10 kW 3-level NPC2 inverter reference design

REF-10KW3LNPC2

About this document

Scope and purpose

This user guide describes the NPC2 inverter reference design REF-10KW3LNPC2 and its main features, key data, pin assignments, mechanical dimensions, and electrical interfaces.

Intended audience

This user guide is meant for engineers and technical specialists working on solar photovoltaic solutions and similar domains. The concept of this power conversion reference design is modular so that the hardware can be reused for various power converter applications and use cases, with a special focus on solar photovoltaic solutions.

Reference design

This reference design is not a qualified and certified commercial product. The hardware does not necessarily meet any safety, EMI, or quality standard (for example, UL, CE) requirements.

Power conversion board REF-10KW3LNPC2

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Safety precautions

Note: *Please note the following warnings regarding the hazards associated with development systems.*

Table 1 **Safety precautions**

	Warning: *The DC link potential of this board is up to 1000 VDC. When measuring voltage waveforms by oscilloscope, high voltage differential probes must be used. Failure to do so may result in personal injury or death.*
	Warning: *controller board must be connected to the main power board before powering the DC bus.*
	Warning: *The evaluation or reference board contains DC bus capacitors which take time to discharge after removal of the main supply. Before working on the system, wait five minutes for capacitors to discharge to safe voltage levels. Failure to do so may result in personal injury or death. Darkened display LEDs are not an indication that capacitors have discharged to safe voltage levels.*
	Caution: *The heat sink and device surfaces of the evaluation or reference board may become hot during testing. Hence, necessary precautions are required while handling the board. Failure to comply may cause injury.*
	Caution: *Only personnel familiar with power electronics should plan, install, commission and subsequently service the system. Failure to comply may result in personal injury and/or equipment damage.*
	Caution: *The evaluation or reference board contains parts and assemblies sensitive to electrostatic discharge (ESD). Electrostatic control precautions are required when installing, testing, servicing or repairing the assembly. Component damage may result if ESD control procedures are not followed. If you are not familiar with electrostatic control procedures, refer to the applicable ESD protection handbooks and guidelines.*
	Caution: *The reference board is shipped with packing materials that need to be removed prior to installation. Failure to remove all packing materials that are unnecessary for system installation may result in overheating or abnormal operating conditions.*

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1 The power conversion board at a glance

1.1 Introduction

REF-10KW3LNPC2 comes as a kit and includes different boards that can help the user to build and operate an NPC2 inverter power stage:

- REF-10KW3LNPC2: NPC2 inverter power stage main board
- ISODRV-3240C4P15N05-1: 4-channel gate driver boards for each leg of the NPC2 type
- PB-APS-24V-5V ISO: Isolated auxiliary power supply
- REF-10KW3LNPC2-Filter: LCL filter board
- PB-CAPTANK-1.1KV: DC-link capacitor board

The REF-10KW3LNPC2 main board consists of a 3-phase 3-level NPC2 power stage and carries power semiconductors, gate drivers and auxiliary power supply. It also offers connectors that the user can connect their own passives (filters and DC-link capacitors).

The user can also get separately an XMC7200-based control board which comes with all the signal conditioning circuits, power conversion software and a GUI that can allow the user to operate the inverter in open-loop configuration.

The XMC7200 control board is available under the name REF-CLBXMC7PEC.

Figure 1 shows the completely assembled 10 kW 3-level NPC2 inverter reference design.

Figure 1 **Power conversion reference design REF-10KW3LNPC2**

1.2 Top level specifications

Table 2 **Specifications**

Parameter	Typical	Maximum	Unit
Input voltage	650	850	V_{dc}
Output voltage	380	400	$V_{ll\text{-}rms}$
Output current		15.2	A
Output power		10	kW
Switching frequency	24	24	kHz
Output frequency	50	65	Hz

1.3 Key design building blocks

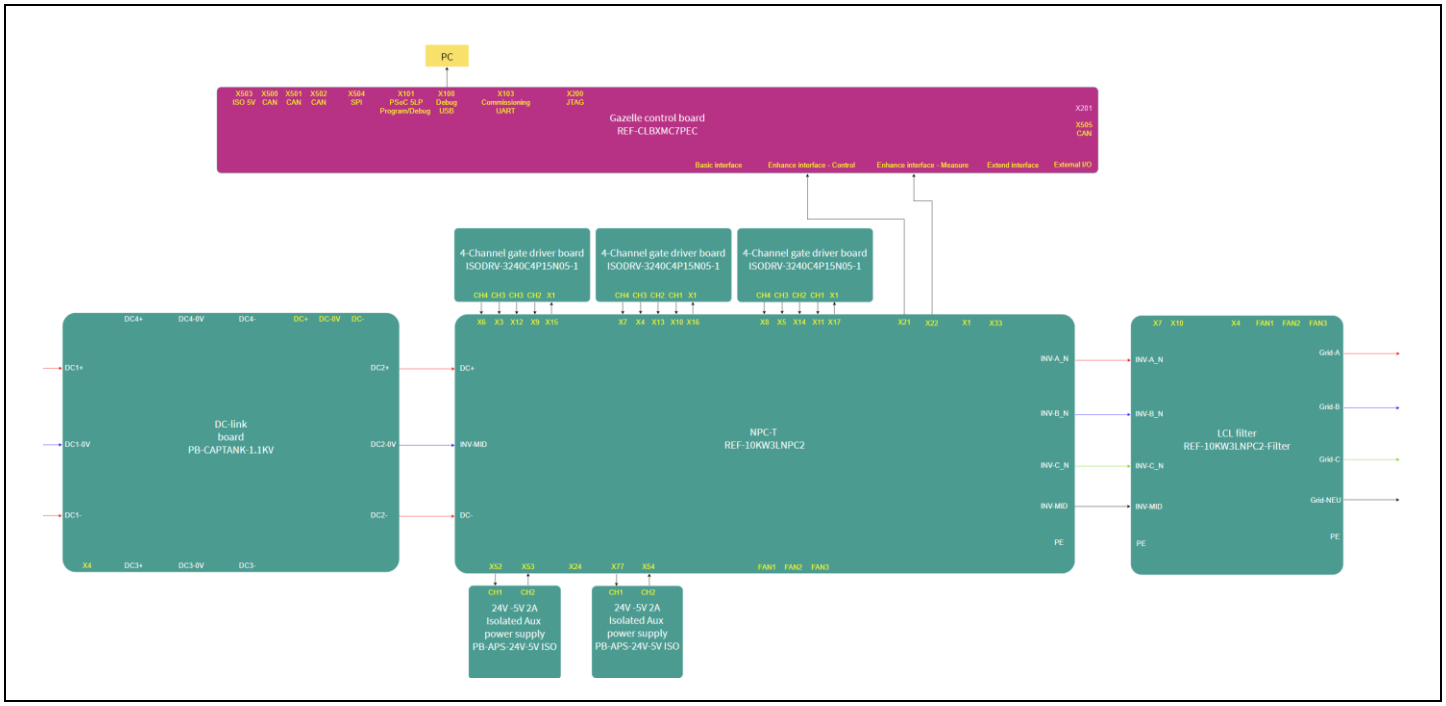

Figure 2 **Assembly diagram**

Figure 2 shows how the different boards are connected to construct the NPC2 inverter. Starting from the left, the DC power supply is connected to the DC-link board. The output three terminals (Positive, neutral and negative) are then connected to the power board. A total of three 4-channel gate driver boards are mounted on the top of the power board. An isolated power supply subsidiary card is also mounted on the top of the power board to provide an isolated 5V rail. A second isolated power supply card is also mounted but is not necessary for operation. On the other side the 3-phases and the mid-point of the DC-link are connected to the filter board. The filter board contains an LCL filter and an EMI filter.

Figures 3,4,5,6 and 7 show the stand-alone REF-10KW3LNPC2, ISODRV-3240C4P15N05-1, PB-APS-24V-5V ISO, REF-10KW3LNPC2-Filter and PB-CAPTANK-1.1KV.

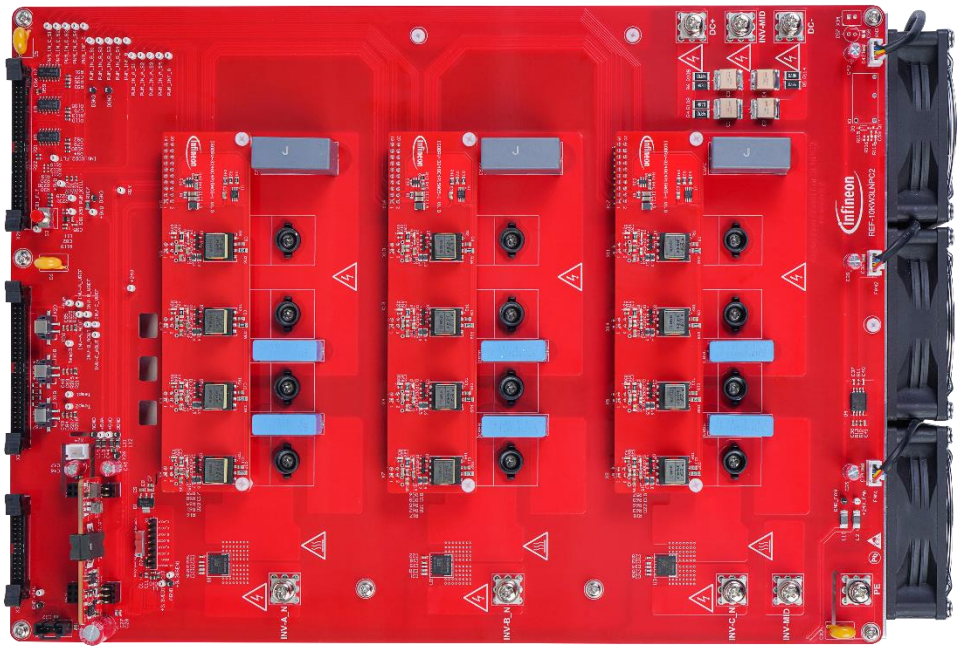

Figure 3 **REF-10KW3LNPC2**

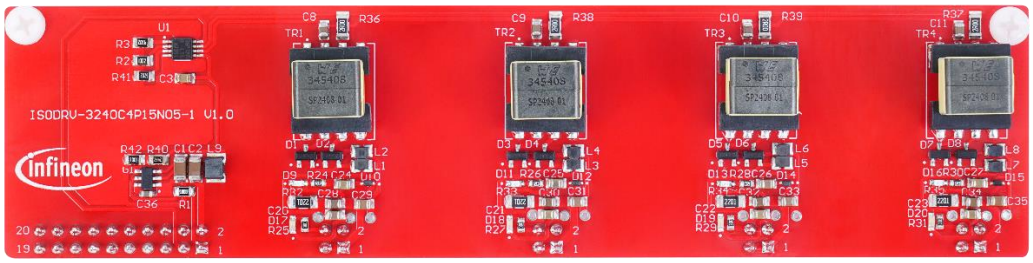

Figure 4 **ISODRV-3240C4P15N05-1**

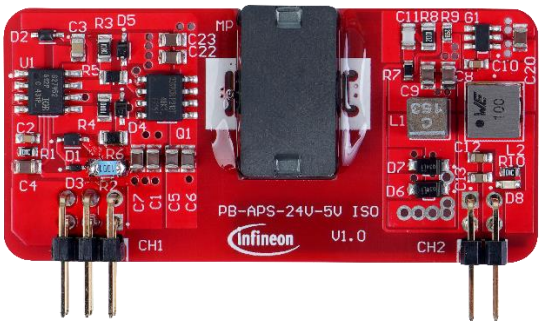

Figure 5 **PB-APS-24V-5V ISO**

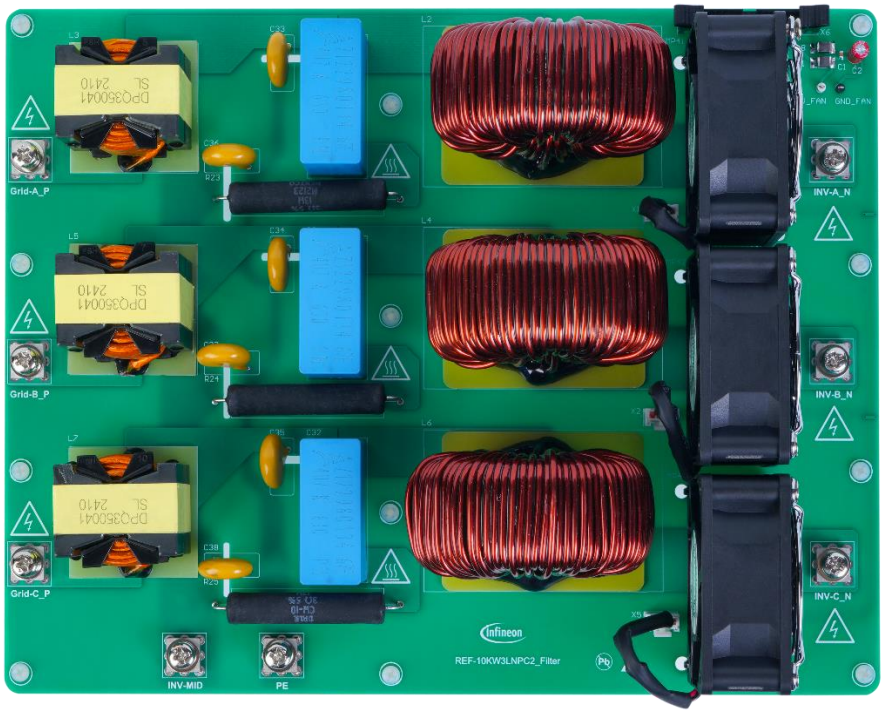

Figure 6 **REF-10KW3LNPC2-Filter**

Figure 7 **PB-CAPTANK-1.1KV**

1.4 Preferred components

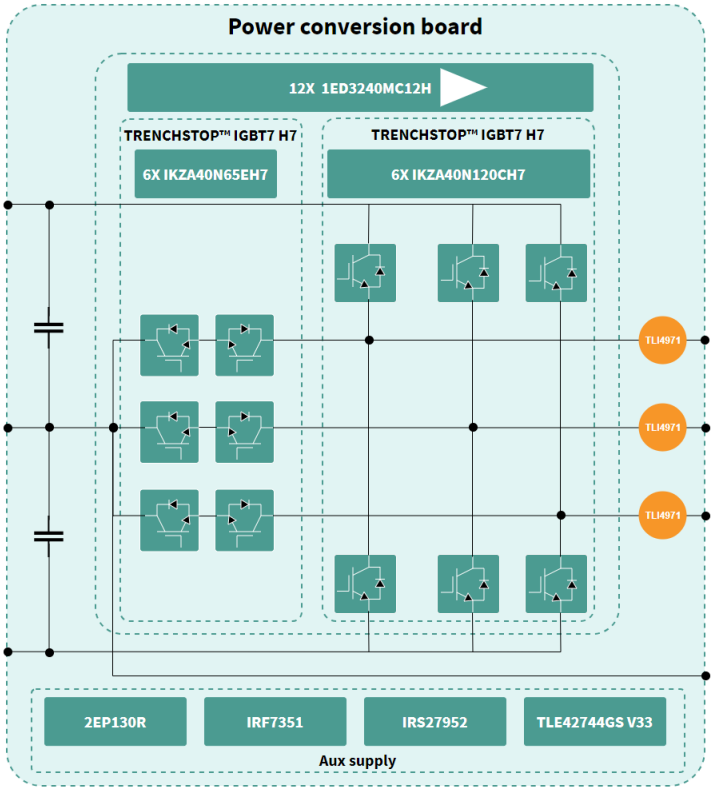

Figure 8 **Preferred Infineon components**

Figure 8 shows the main semiconductors offered in the 10 kW NPC2 inverter reference design.

- Power semiconductors:
  - TRENCHSTOP™ IGBT7 H7: IKZA40N120CH7
  - TRENCHSTOP™ IGBT7 H7: IKZA40N65EH7
- Gate driver:
  - Single channel isolated gate driver with 2-level slew rate control: 1ED3240MC12H
- Current sensor:
  - XENSIV™ magnetic current sensor: TLI4971
- Auxiliary power supply:
  - 2EP130R: Full-bridge transformer driver
  - IRS27952: Half Bridge controller IC
  - IRF7351: 60V dual N-channel HEXFET power MOSFET

2 Board functional description

This chapter lists the features available for the 10 kW NPC2 inverter reference design.

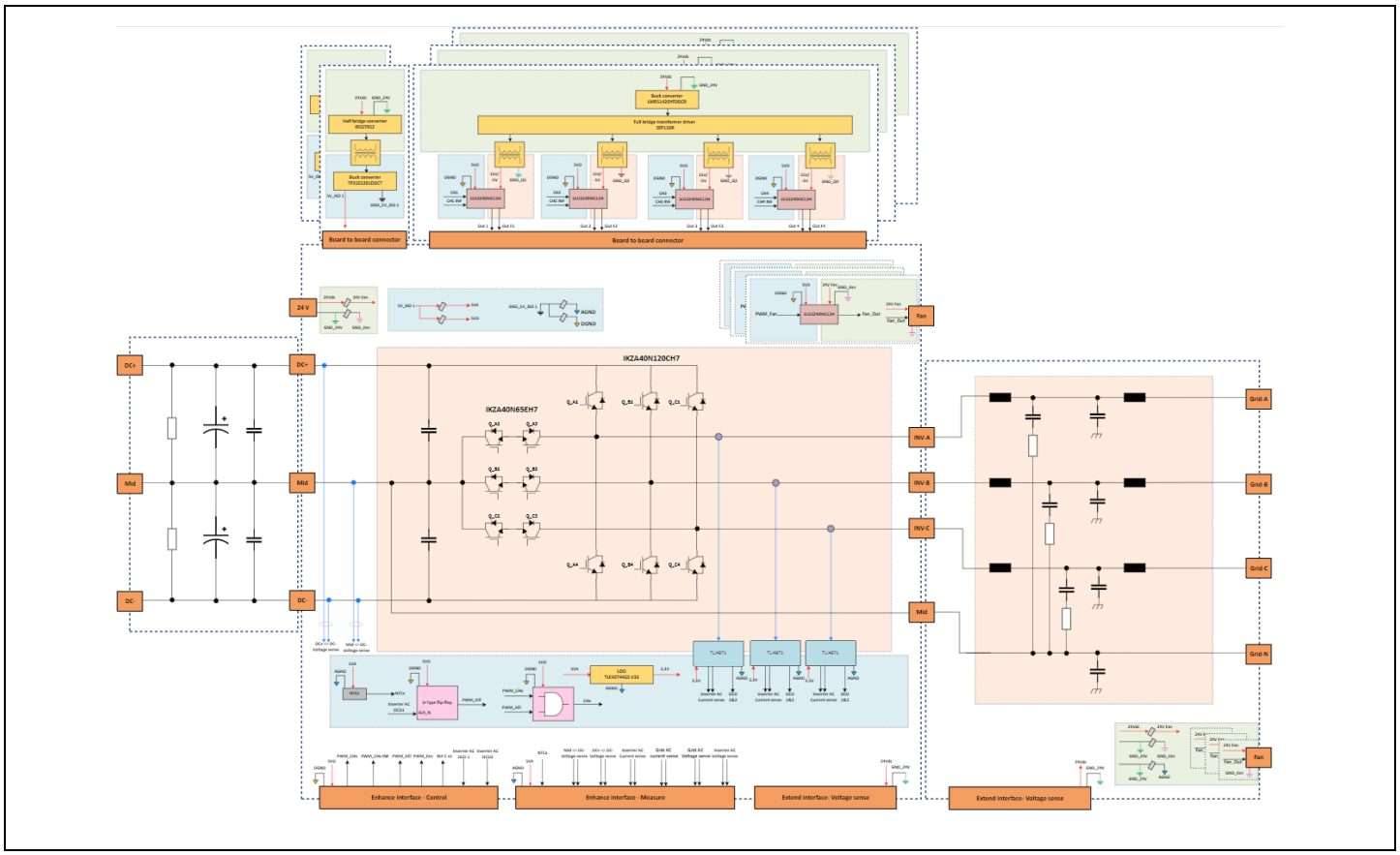

Figure 9 **Block diagram of REF-10KW3LNPC2**

2.1 Description of the functional blocks

2.1.1 Switching devices

The inverter stage is realized using the TRENCHSTOP™ IGBT7 H7 products IKZA40N120CH7 and IKZA40N65EH7.

