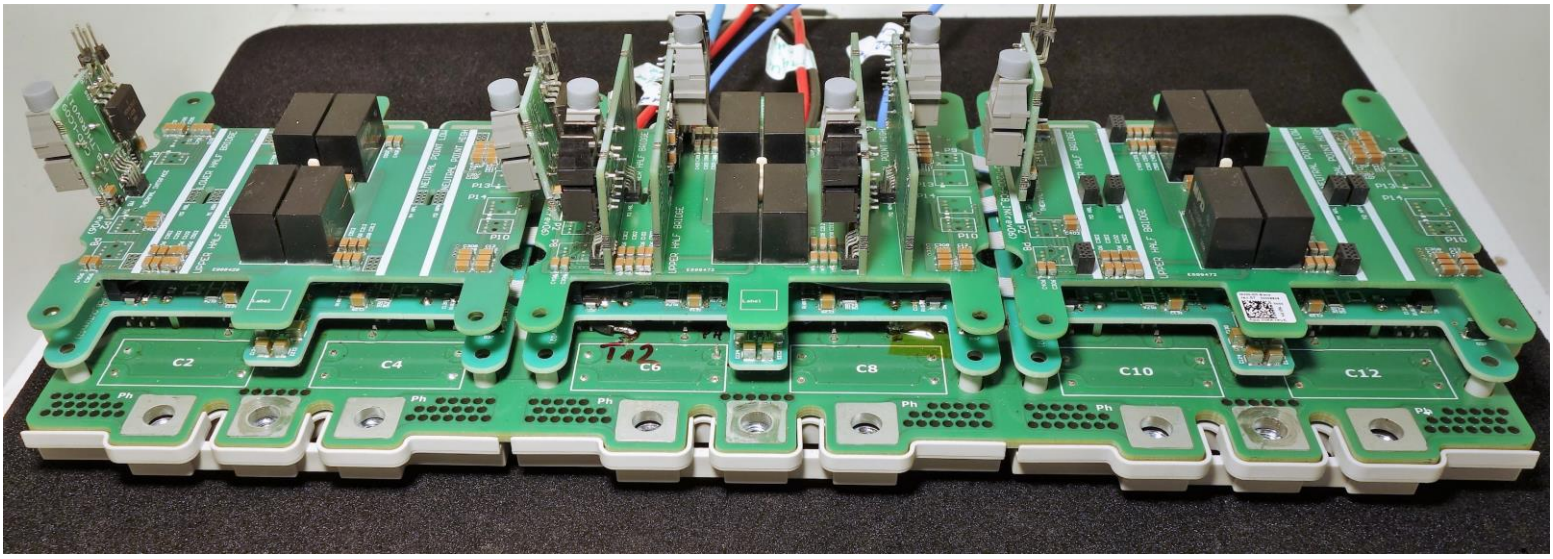
Vincotech

AN for VINcoMNPC X12 (LC09FP70)

How to drive it using the GD-LC00FP70 Vincotech gate driver



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Revision History

Date	Revision Level	Description	Page Number(s)
2018.10.31.	1	First release	36

1 Abstract

This application note describes the gate driver for 70-W612NMA1K8M702-LC09FP70 Vincotech three-level module. The AN will give a short description of the power module and a definition of the suitable Vincotech gate driver for this 1200 V /1800 A MNPC (T-Type) power module.

2 Introduction

The 70-W612NMA1K8M702-LC09FP70 is a new member of the Vincotech MNPC power modules family VINcoMNPC X12 with increased power range. It's a new entrant featuring the VINco X12 housing and a fresh member in the MNPC topology. The IGBT M7 1200 V, IGBT M7 600 V, diode M7 1200 V and diode M7 650 V offer a perfect match for the VINcoMNPC X12 family. The new chip generation offers lower V_{CEsat} which results lower static losses that are significant in this application. With its power range 1200 V/1800 A targets the Solar PV Central Inverter market. To learn more about Vincotech power modules, please visit: www.vincotech.com

3 The power module.

70-W612NMA1K8M702-LC09FP70 (LC09FP70 for short) is the latest high efficient MNPC topology in VINco X12 housing to meet the challenging requirements for central inverters, while retaining the string inverter's speed and flexibility. The power module is designed considering a low inductive layout. It also has DC snubber capacitors built-in.

