1	Ter1,
Terminal_2*3.5mm		Any	1	Ter2,
SMD Inductor 3.3uH−9.5A	74437377033	WURTH	2	L13,L15,
SMD Inductor 1.5uH−5A	74437346015	WURTH	1	L301,
Common Choke 16uH 10A	7448421016	WURTH	1	L14,
MID−Flyback Transformers	30400R−LF1	WURTH	1	T301,
IC RS−232 Line Driver/Receiver		Any	1	U2,
Chip resister 0805 10Kohm−J		Any	10	R1, R2, R3, R9, R10, R11, R21, R22, R25,R311
Chip resister 0805 5.1Kohm−J		Any	6	R4, R8, R12, R17, R26, R36,
Chip resister 1206 100ohm−J		Any	10	R5, R6, R7, R13, R15, R16, R27, R34, R35,R310,
Chip resister 0805 1Kohm−J		Any	8	R19, R23, R28, R29, R53, R54, R55, R56,
Chip resister 2512 1Kohm−J		Any	1	R14,
Chip resister 0603 5.1Kohm−J		Any	4	R18, R24, R31, R33,
Chip resister 0603 51ohm−J		Any	2	R20, R30,
Chip resister 0805 5.6Kohm−J		Any	1	R37,
Chip resister 0805 1.5Kohm−J		Any	1	R39,
Chip resister 0603 1Kohm−J		Any	8	R41, R44, R48, R51, R203, R287, R303, R306,
Chip resister 0603 5.1Kohm−J		Any	4	R42, R43, R49, R50,
Chip resister 0805 100Kohm−J		Any	2	R45, R46,
Chip resister 1206 150Kohm−J		Any	6	R278, R281, R285, R286, R282, R283,
Chip resister 0603 3.3Kohm−J		Any	1	R292,
Chip resister 0603 510ohm−J		Any	1	R301,
Chip resister 0603 4.1Kohm−J		Any	1	R302,
Chip resister 1206 2.2Kohm−J		Any	1	R304,
Chip resister 0603 4.7ohm−J		Any	1	R305,
Chip resister 0603 10Kohm−J		Any	2	R307, R309,
Chip resister1206 0.082ohm−J		Any	1	R308,

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