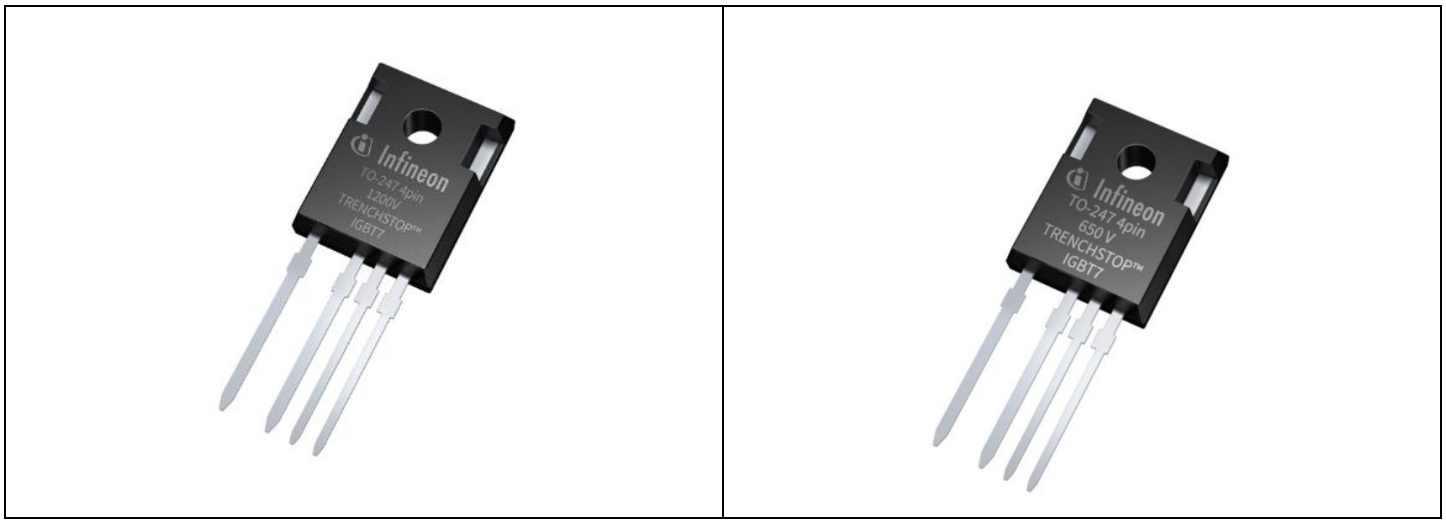

Figure 10 **IKZA40N120CH7 and IKZA40N65EH7**

IKZA40N120CH7 and IKZA40N65EH7 belong to the TRENCHSTOP™ IGBT7 H7 family. They come in discrete in TO-247 4pin package technology that has been developed to fulfill the demand in applications focusing on decarbonization such as solar photovoltaic, uninterruptible power supplies and battery chargers.

2.1.2 Gate driver

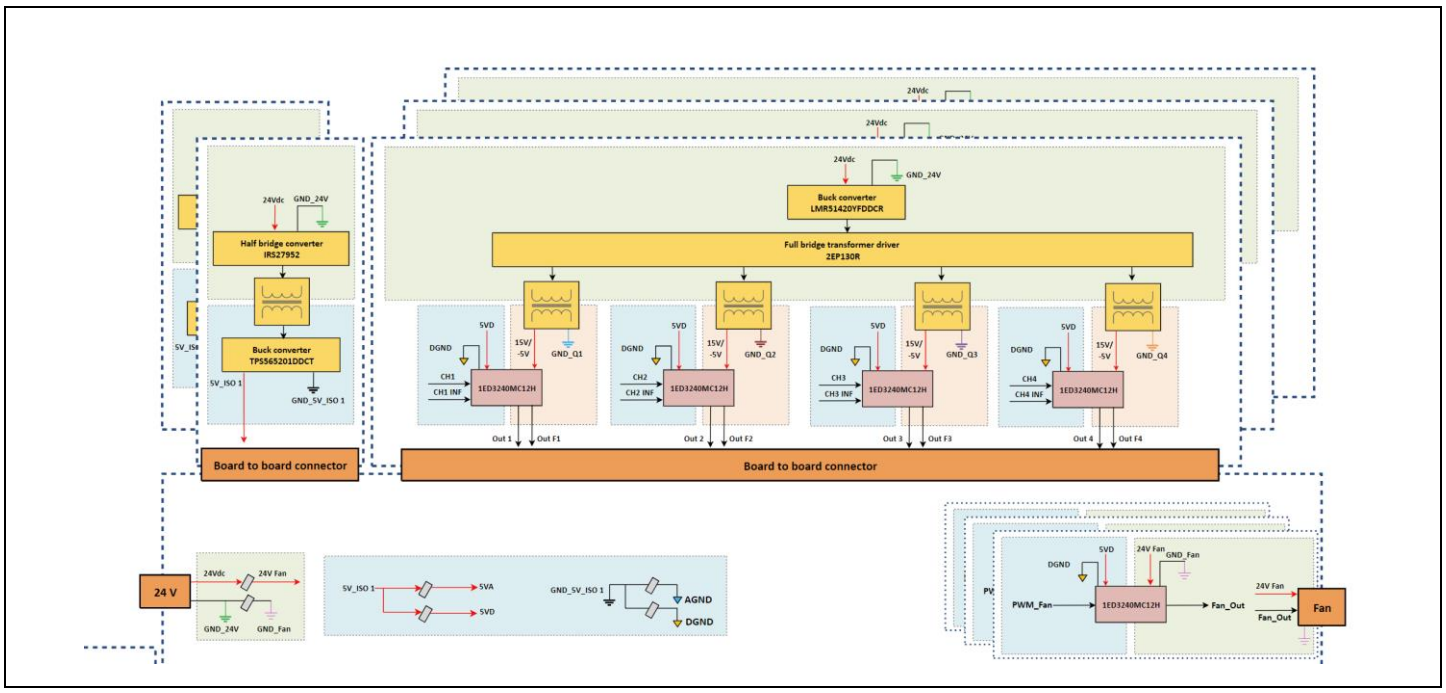

Figure 11 **Gate driver card functional block diagram**

Four gate single-channel isolated gate drivers are used to drive the 4 IGBTs. The gate driver used is 1ED3240MC12H.

Figure 12 **1ED3240MC12H**

1ED3240MC12H belongs to the EiceDRIVER™ 2L-SRC Compact 1ED32xx family and is a single-channel isolated gate driver with two-level slew-rate control (2L-SRC) and 10 A typical sinking and sourcing peak output current in DSO-8 wide-body package with large creepage distance (>8 mm) for IGBTs, MOSFETs and SiC MOSFETs. 1ED3240MC12H offers two separate outputs with 10 A typical peak output current to control two independent gate resistances for both turn-on and turn-off thus enabling two-level slew-rate control. The driver can operate over a wide supply voltage range, either unipolar or bipolar.

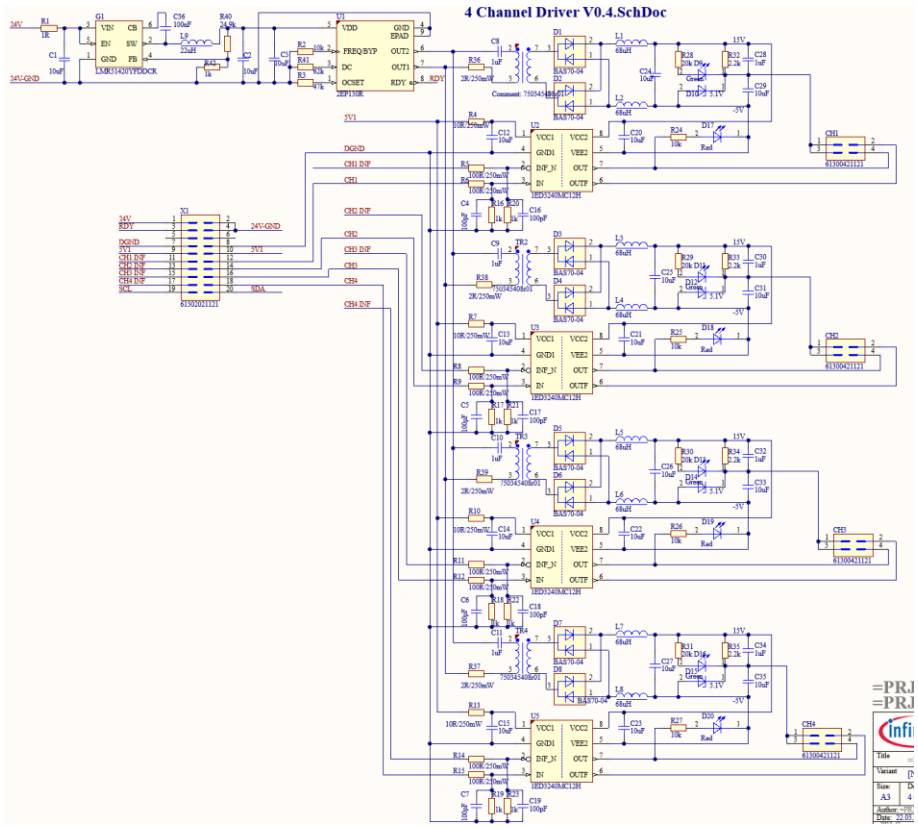

Figure 13 **Gate driver card**

The 24 V and the PWM signals come from the power board and are used as an input to the gate drive card. The 24 V is then stepped down and used as an input to the 2EP130R full-bridge transformer driver. A transformer is then used to provide functional isolation and the voltages 15 V and -5V are then generated on the rectifier side to be used as the positive and negative voltage for driving the IGBTs on the power board. The gate resistors are located on the power board.

2.1.3 Internal power supplies

24V needs to be supplied externally by the user to the power board. The 24 V are then fed to a power supply card which generates an isolated 5V. The 24 V is fed to the gate driver card which generates the isolated 15V / -5V needed to drive the IGBTs. The isolated 5 V is fed to the primary side of the gate driver.

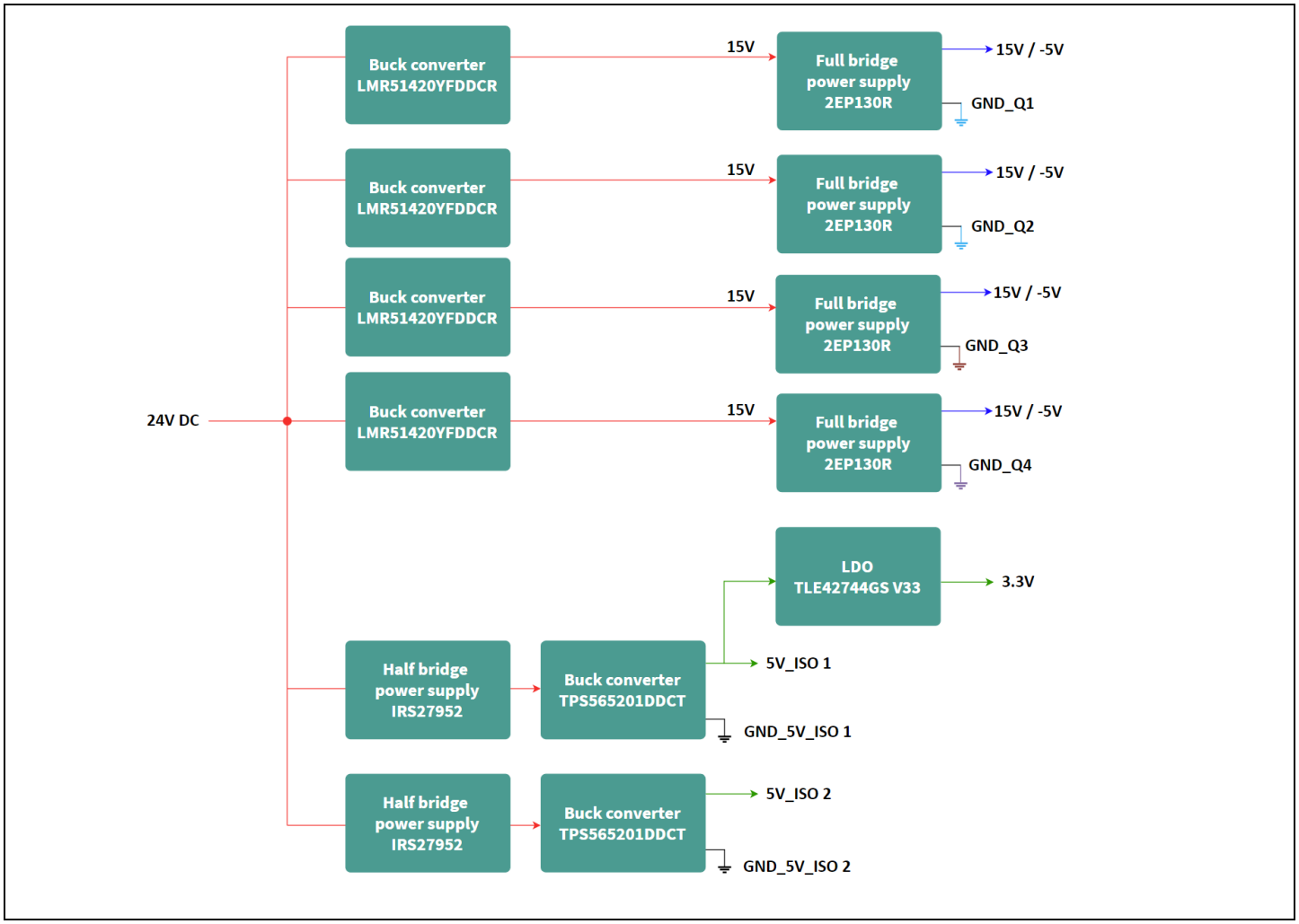

Figure 14 **Auxiliary power supply tree**

The specifications of the power supply card are as follows:

Table 3 **Specifications of the power supply card**

Parameter	Minimum	Typical	Maximum	Unit
Input voltage	21.6	24	26.4	V_{dc}
Input current			0.5	A
Output voltage	4.75	5	5.25	V_{dc}
Output current			2	A
Switching frequency		226		kHz
Half bridge IC used		IRS27952		-

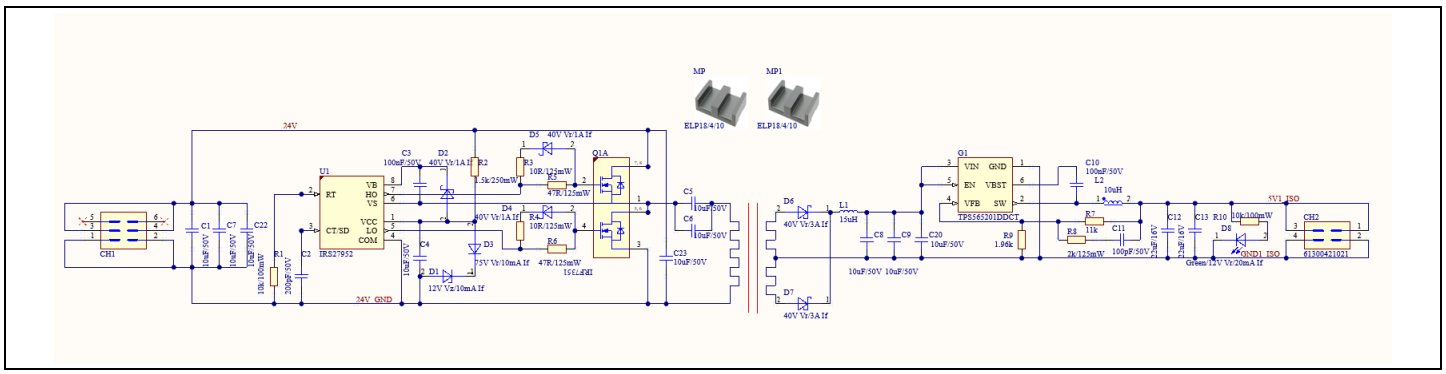

Figure 15 **Power supply card schematics**

2.1.4 Sensing and protection

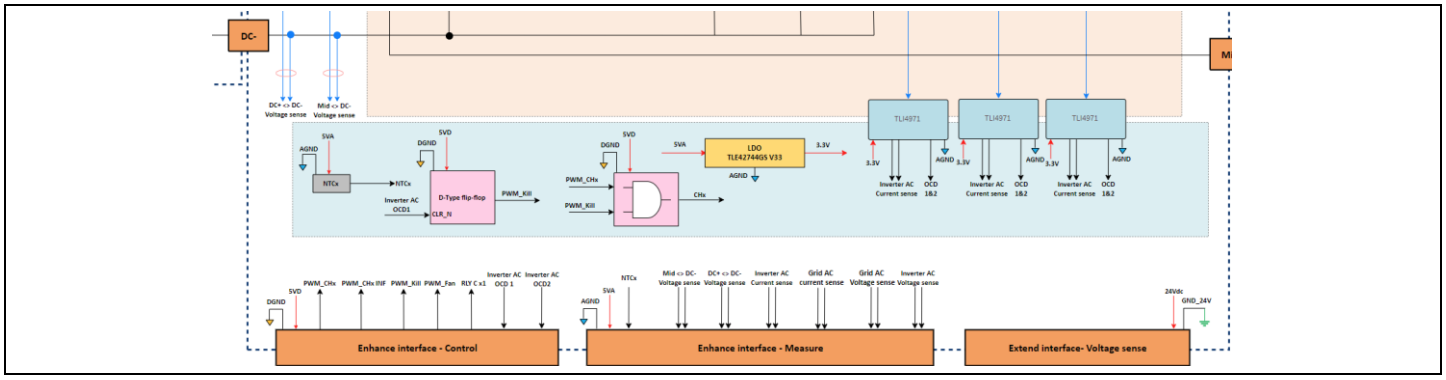

Figure 16 **Functional block diagram of the measurement signals on the power board**

2.1.4.1 Current sense

The inductor currents are sensed using TLI4971 current sensor.