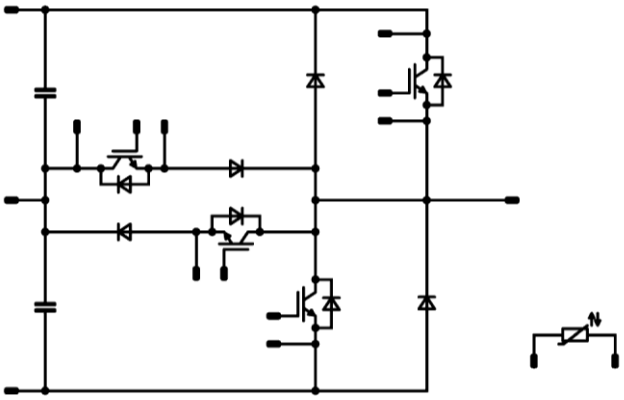


Figure 1: The simplified schematic of the power module

The IGBT M7 and diodes M7 are the perfect match for the VINcoMNPC X12 family. M7 dies are up to 25% smaller than those used in the current VINcoMNPC X12 for the same current rating, so the nominal current may be stepped up from 1200 A to 1800 A. On top of that, conduction losses are up to 20% lower.

Module main features:

- Optimized connections for three-level topologies
- Low internal inductance (2 nH) enables higher frequencies
- Fully symmetrical layouts for uniform current sharing
- Modular constructions for better thermal performance

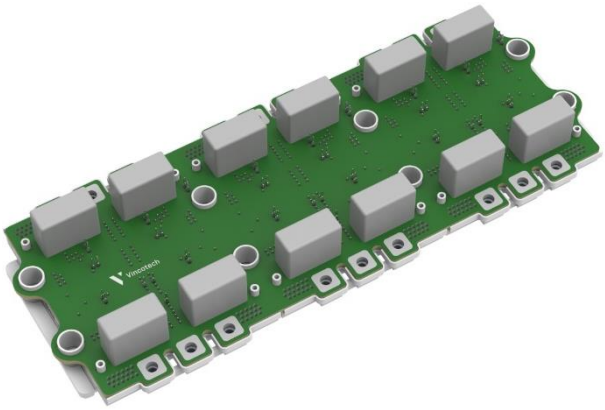


Figure 2: LC09FP70 in a VINco X12 housing

3.1 Mechanical dimensions, housing

The housing of the LC09FP70 is VINco X12, which can be seen at **figure 3** with its main dimensions. This new housing from power point of view is a triplication of VINco X4 joined together with a common PCB. The input screw connections **DC+**, **GND**, **DC-**, the output screw connections **Ph** are connected together by the power PCB (figure 5), but externally they must be connected together, with a special attention paid for a symmetrical connection to achieve a balanced current sharing.