XENSIV™ TLI4971-A120T5-U-E0001 is an Infineon high precision miniature coreless magnetic current sensor for AC and DC measurements with analog interface and dual fast over-current detection outputs. The two over current detection (OCD) pins are used to implement protection on hardware and software levels.

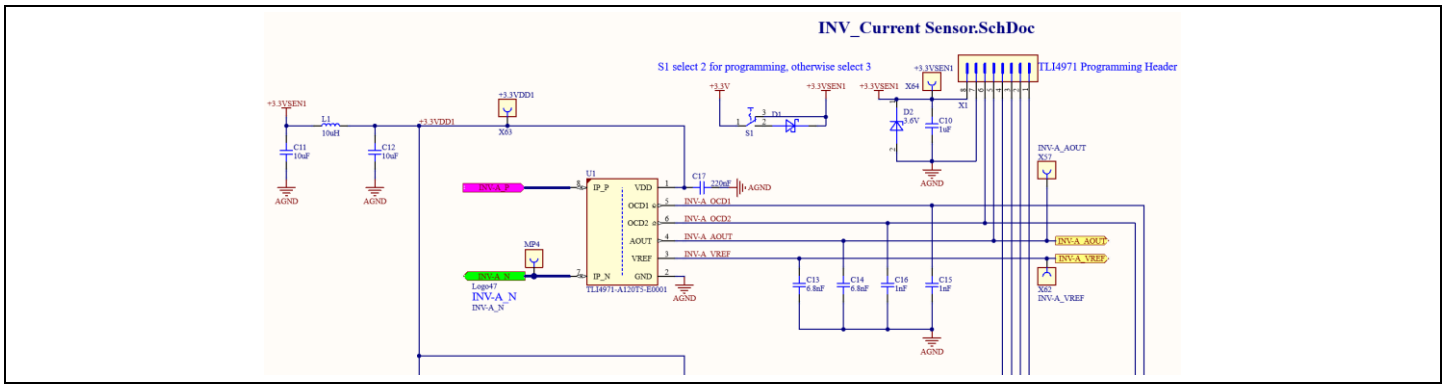

Figure 17 **Current sense circuit**

One way to reprogram the current sensor if needed is by using the XENSIV™ - TLI4971, TLE4972 current sensor programmer board. Details can be found in the board user guide.

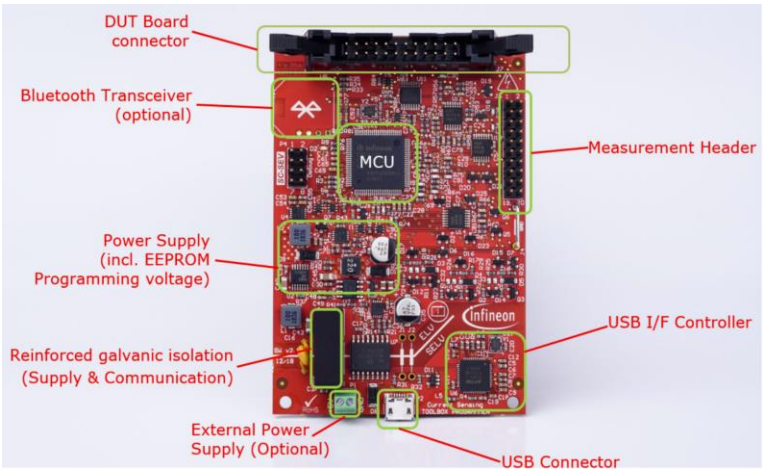

Figure 18 **Current sensor programmer board**

The board needs to be connected to the user's PC and the DUT board connector needs to be interfaced with the power board.

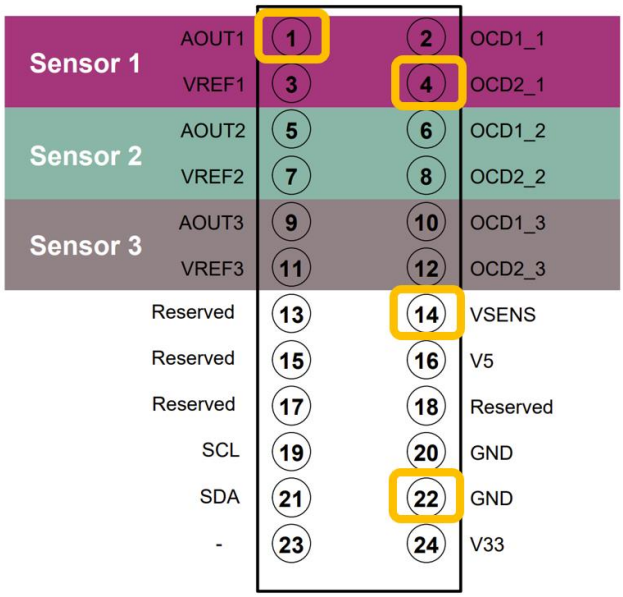

Figure 19 **DUT board connector on the programmer board**

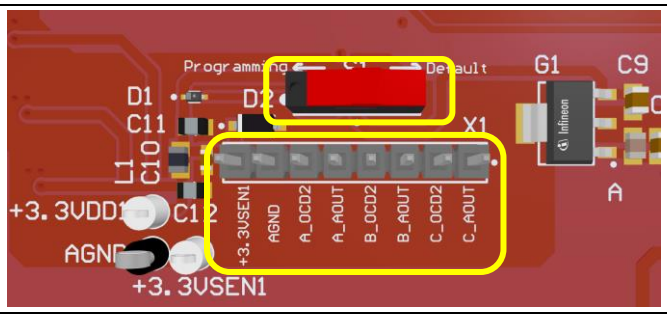

Figure 20 **Current sensor programming connector on the power board**

The previous two figures show the two connectors that need to be interfaced together on the programming board and the power board.

Steps to reprogram the current sensor:

1. Connect the programmer board with X1 on the power board and also with a USB cable to PC
2. Place the switch S1 in programming mode
3. Start the TLI4971 programming software
4. In the GUI, go to memory and then basic configuration
5. Set all the data, and press 'Burn EEPROM'
6. Repeat the previous steps to program the other current sensors
7. Remove all connections
8. Place the switch S1 back in default mode

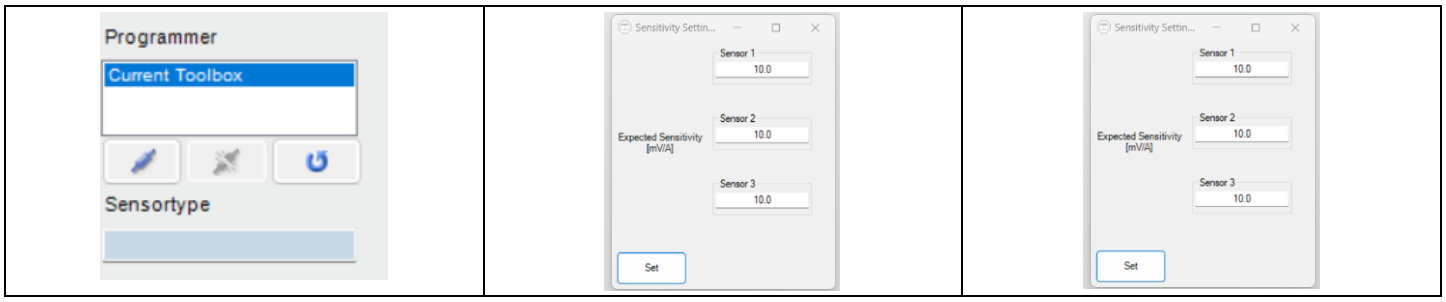

Figure 21 **GUI**

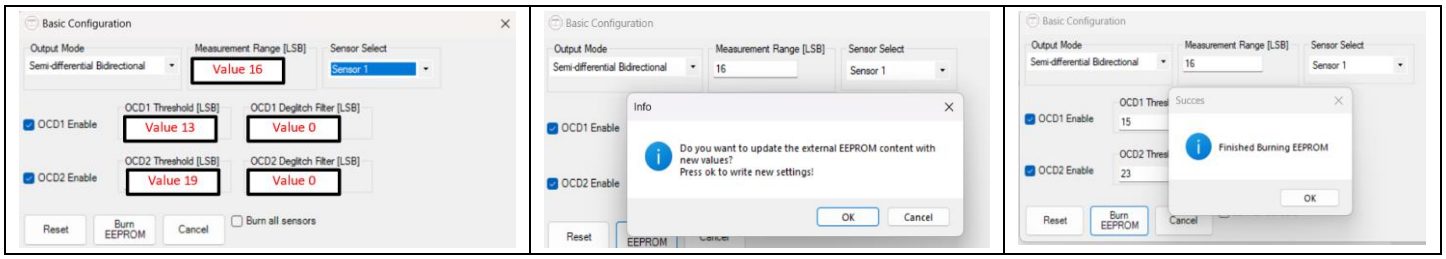

Figure 22 **GUI**

2.1.4.2 Voltage sense

The DC-link voltages are measured on the power board.

Warning: controller board has to be connected with the main power board before powering the power board. Failure to do so can lead to a hazardous situation.

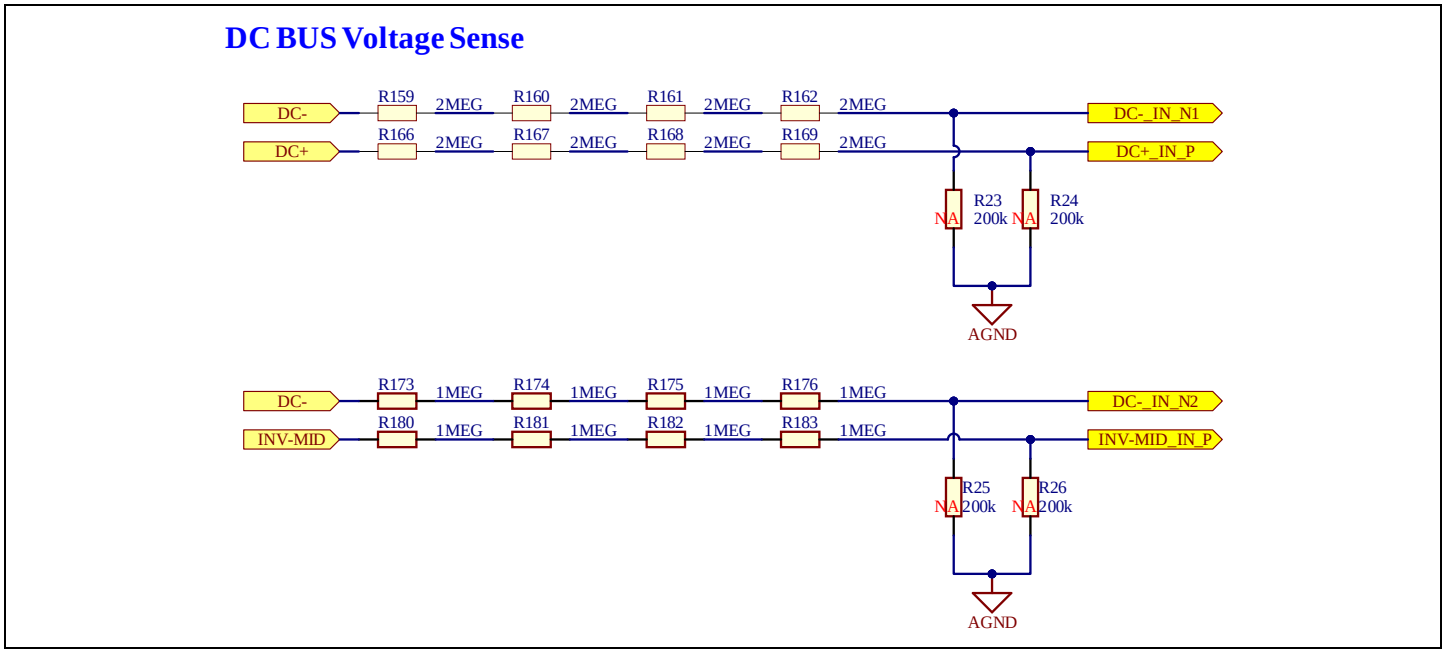

Figure 23 **DC bus voltage sense**

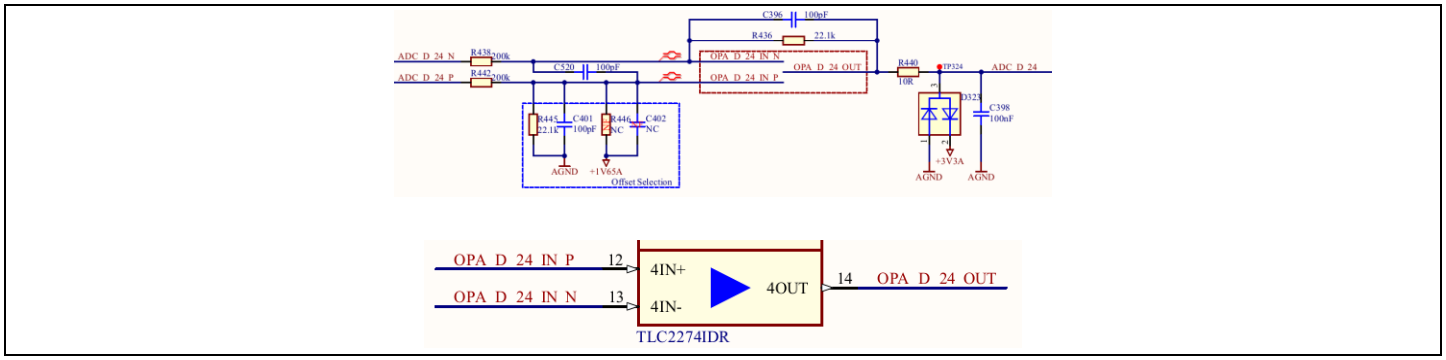

Figure 24 **Signal conditioning circuit used on the control board**

2.1.4.3 Temperature sense

Three temperature measurements are provided on the power board using NTCs. The NTCs can be connected to the heat sink to measure the temperature and feed it back to the connector which can be connected to a control board.

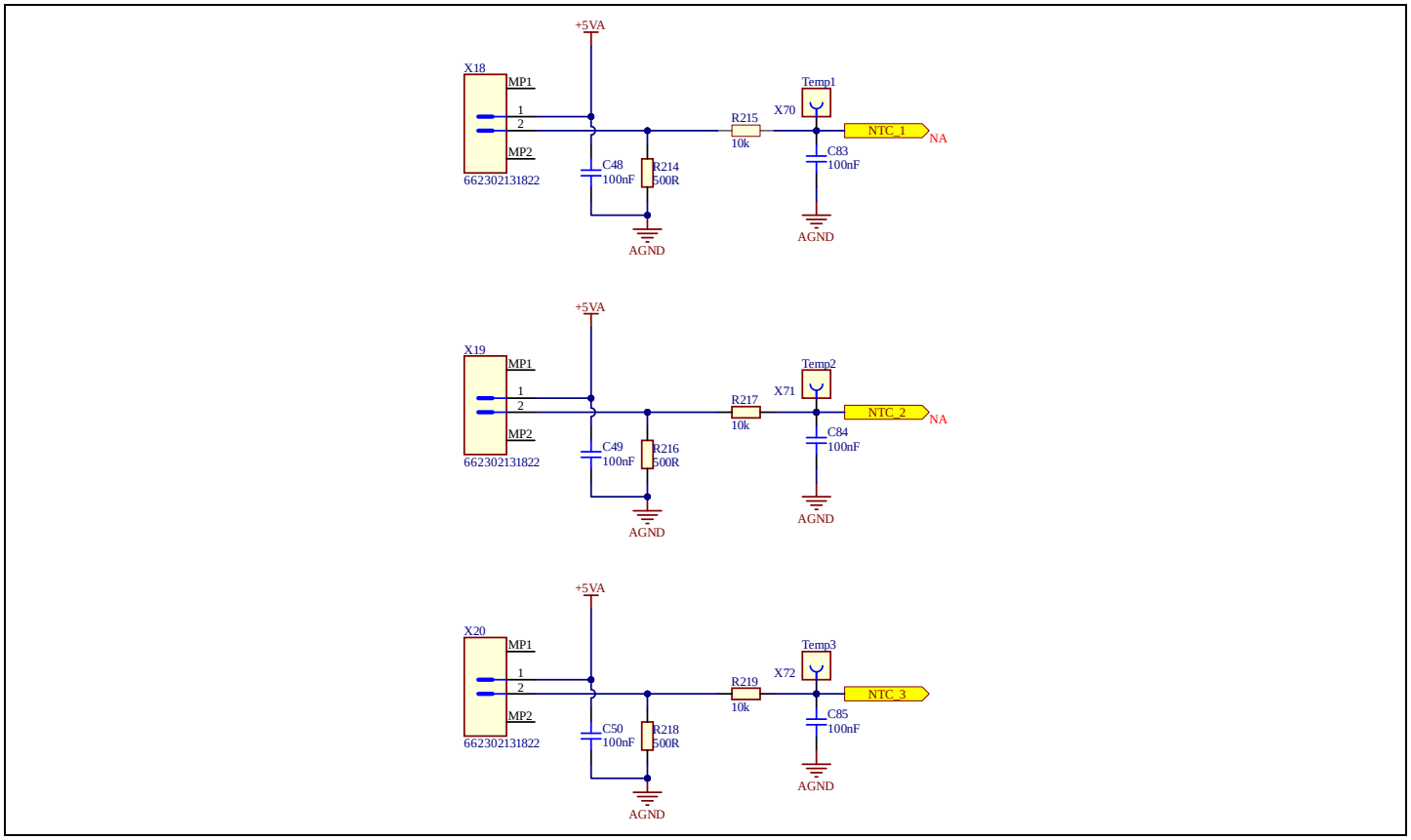

Figure 25 **Temperature sense circuit**

2.1.4.4 Fault and latch circuit

Fault and latch circuits are provided to disable the PWMs in the case of a fault which can be seen in the following figure:

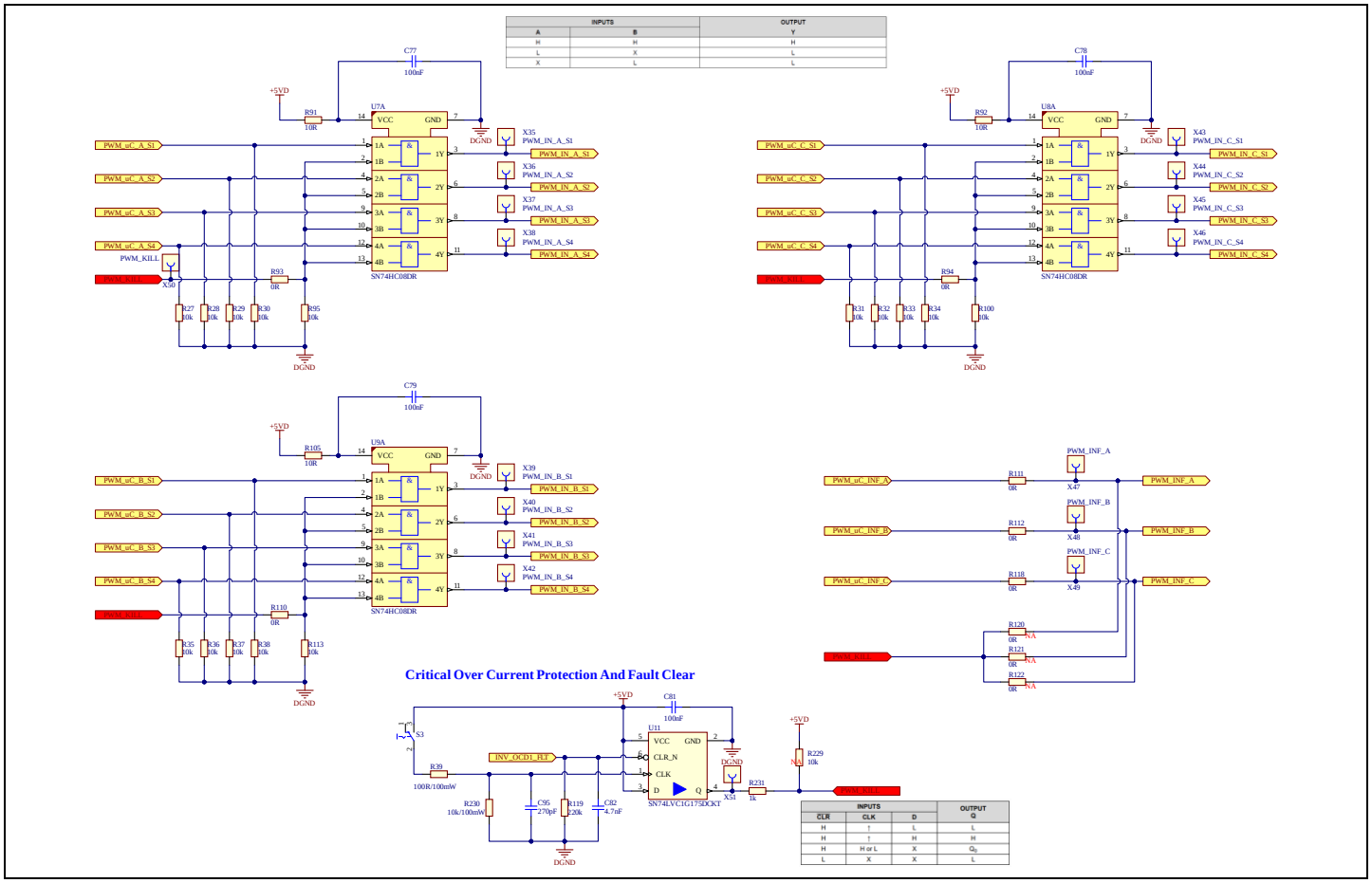

Figure 26 **Fault and latch circuit**

2.1.5 Fan control

Additional fan control circuits are also provided in case the user needs to use forced air-cooling during evaluation.

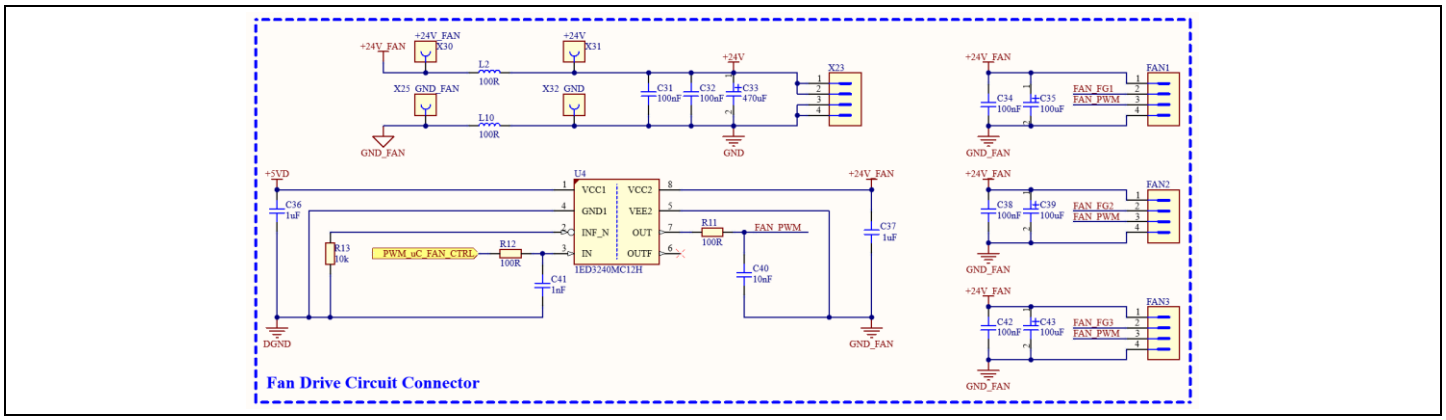

Figure 27 **Fan control circuits**

2.1.6 Connectors

2.1.6.1 Extended interface-voltage sense

The connector is used to interface the filter board with the power board to power up the fans. It is also suitable for future modifications in order to sense the AC voltages and currents.

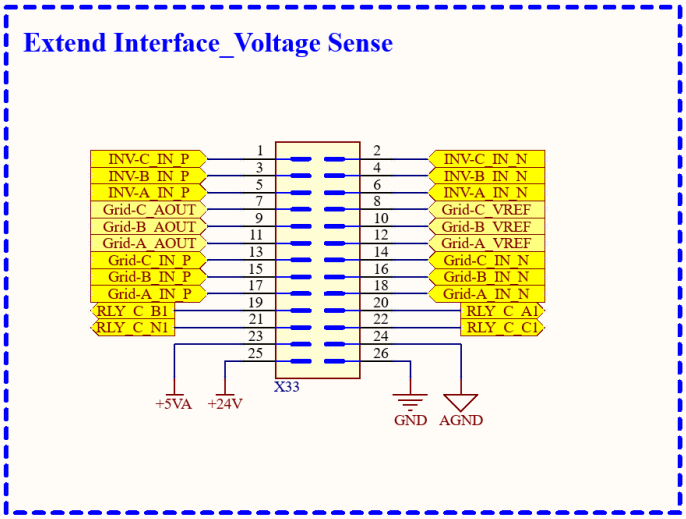

Figure 28 **Extended interface-voltage sense**

Table 4 **Extended interface-voltage sense**

Input voltage sense interface		
Pin	**Signal**	**Description**
1	INV-C_IN_P	Inverter Phase C Voltage P
2	INV-C_IN_N	Inverter Phase C Voltage N
3	INV-B_IN_P	Inverter Phase B Voltage P
4	INV-B_IN_N	Inverter Phase B Voltage N
5	INV-A_IN_P	Inverter Phase A Voltage P
6	INV-A_IN_N	Inverter Phase A Voltage N
7	Grid-C_AOUT	Grid Phase C Current P
8	Grid-C_VREF	Grid Phase C Current N
9	Grid-B_AOUT	Grid Phase B Current P
10	Grid-B_VREF	Grid Phase B Current N
11	Grid-A_AOUT	Grid Phase A Current P
12	Grid-A_VREF	Grid Phase A Current N
13	Grid-C_IN_P	Grid Phase C Voltage P
14	Grid-C_IN_N	Grid Phase C Voltage N
15	Grid-B_IN_P	Grid Phase B Voltage P
16	Grid-B_IN_N	Grid Phase B Voltage N
17	Grid-A_IN_P	Grid Phase A Voltage P
18	Grid-A_IN_N	Grid Phase A Voltage N
19	RLY_C_B1	Grid Phase B Relay Control
20	RLY_C_A1	Grid Phase A Relay Control
21	RLY_C_N1	Grid Phase N Relay Control
22	RLY_C_C1	Grid Phase C Relay Control
23	+5VA	Analog Power
24	AGND	Analog Power
25	+24V	Power
26	GND	Power

2.1.6.2 Enhanced interface-Measure

All the measurement signals are fed to the control board using connector X22 located on the power board.

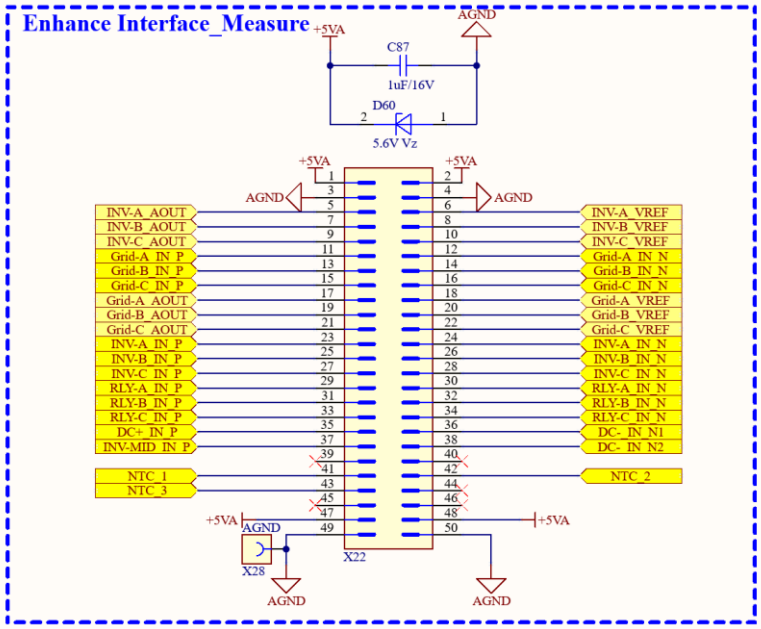

Figure 29 **Enhanced interface-Measure**

Table 5 **Enhanced interface-Measure**

Basic interface		
Pin	**Signal**	**Description**
1	+5VA	Analog Power
2	+5VA	Analog Power
3	AGND	Analog Power
4	AGND	Analog Power
5	INV-A AOUT	Inverter Phase A Current P
6	INV-A VREF	Inverter Phase A Current N
7	INV-B AOUT	Inverter Phase B Current P
8	INV-B VREF	Inverter Phase B Current N
9	INV-C AOUT	Inverter Phase C Current P
10	INV-C VREF	Inverter Phase C Current N
11	Grid-A_IN_P	Grid Phase A Voltage P
12	Grid-A_IN_N	Grid Phase A Voltage N
13	Grid-B_IN_P	Grid Phase B Voltage P
14	Grid-B_IN_N	Grid Phase B Voltage N
15	Grid-C_IN_P	Grid Phase C Voltage P
16	Grid-C_IN_N	Grid Phase C Voltage N
17	Grid-A AOUT	Grid Phase A Current P
18	Grid-A VREF	Grid Phase A Current N
19	Grid-B AOUT	Grid Phase B Current P
20	Grid-B VREF	Grid Phase B Current N

21	Grid-C AOUT	Grid Phase C Current P
22	Grid-C VREF	Grid Phase C Current N
23	INV-A_IN_P	Inverter Phase A Voltage P
24	INV-A_IN_N	Inverter Phase A Voltage N
25	INV-B_IN_P	Inverter Phase B Voltage P
26	INV-B_IN_N	Inverter Phase B Voltage N
27	INV-C_IN_P	Inverter Phase C Voltage P
28	INV-C_IN_N	Inverter Phase C Voltage N
29	RLY-A_IN_P	Relay Phase A Voltage P
30	RLY-A_IN_N	Relay Phase A Voltage N
31	RLY-B_IN_P	Relay Phase B Voltage P
32	RLY-B_IN_N	Relay Phase B Voltage N
33	RLY-C_IN_P	Relay Phase C Voltage P
34	RLY-C_IN_N	Relay Phase C Voltage N
35	DC+_IN_P	Bus+ Voltage P
36	DC-_IN_N1	Bus+ Voltage N
37	INV-MID_IN_P	Bus- Voltage P
38	DC-_IN_N2	Bus- Voltage N
39	NC	NC
40	NC	NC
41	NC	NC
42	NC	NC
43	NTC1	NTC1
44	NTC2	NTC2
45	NTC3	NTC3
46	NC	NC
47	+5VA	Analog Power
48	+5VA	Analog Power
49	AGND	Analog Power
50	AGND	Analog Power

2.1.6.3 Enhanced interface-control

Connector X21 contains all the signals related to the PWMs, faults and relay control.

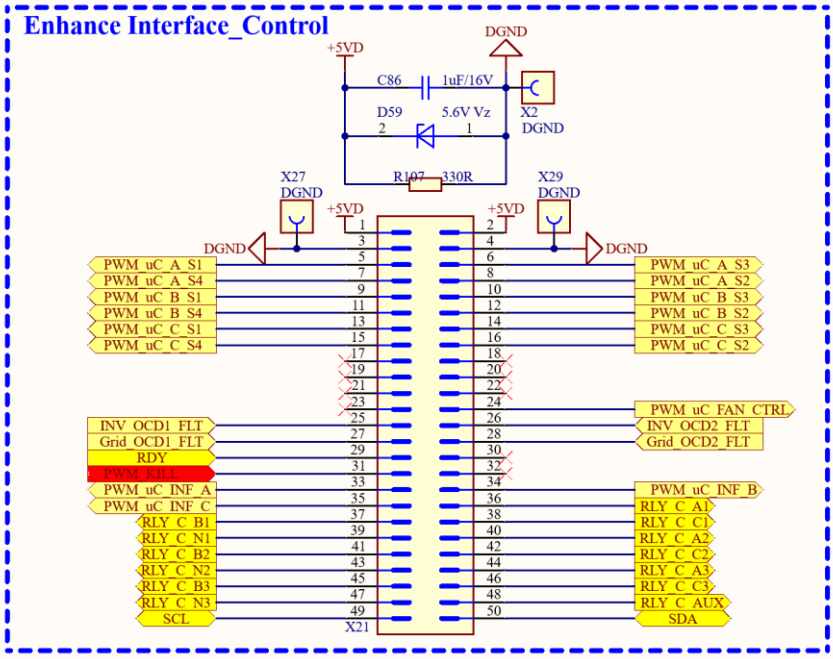

Figure 30 **Enhanced interface-control**

Table 6 **Enhanced interface-control**

Basic interface		
Pin	**Signal**	**Description**
1	+5VD	Digtial Power
2	+5VD	Digtial Power
3	DGND	Digtial Power
4	DGND	Digtial Power
5	PWM_uC_A_S1	Phase A T1 PWM
6	PWM_uC_A_S3	Phase A T3 PWM
7	PWM_uC_A_S4	Phase A T4 PWM
8	PWM_uC_A_S2	Phase A T2 PWM
9	PWM_uC_B_S1	Phase B T1 PWM
10	PWM_uC_B_S3	Phase B T3 PWM
11	PWM_uC_B_S4	Phase B T4 PWM
12	PWM_uC_B_S2	Phase B T2 PWM
13	PWM_uC_C_S1	Phase C T1 PWM
14	PWM_uC_C_S3	Phase C T3 PWM
15	PWM_uC_C_S4	Phase C T4 PWM
16	PWM_uC_C_S2	Phase C T2 PWM
17	NC	NC
18	NC	NC
19	NC	NC
20	NC	NC
21	NC	NC
22	NC	NC

23	NC	NC
24	PWM_uC_FAN_CTRL	NPC2 FAN Control
25	INV_OCD1_FLT	Inv Current Sensor ODC1 Combine
26	INV_OCD1_FLT	Inv Current Sensor ODC2 Combine
27	Grid_OCD1_FLT	Grid Current Sensor ODC1 Combine
28	Grid_OCD2_FLT	Grid Current Sensor ODC2 Combine
29	RDY	NC
30	NC	NC
31	PWM_KILL	PWM Kill
32	NC	NC
33	PWM_uC_INF_A	Phase A Gate Driver Control
34	PWM_uC_INF_B	Phase B Gate Driver Control
35	PWM_uC_INF_C	Phase C Gate Driver Control
36	RLY_C_A1	Grid Phase A Relay Control
37	RLY_C_B1	Grid Phase B Relay Control
38	RLY_C_C1	Grid Phase C Relay Control
39	RLY_C_N1	Grid Phase N Relay Control
40	RLY_C_A2	Bypass Phase A Relay Control
41	RLY_C_B2	Bypass Phase B Relay Control
42	RLY_C_C2	Bypass Phase C Relay Control
43	RLY_C_N2	Bypass Phase N Relay Control
44	RLY_C_A3	Inverter Phase A Relay Control
45	RLY_C_B3	Inverter Phase B Relay Control
46	RLY_C_C3	Inverter Phase C Relay Control
47	RLY_C_N3	Inverter Phase N Relay Control
48	RLY_C_AUX	Pre-Charge Rlay Control
49	I2C2_SCL	Gate Driver Config (If needed)
50	I2C2_SDA	Gate Driver Config (If needed)

2.7 Isolation coordination

The 10 kW NPC2 inverter reference design follows a hot-side control structure where all the measurements and the gate-drive power supply offer functional isolation. Two microcontrollers are used then on the board where one is responsible for the control of the converter. A digital isolator is then implemented and a second microcontroller that the user can deal with safely is used for communication. IEC 62109-1 was used for clearance and creepage requirements.

3 Testing

The testing of the 10 kW NPC2 inverter reference design was done using the XMC7200-based power control board reference design REF-CLBXMC7PEC that can be purchased separately. It was operated in open loop and tested using a resistive load. The filter board of the converter is not optimized to be used with AC electronic loads, the user needs to stick to resistive loads while using the 10 kW NPC2 kit.