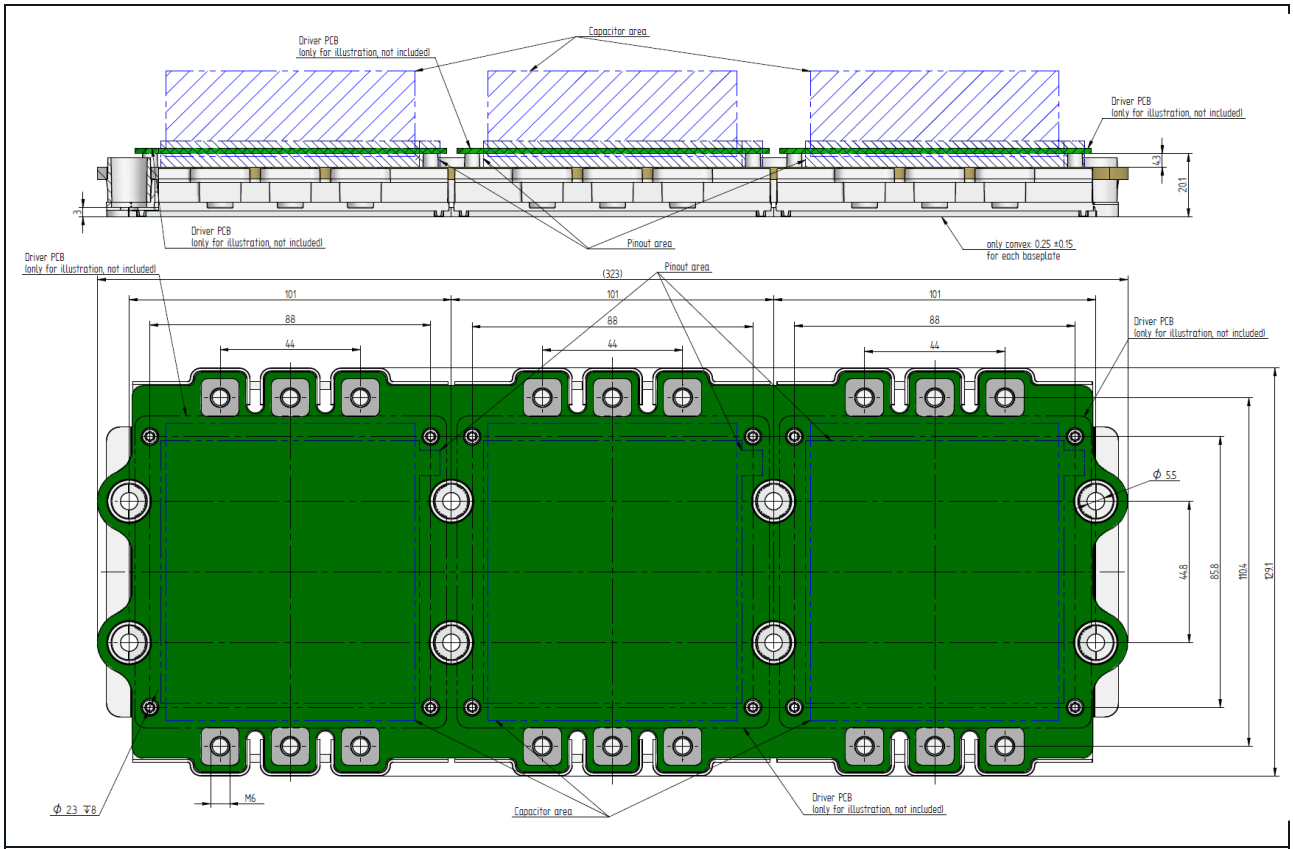
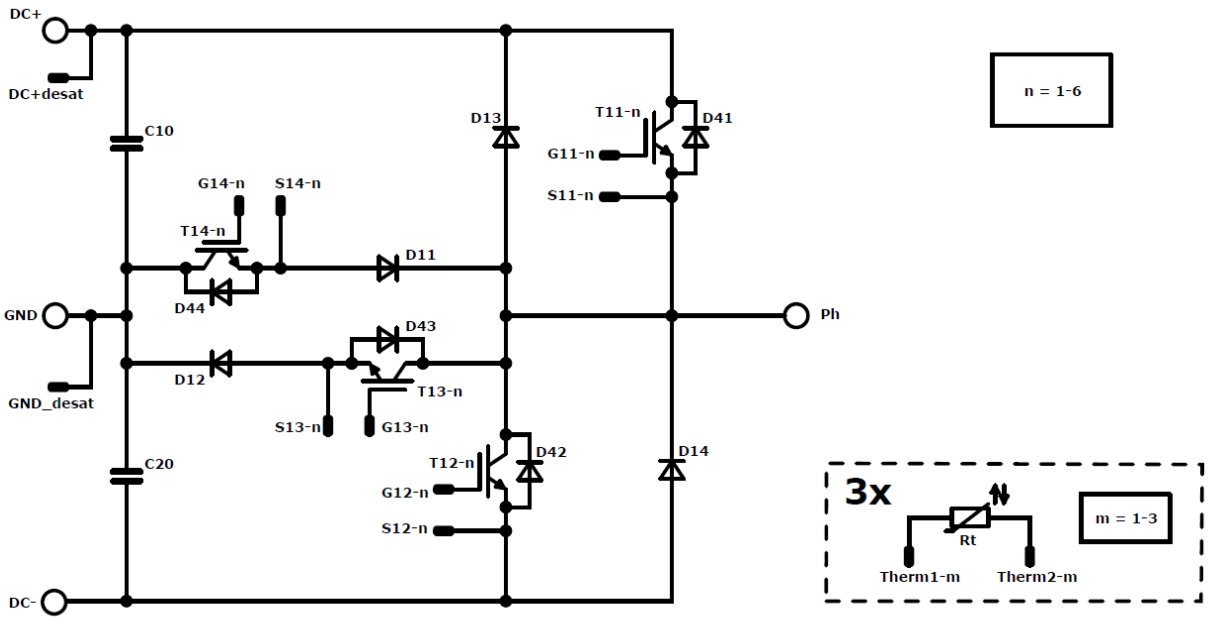


Figure 3: VINco X12

3.2 **Schematic**

The VINcoMNPC X12 is an MNPC topology realized with a triplication of VINcoMNPC X4 in parallel connection. The parallel connection is made by the high power pressed in power PCB, which gives the low stray inductance interconnection. The driver pins are not paralleled by the high power PCB, this one must be made externally by the gate drivers; for more details please refer to the next chapters. The schematic at topology level is shown at **figure 4. Table 1** shows the basic function of each component and their voltage/current ratings.