3.1 Flashing the firmware

Steps to flash the firmware:

1. Connect 24 V to the control board
2. Add three jumper headers like shown in figure 31
3. Connect the debug port of the control board to PC using a USB cable

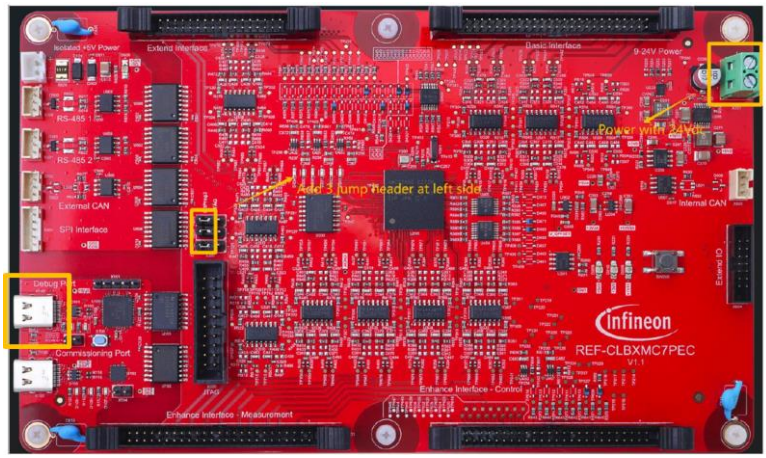

Figure 31 **REF-CLBXMC7PEC debug configuration**

4. Install ModusToolbox™ software
5. Add windows system path variable as shown below:

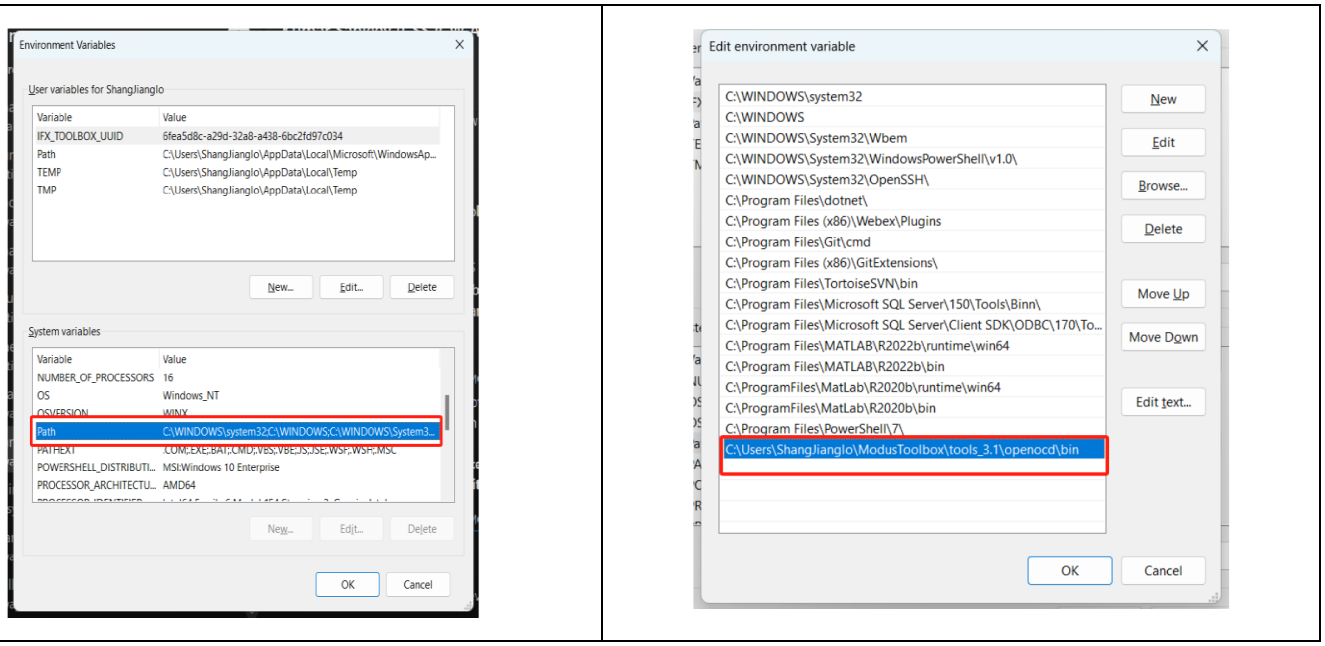

Figure 32 **Adding environment variable**

6. Start the command prompt on your PC and type ‘openocd’ to verify that the previous steps were made correctly

7. Type the following using the address of the location where the firmware is located on your PC:

   openocd -s ../scripts -f interface/kitprog3.cfg -f target/cat1c.cfg -c "program C:/Users/AN/Desktop/Firmware/app_combined.hex verify exit"

   Note: The user needs to change this path (C:/Users/AN/Desktop/Firmware/app_combined.hex verify exit) to their own

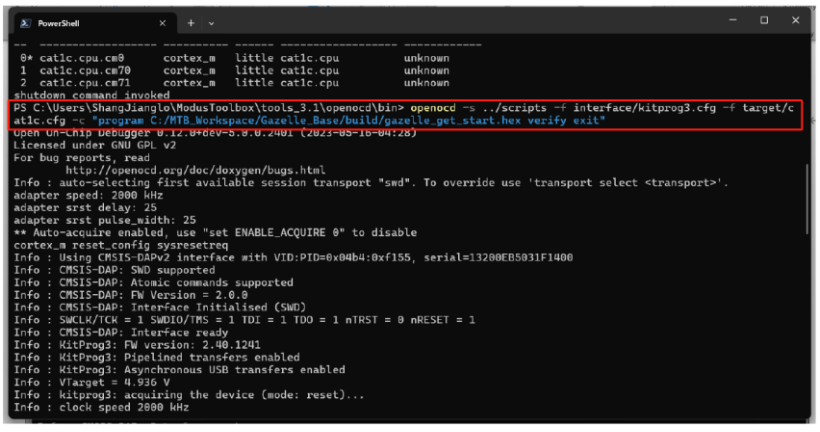

Figure 33 **Flashing the firmware**

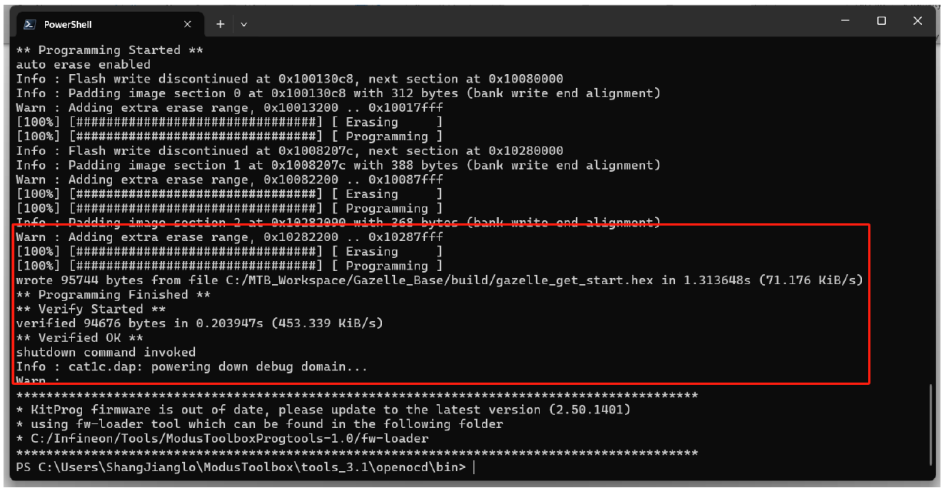

Figure 34 **Flashing the firmware**

8. Remove the jumpers present on the control board
9. Disconnect the external 24V power supply
10. Connect the USB cable to the commissioning port instead of the debug port

3.2 Control

The firmware allows the user to operate the NPC2 in open loop using SPWM scheme. The firmware also allows the user to change the modulation index.

3.3 GUI

3.3.1 Establishing communication

The GUI can be seen in figure 35:

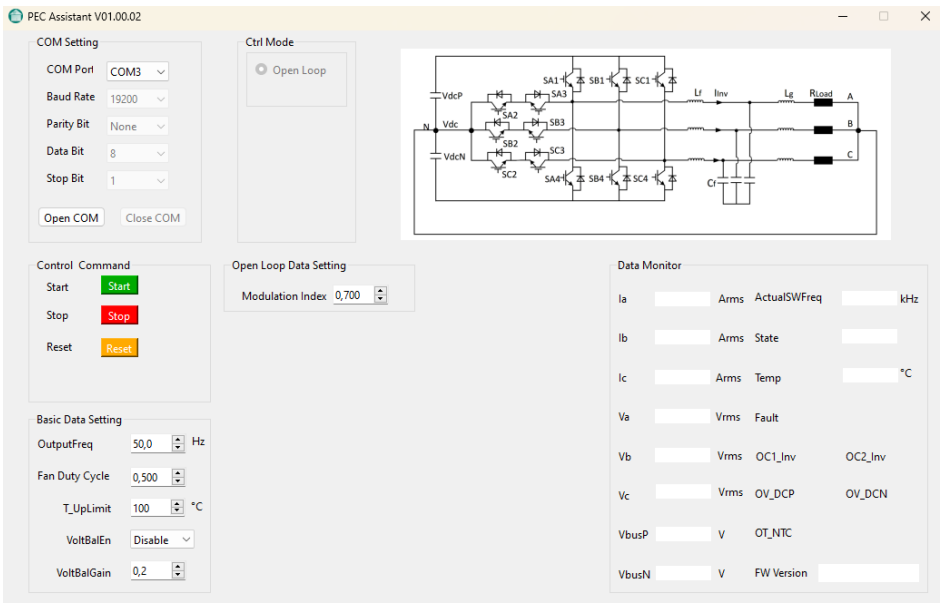

Figure 35 **GUI**

Steps to establish connection between PC and control board:

1. Make sure that the NPC2 board and the control board are connected as shown in the upcoming Bench setup section

   The signal cables from the power board provide the control board with power, no external power supply is needed to be connected to the control board

2. Connect an external 24V to the power board of the NPC2

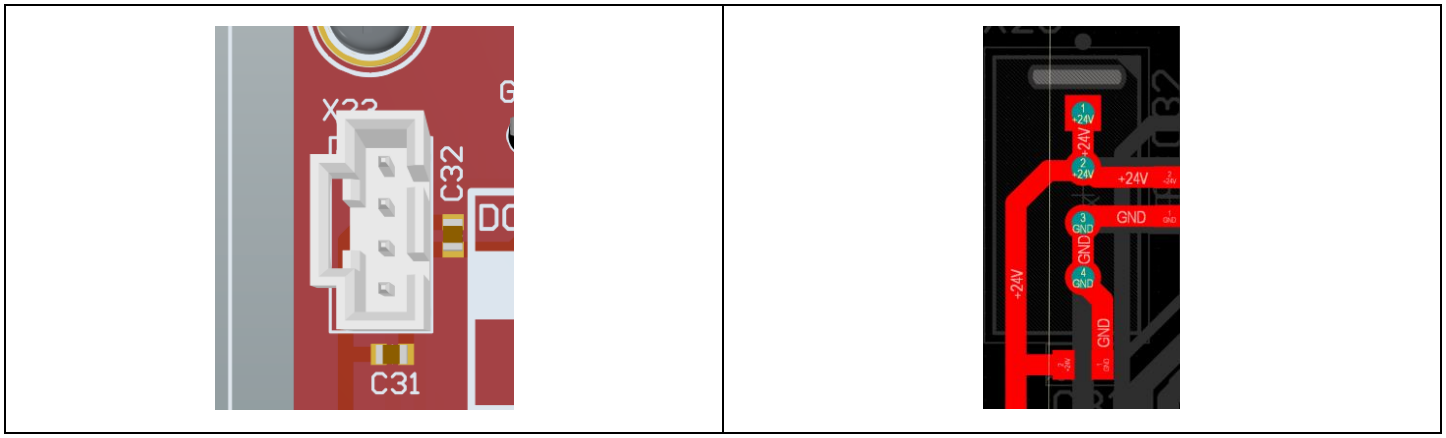

Figure 36 **24V connector**

3. Open the GUI and log in and choose normal mode, the password is 123456

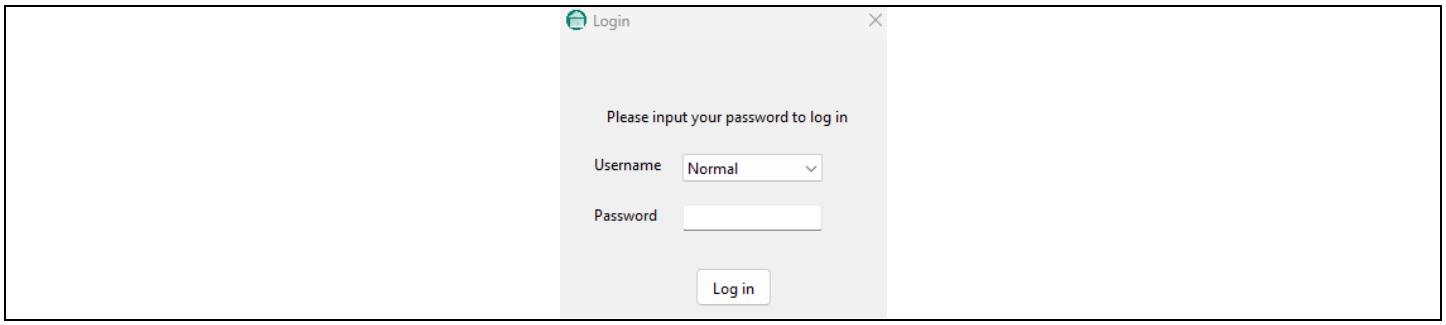

Figure 37 **Logging in**

4. In the COM port setting in the GUI, choose the COM port the control board is connected to, the user can check that in the device manager
5. If everything is set correctly the right section (Measurement section) will start showing values
6. Once the bench setup is set, the user can press start to start evaluating the hardware

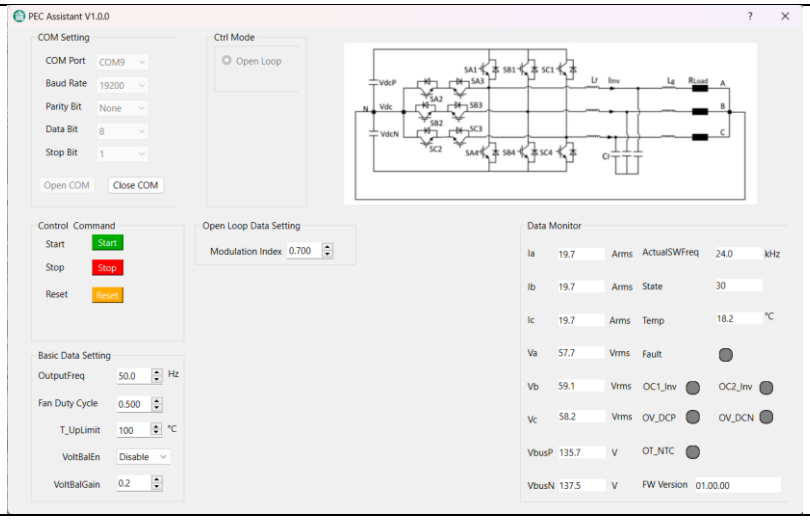

Figure 38 **GUI after successful connection**

3.3.2 GUI parameters

Table 7 **GUI parameters**

Pin	Signal	Range
Open COM	Establish communication between the GUI and the microcontroller	
Start	Start the inverter	
Stop	Stop the inverter	
Reset	Reset faults	
Output frequency	Adjust the output frequency between (40Hz and 65 Hz)	40 Hz – 65 Hz
Fan Duty Cycle	Adjust the duty cycle of the fans mounted on the heatsink	0 – 1
T_Upl Limit	Set temperature protection threshold	0 – 200
VoltBalEn	Enable the voltage balancing function for the DC-link	0 or 1
VoltBalGain	Set the DC link voltage balance control gain	0 – 20
Modulation Index	Set the modulation index for open-loop operation	0 – 1
I_a	Phase a measured current	
I_b	Phase b measured current	
I_c	Phase c measured current	
V_a	Not implemented (Future development)	
V_b	Not implemented (Future development)	
V_c	Not implemented (Future development)	
OC1_Inv	Hardware over current protection	
OC1_Inv	Software overcurrent protection	
OV_DCP	DC bus positive over voltage protection	
OV_DCN	DC bus negative over voltage protection	
VbusP	Measured voltage on the upper DC-link	
VbusN	Measured voltage on the lower DC-link	

3.4 Open-loop test results

3.4.1 Bench setup

The inverter is operated in open-loop, caution must be taken in order not to accidently operate the inverter outside the voltages, currents and frequencies specified. The inverter was tested only for the specifications shown in table 2 with a resistive load. In case the user decides to operate outside these specifications, performance is not guaranteed. The firmware gives the user the possibility of using a DC-link voltage balancing function, the user needs to increase the DC-link voltage gradually, monitor it and decide to use it in case it is needed.

The following equipment are needed to start testing:

- 10 kW NPC2 kit
- REF-CLBXMC7PEC kit with the NPC2 firmware
- GUI
- Resistive load: 3-phase star connected (Neutral is connected to DC-link mid-point)
- DC power source

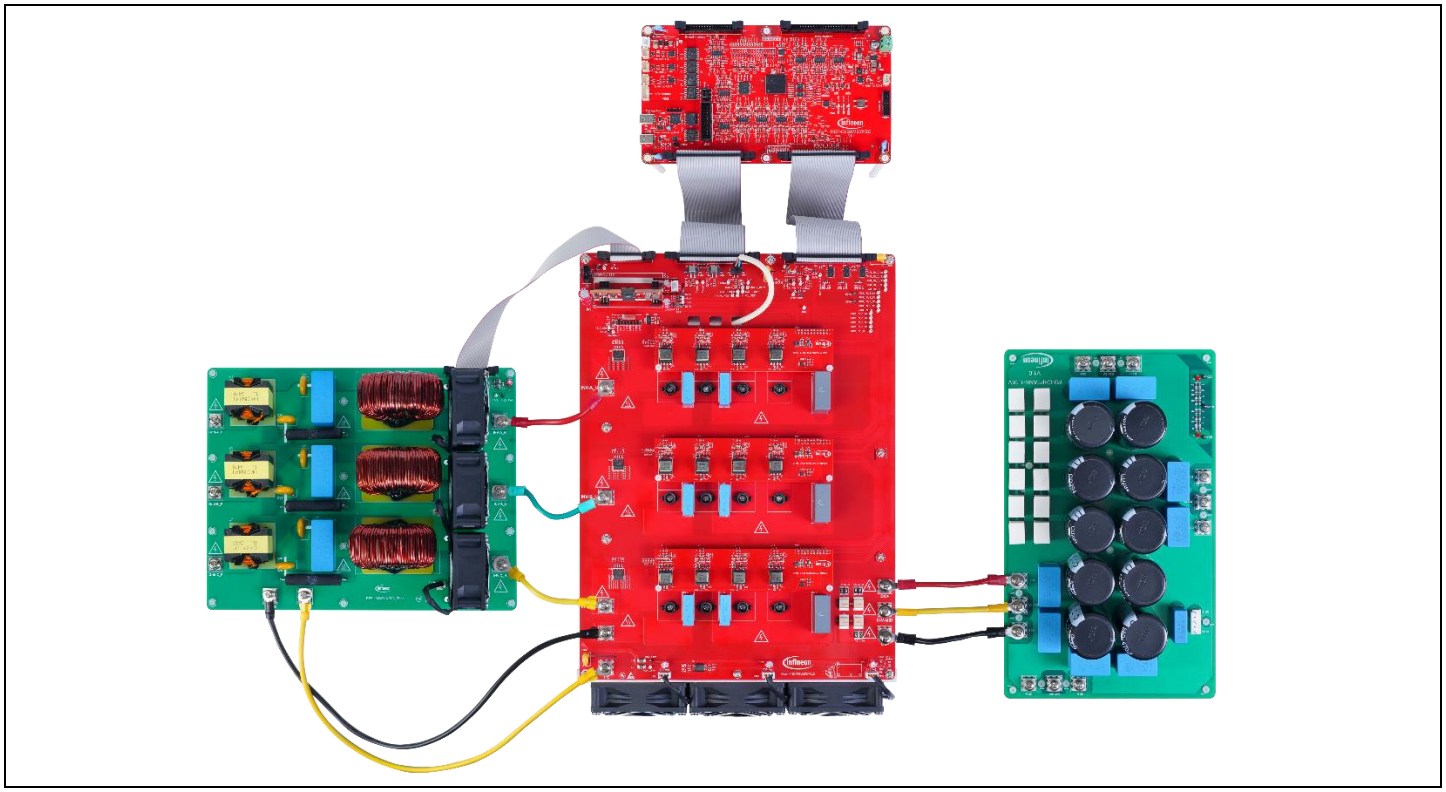

Figure 39 **Test setup**

3.4.2 Output AC voltage against different DC input voltages

The design was tested at 3 input DC voltages 680V, 750V and 850V. The output line to line rms voltage was kept at around 380 V at a power of 10 kW.

Table 8 DC input voltage range

Input voltage	680， 750 and 850 V_{dc}
PWM	SPWM, 24 kHz
Output power	10 kW, V_{out}=380 $V_{l\text{-}l\ rms}$/ 50 Hz

Table 9 Test data

MI	Input voltage (V_{dc})	Input Power (kW)	Output Voltage ($V_{l\text{-}l\ rms}$)			Output Current (A_{rms})			Waveform
			V_a	V_b	V_c	I_a	I_b	I_c	
0.95	680	10.89	382.7	389.2	385.3	15.66	15.60	15.30	Figure 36
0.87	750	10.85	381.6	388.2	384.1	15.62	15.70	15.40	Figure 37
0.77	850	10.79	380.2	386.7	382.7	15.61	15.50	15.20	Figure 38
Legend	CH1: $V_{l\text{-}l\ ab}$, CH2: $V_{l\text{-}l\ bc}$, CH3: $V_{l\text{-}l\ ca}$, CH4: I_a								

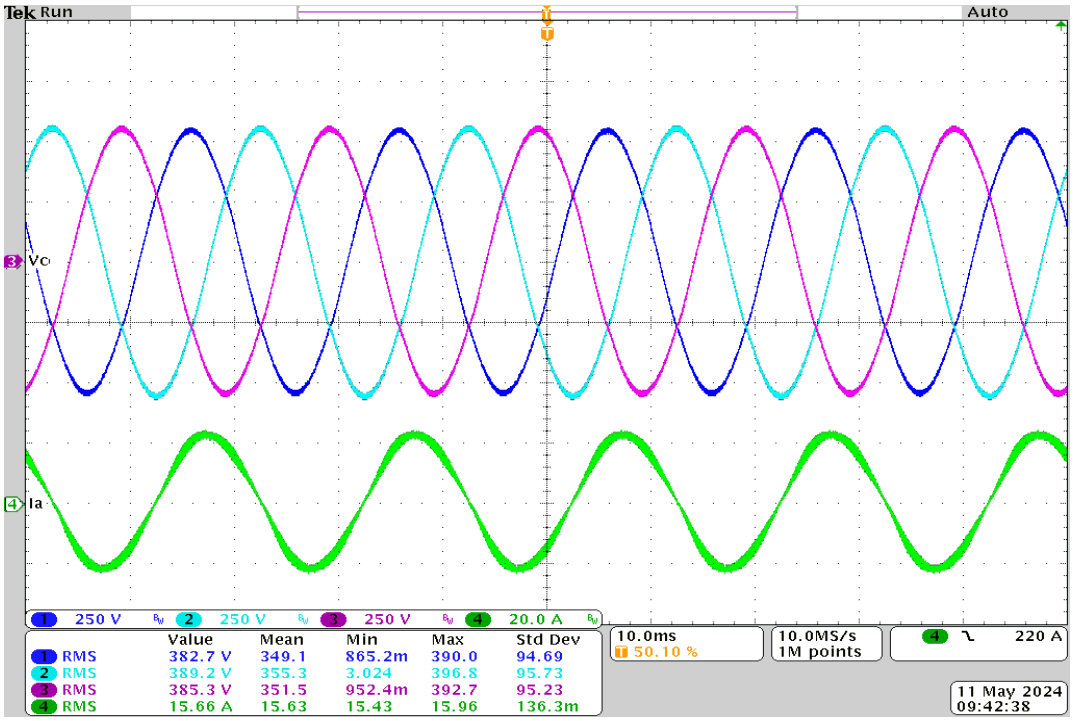

Figure 40 **Input DC voltage = 680 V**

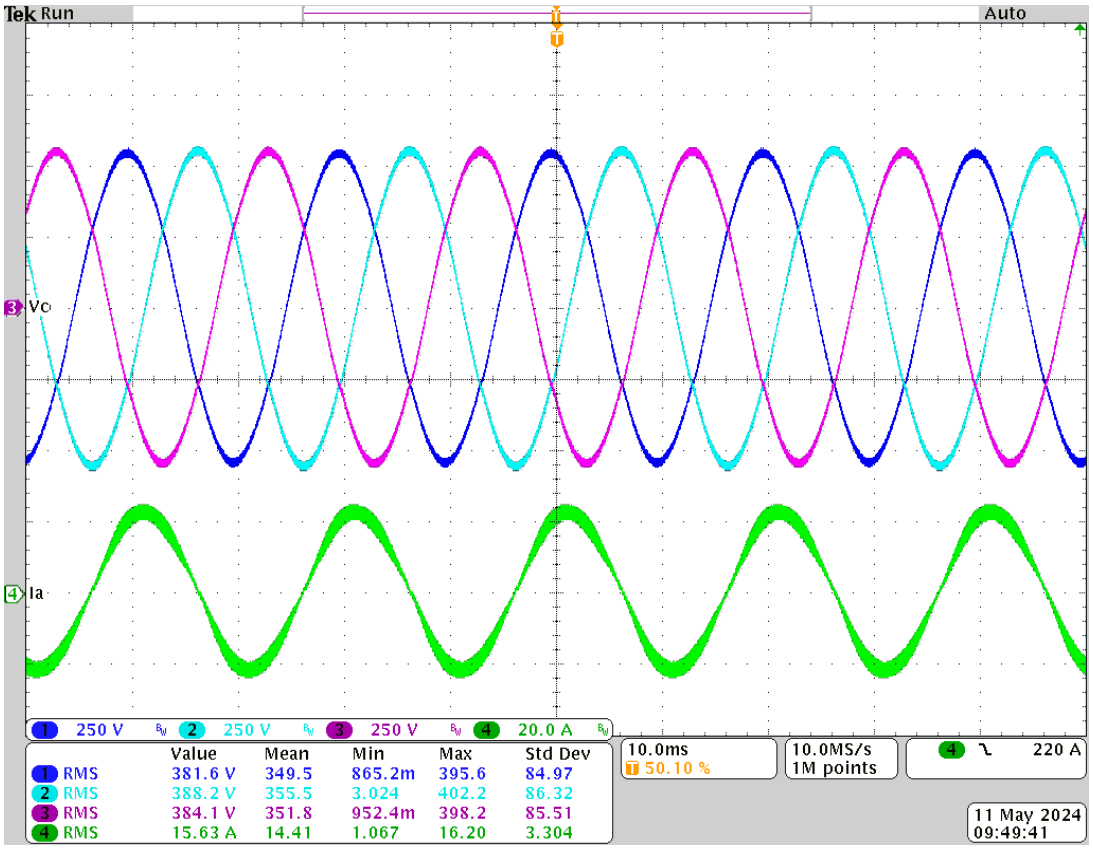

Figure 41 **Input DC voltage = 750 V**

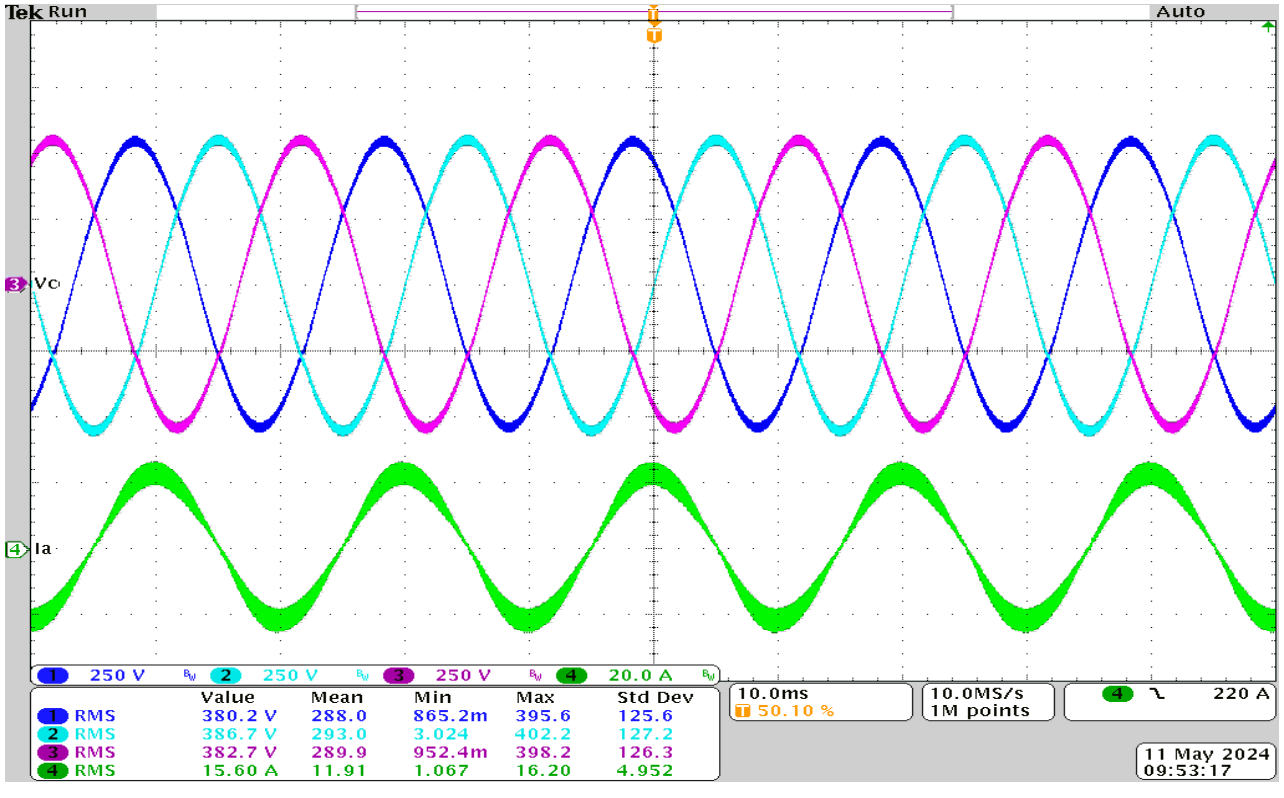

Figure 42 **Input DC voltage = 850 V**

3.4.3 Auxiliary power supply output voltage against input DC-link voltage variation

Condition: A 24V power supply is connected externally, the 24V, 5V and 3.3V rails are then observed.

Table 10 Auxiliary power supply measurements

DC BUS (V)	3.3V (V)	5V (V)	24V (V)
680	3.310	4.90	24.20
750	3.310	4.90	24.20
850	3.310	4.90	24.20

3.4.4 Over current protection

The output current is increased until the over current protection reacts. OCD trips when the peak current is 39.6A.

Legend: CH1: $I_{out\text{-}ph\ a}$, CH2: $I_{out\text{-}ph\ b}$, CH3: $I_{out\text{-}ph\ c}$, CH4: GK

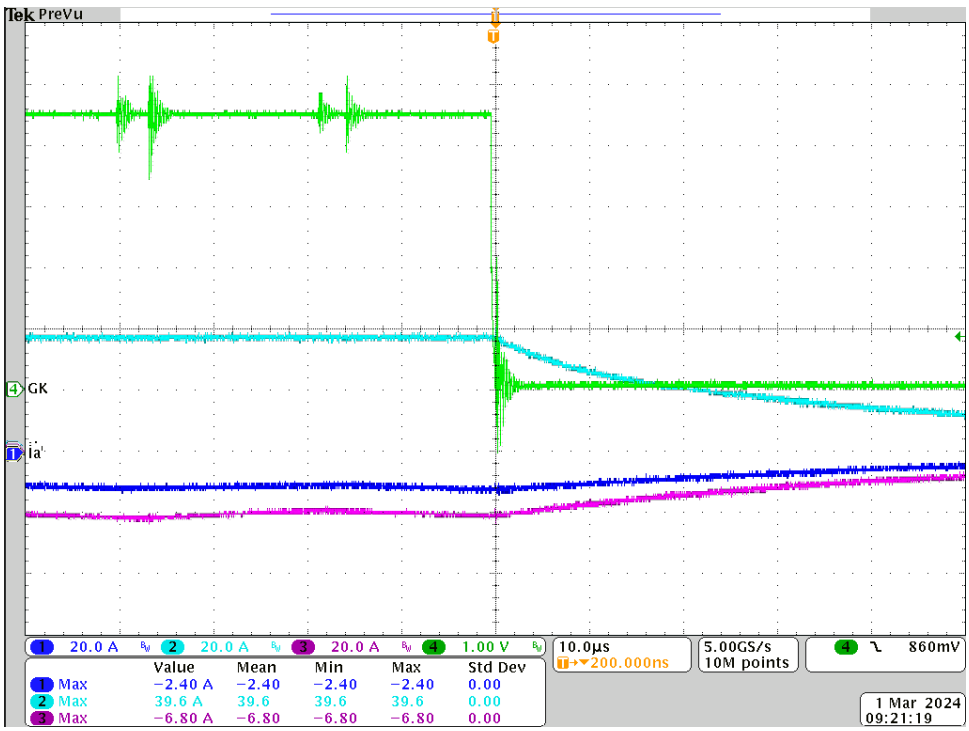

Figure 43 **Over current protection**

3.4.5 Efficiency measurement

Table 1 Power semiconductors efficiency measurement

Specification	Efficiency measurement using Zimmer LMG 670 power analyzer
Condition	M=0.9, V_{phase}=220 V, Loading = 10,20,30,50,75 and 100% Measurements are taken before the LCL filter board (Power semiconductor losses)

Operation	**Efficiency**
10% load	97.8%
20% load	98.3%
30% load	98.4%
50% load	98.5%
75% load	98.5%
100% load	98.4%

4 Board layout

4.1 REF-10KW3LNPC2

Table 2 **Mechanical data**

Dimensions	260mm x 360mm
No. of layers	4
Copper thickness	140 µm
Weight	8.5 kg

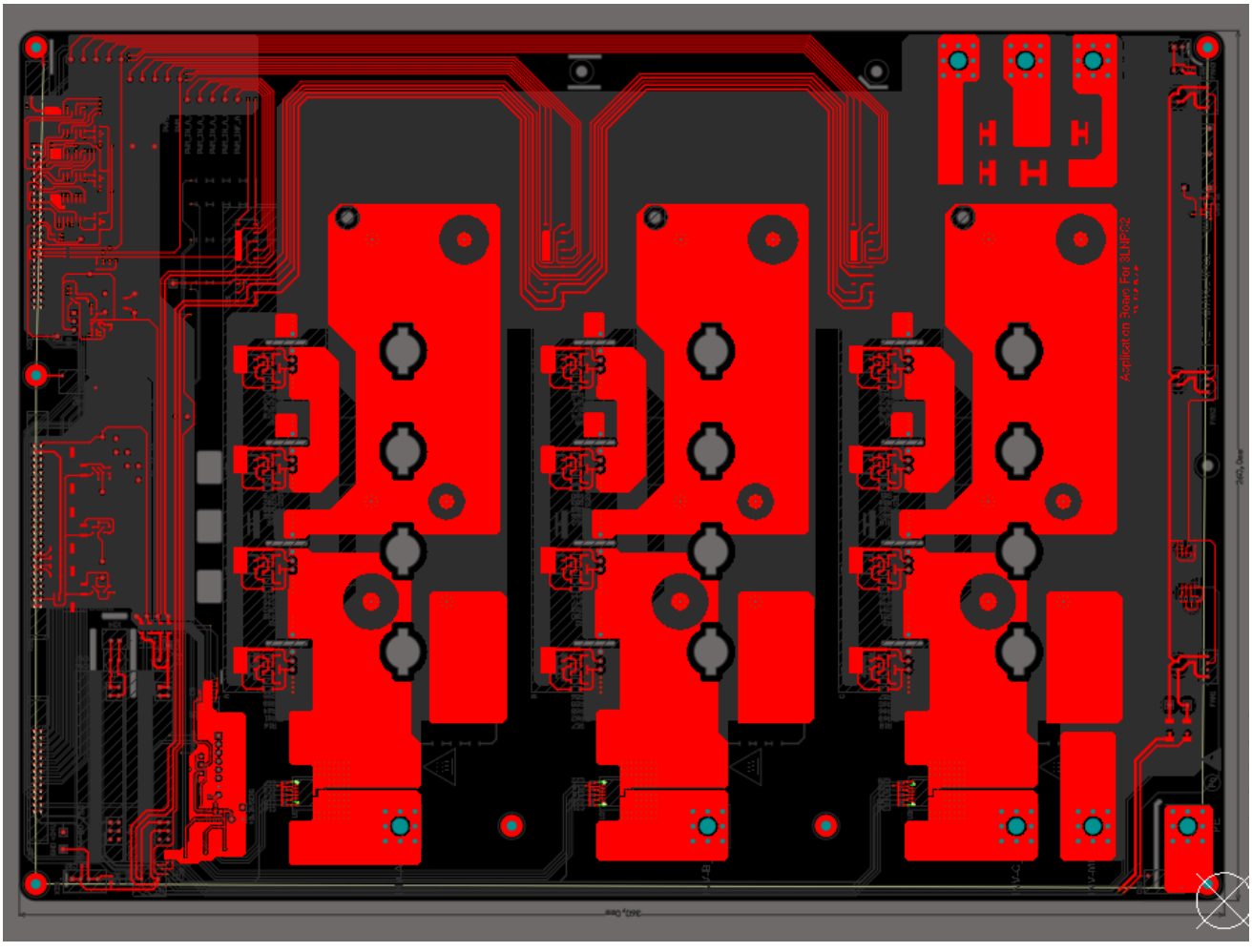

Figure 44 **Layer 1**

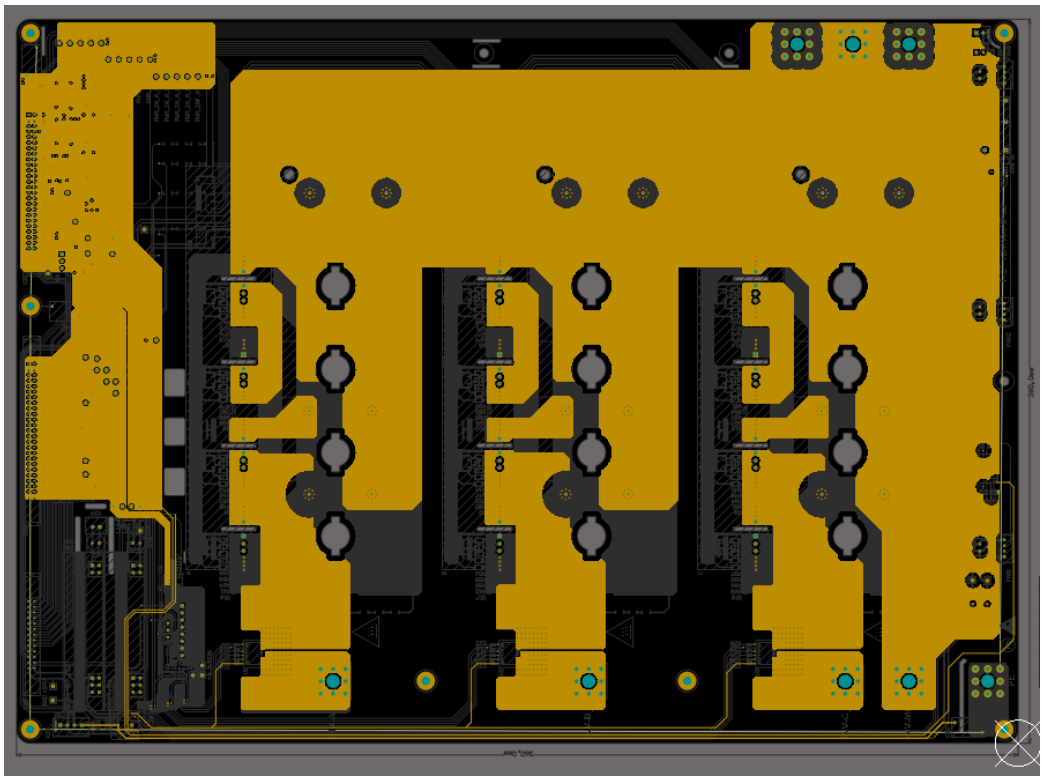

Figure 45 **Layer 2**

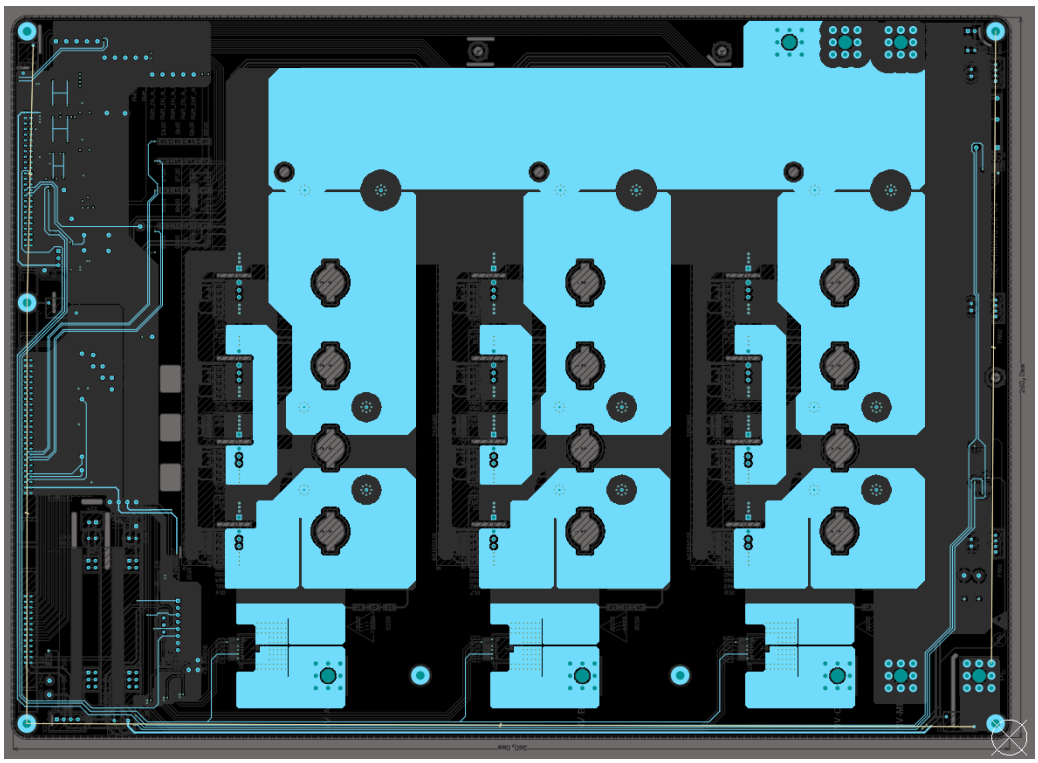

Figure 46 **Layer 3**

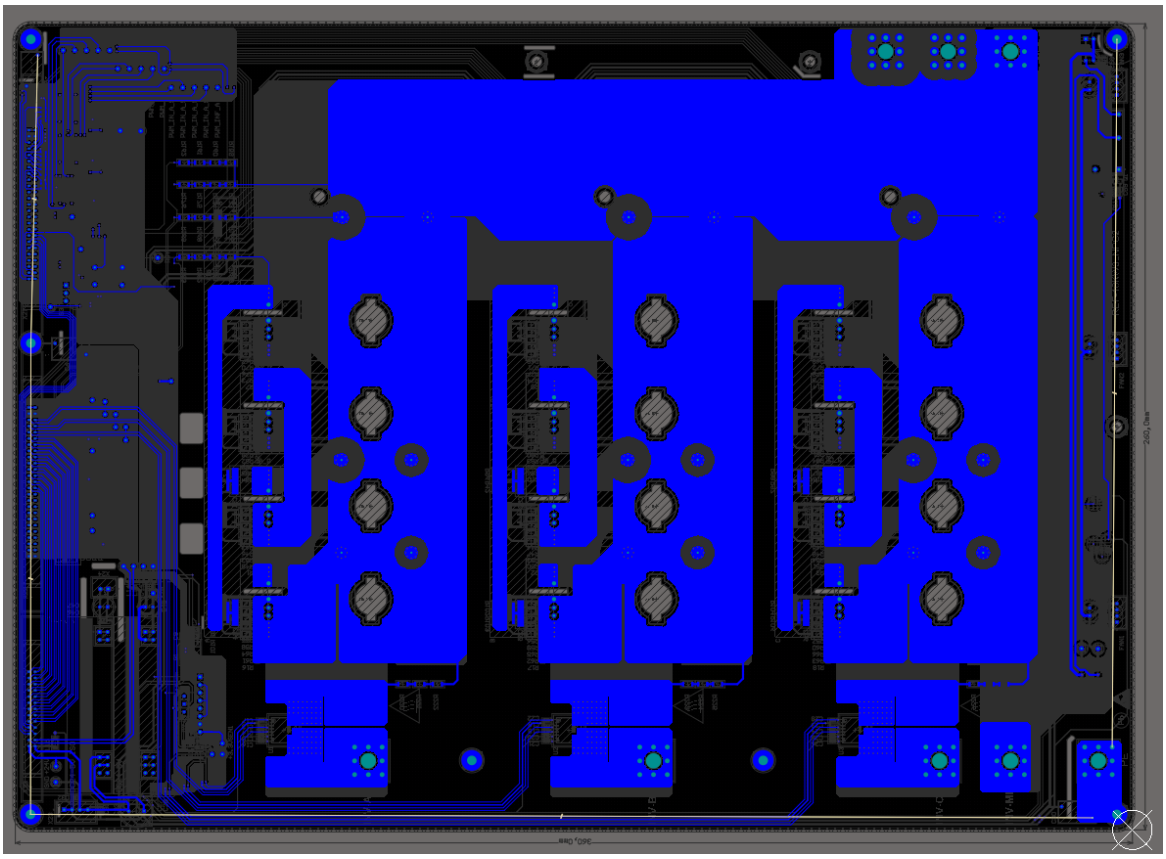

Figure 47 **Layer 4**

4.2 ISODRV-3240C4P15N05-1

Table 3 **Mechanical data**

Dimensions	145mm x 40mm
No. of layers	2
Copper thickness	35 µm

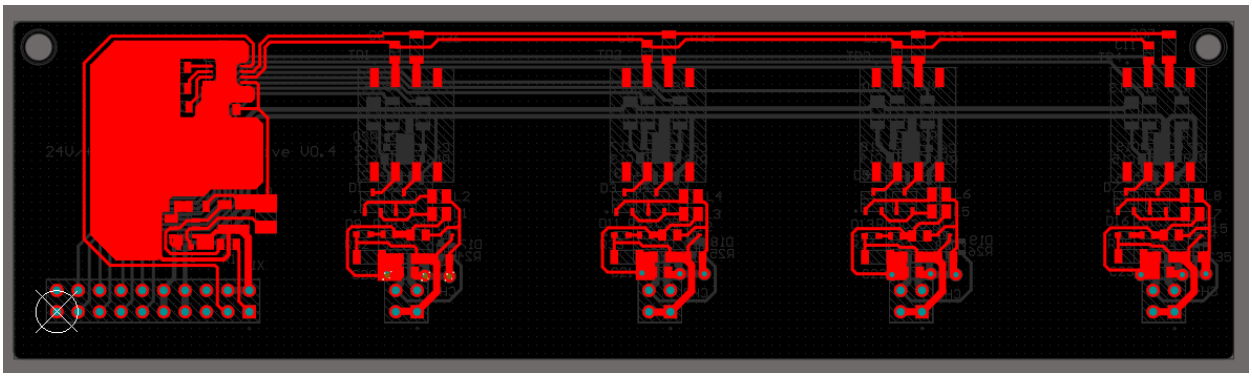

Figure 48 **Layer 1**

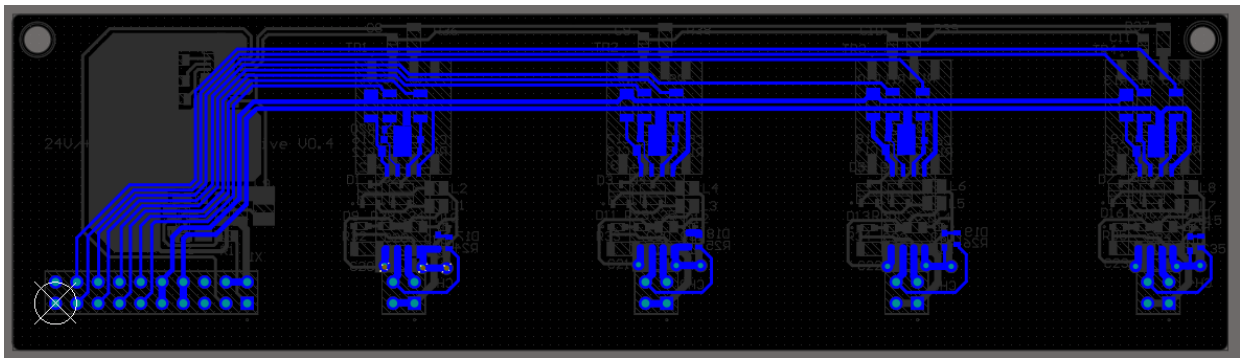

Figure 49 **Layer 2**

4.3 PB-APS-24V-5V ISO

Table 4 **Mechanical data**

Dimensions	57.1mm x 27.1mm
No. of layers	8
Copper thickness	105 µm

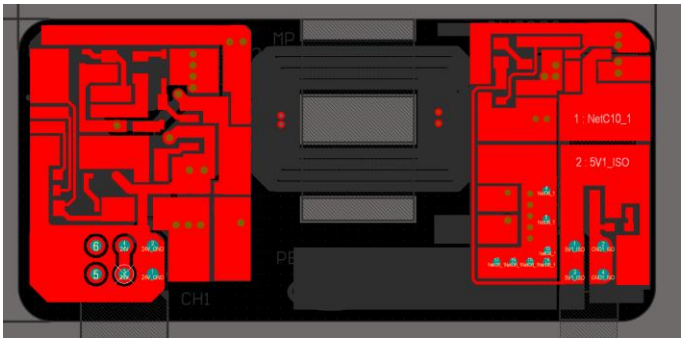

Figure 50 **Layer 1**

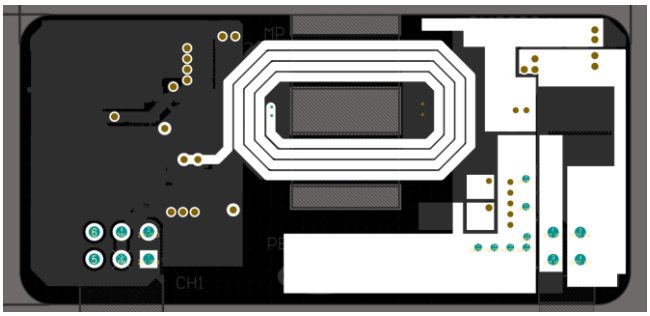

Figure 51 **Layer 2**

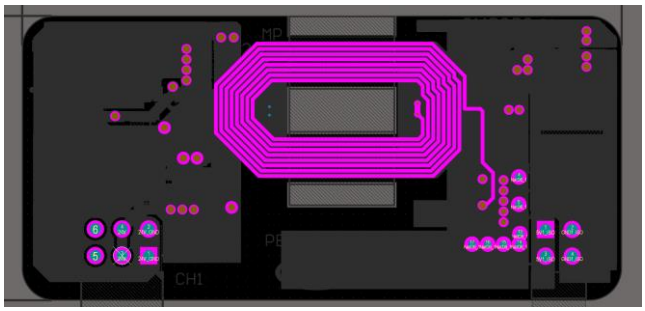

Figure 52 **Layer 3**

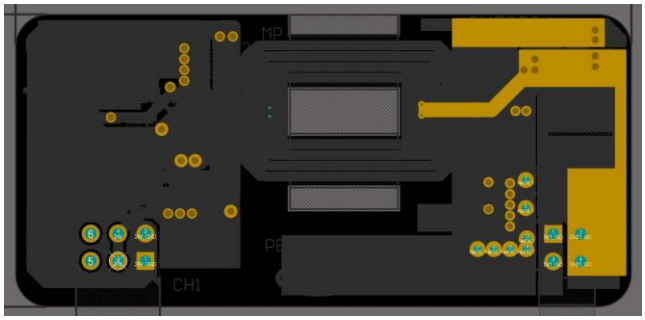

Figure 53 **Layer 4**

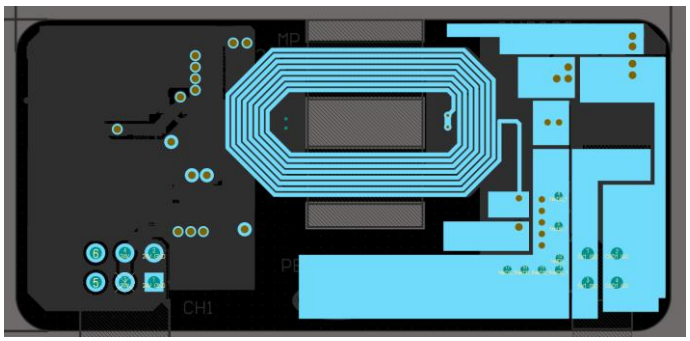

Figure 54 **Layer 5**

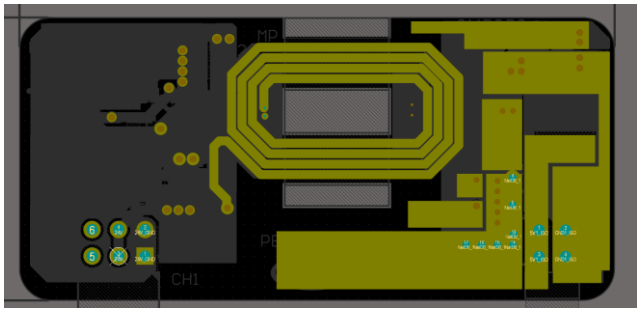

Figure 55 **Layer 6**

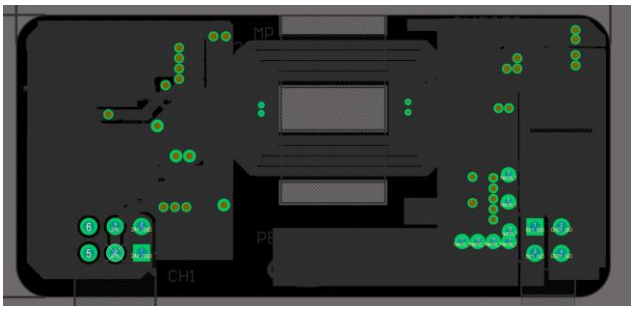

Figure 56 **Layer 7**

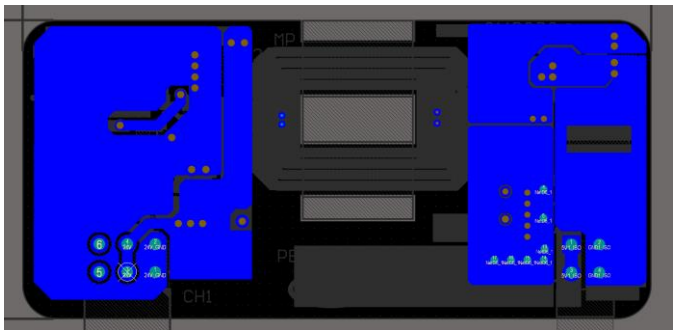

Figure 57 **Layer 8**

4.4 REF-10KW3LNPC2-Filter

Table 5 **Mechanical data**

Dimensions	260mm x 200mm
No. of layers	2
Copper thickness	70 µm
Weight	3 kg

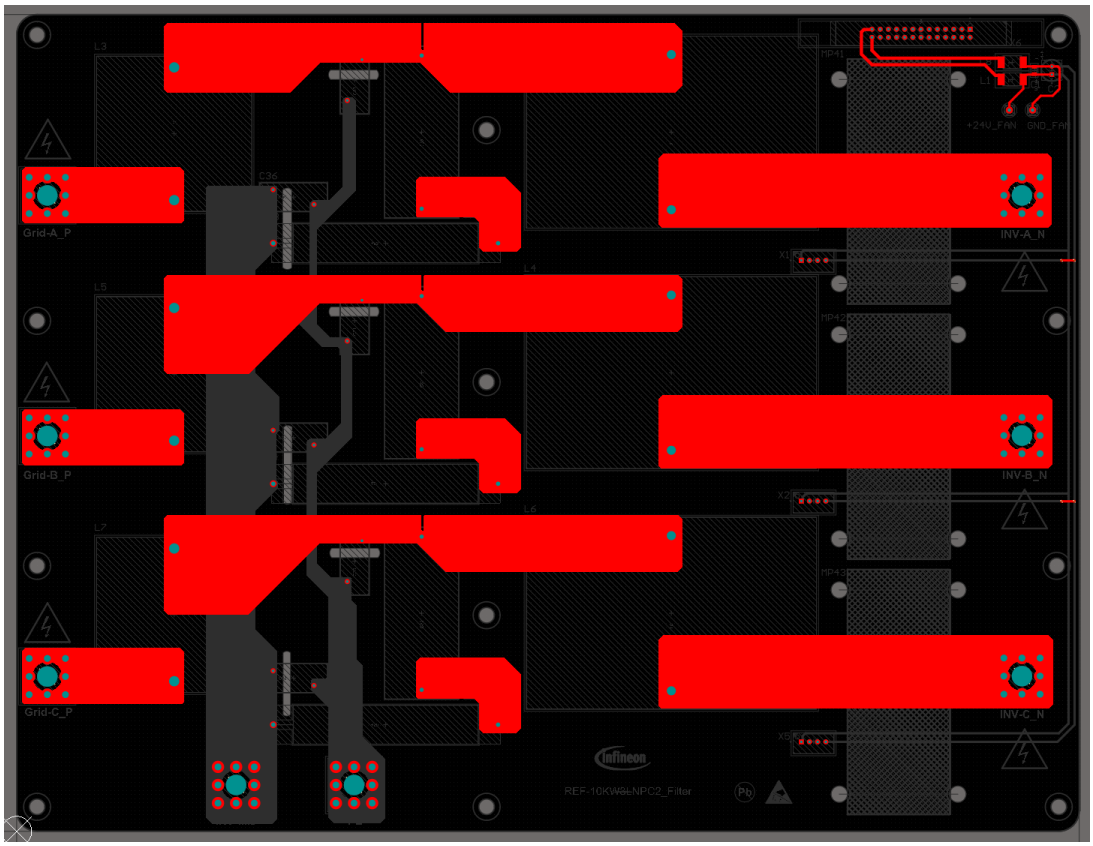

Figure 58 **Layer 1**

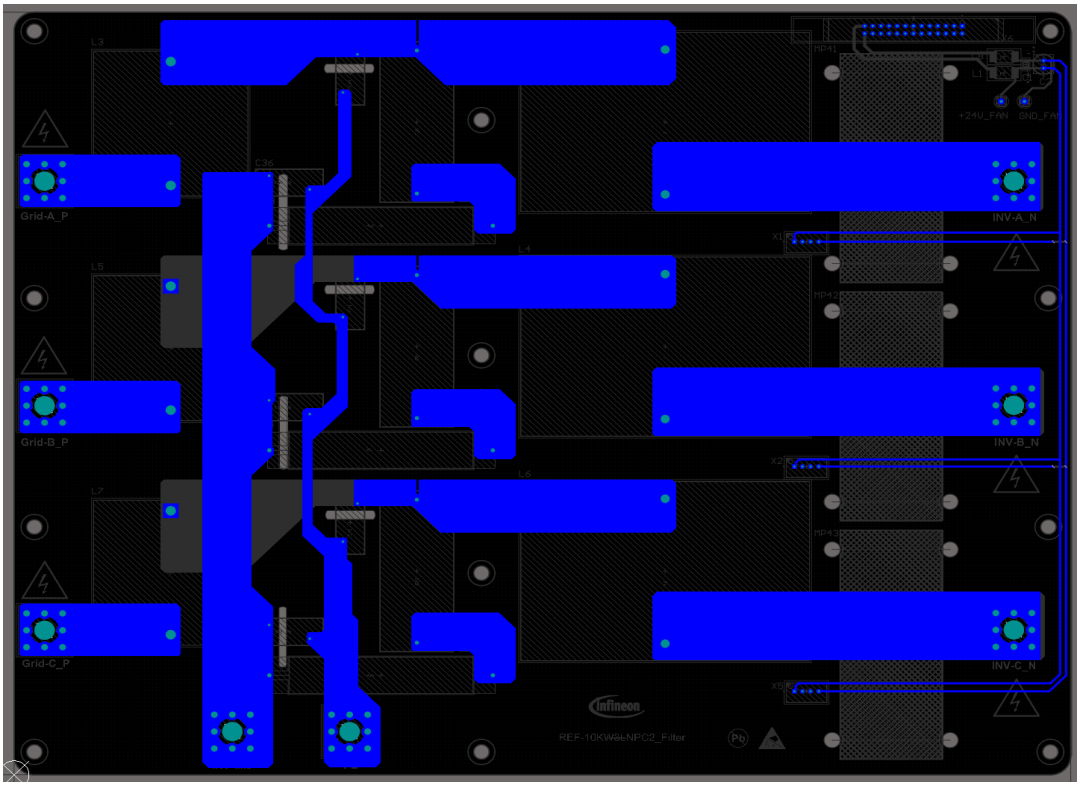

Figure 59 **Layer 2**

4.5 PB-CAPTANK-1.1KV

Table 6 **Mechanical data**

Dimensions	280mm x 170mm
No. of layers	4
Copper thickness	35 µm
Weight	1.7 kg

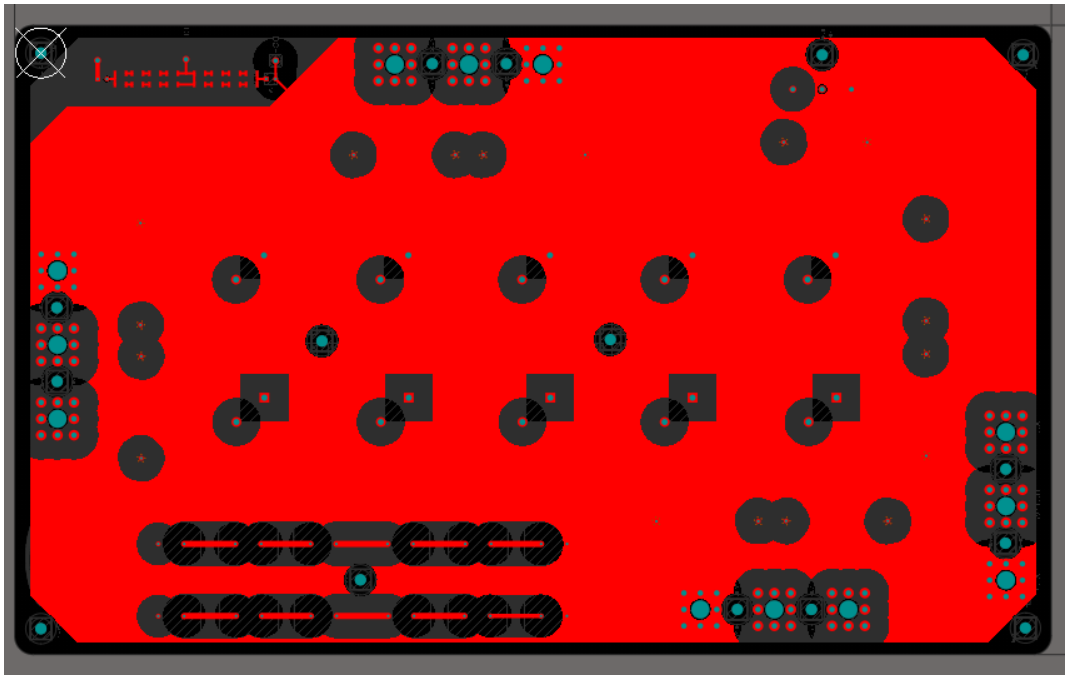

Figure 60 **Layer 1**

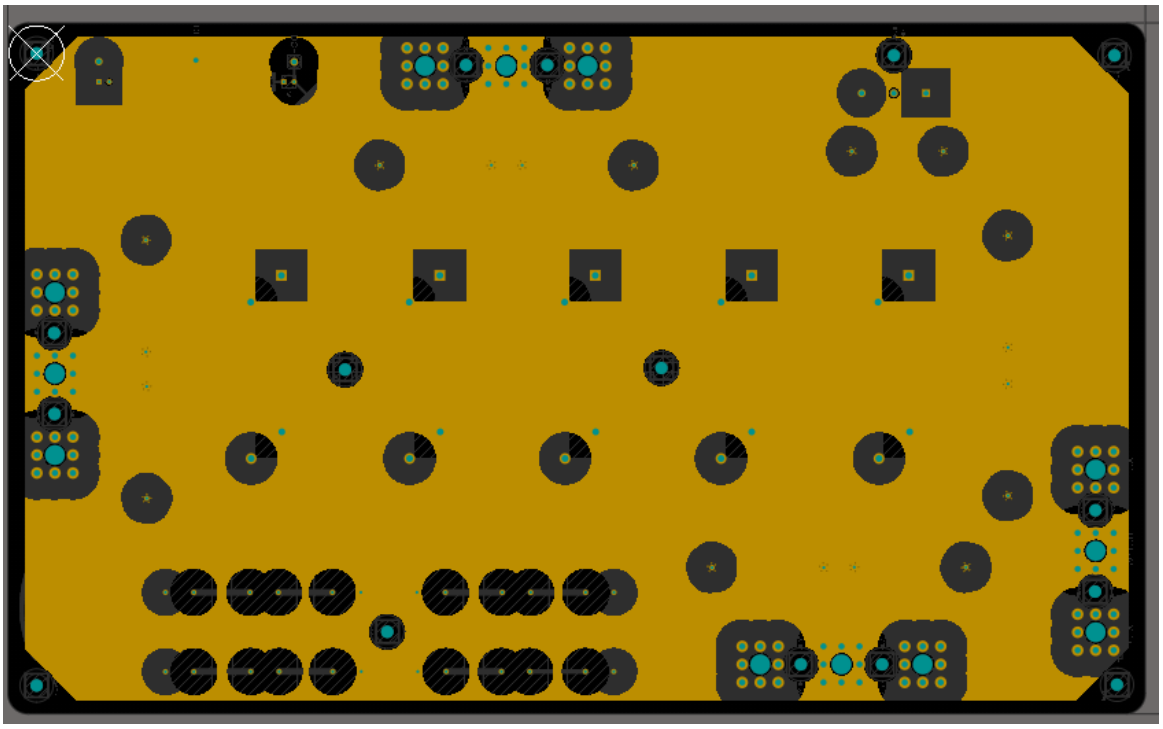

Figure 61 **Layer 2**

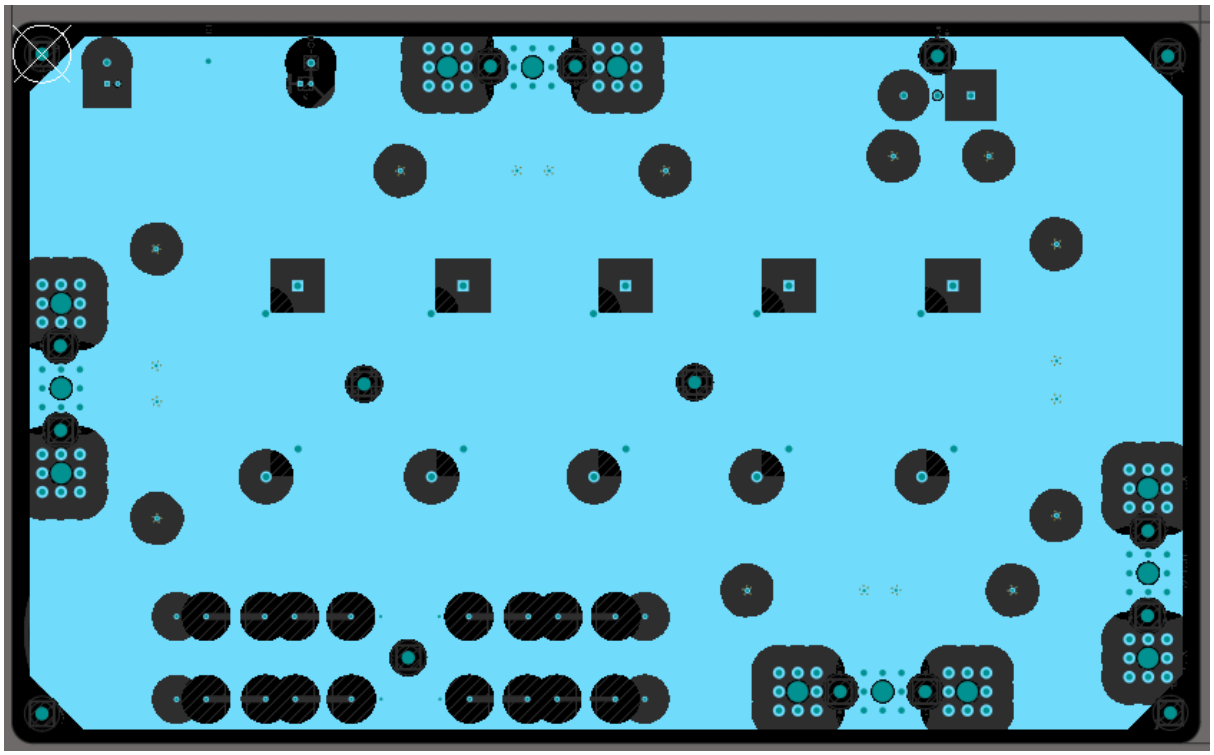

Figure 62 **Layer 3**

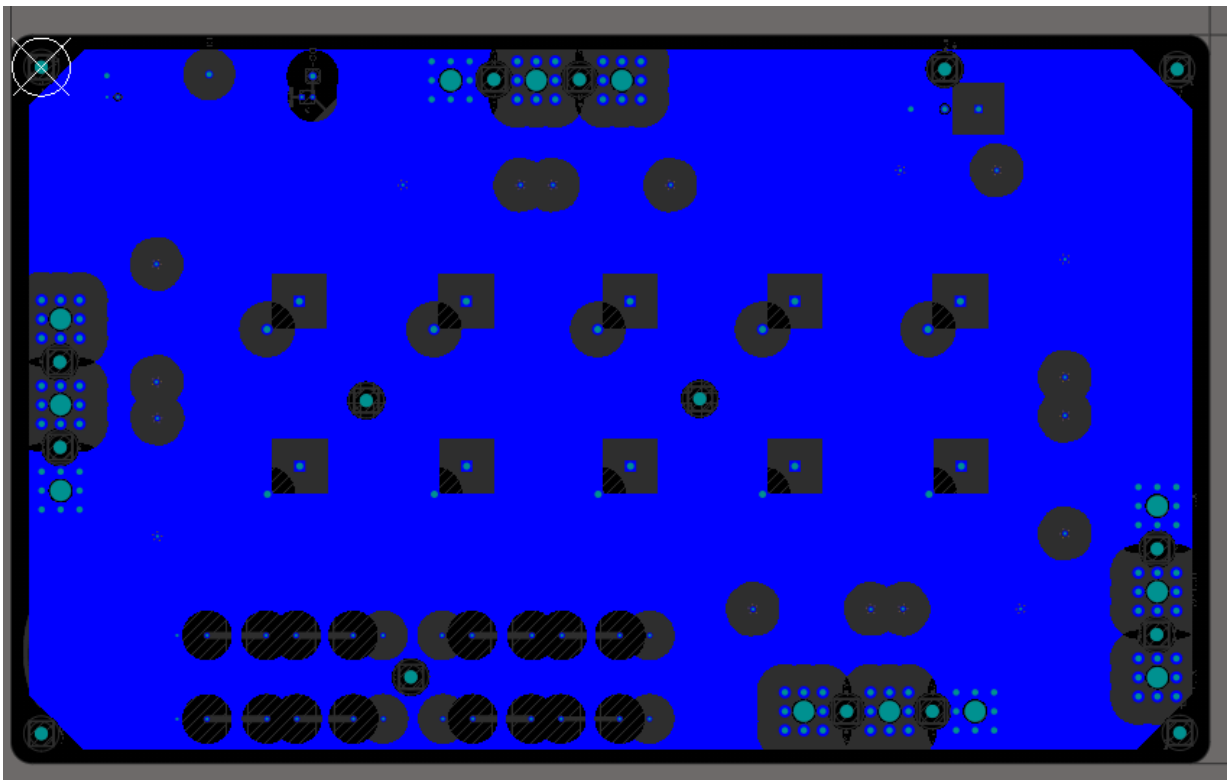

Figure 63 **Layer 4**

5 Bill of key materials

Table 7 **BoM**

Part	Description
IKZA40N120CH7	1200 V, 40 A IGBT with anti-parallel diode in TO-247-4 package
IKZA40N65EH7	650 V, 40 A IGBT with anti-parallel diode in TO247-4 package
1ED3240MC12H	10 A, 5.7 kV (rms) single-channel isolated gate driver with two-level slew-rate control, UL 1577 & VDE 0884-11 certified
TLI4971-A120T5-U-E0001	High precision coreless current sensor for industrial applications
2EP130R	Full bridge transformer driver
IRS27952	Half Bridge High Voltage Controller IC
IRF7351	60V Dual N-Channel HEXFET Power MOSFET in a SO-8 package
TLE42744GS V33	3.3V LDO

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Document version	Date of release	Description of changes
V.1.0	2024-08-07	Initial release

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