Figure 5 describes the parallel connection and the pin assignment of the three MNPC cells.



NOTE: Driver pins for parallel devices are not connected inside the module!

Figure 4: Schematic of the topology

ID	Component	Voltage	Current	Function
T11, T12	IGBT (M7)	1200 V	1800A	Buck IGBT
D11, D12	FWD (M7)	650 V	1800A	Buck Diode
T13, T14	IGBT (M7)	650 V	1800A	Boost IGBT
D13, D14	FWD (M7)	1200 V	1800A	Boost Diode
D41,D42,	FWD	1200 V	90A	Buck IGBT Protection Diode
D43,D44	FWD	650 V	120A	Boost IGBT Protection Diode

Table 1: Components , function , voltage /current rating

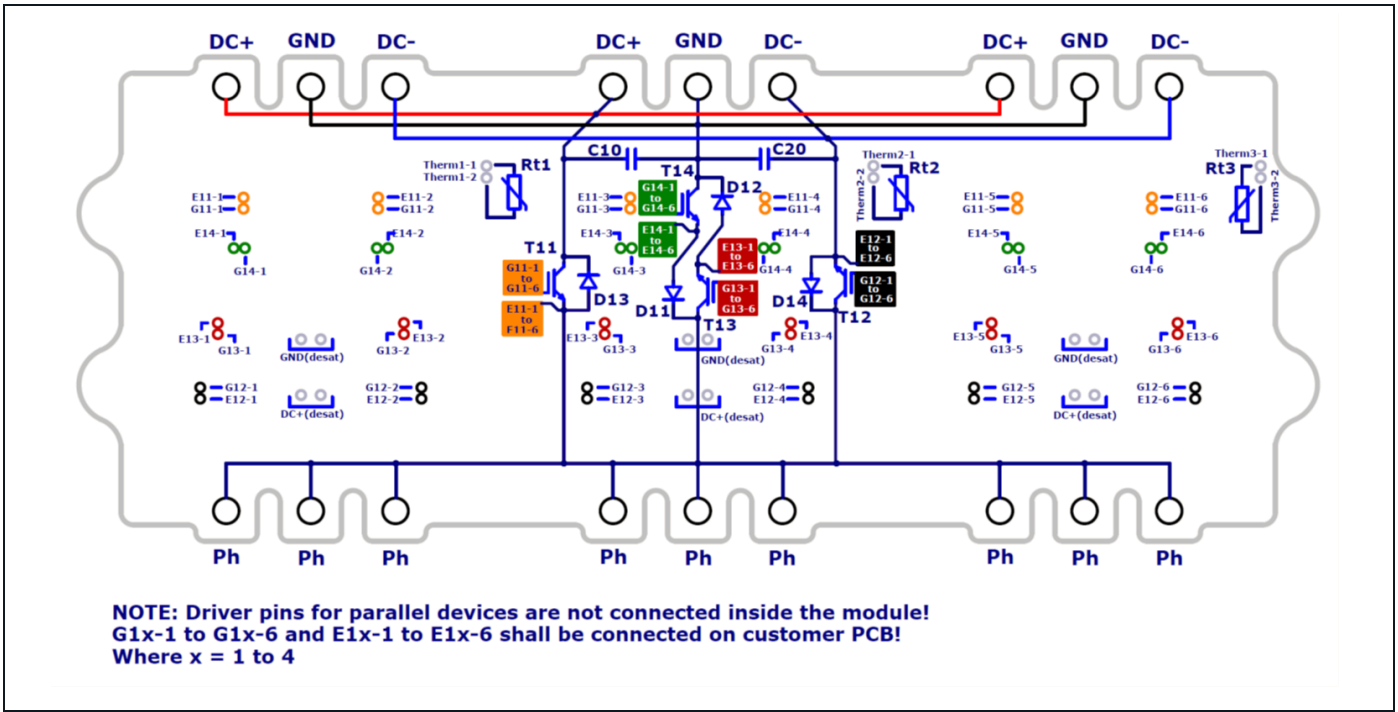


Figure 5: Parallel connection of the 3 MNPC cells

4 The gate driver of VINcoMNPC X12 (LC09FP70)

The gate driver of VINcoMNPC X12 (LC09FP70) is based on VINcoMNPC X4 (M200) gate driver. VINcoMNPC X12 contains three VINcoMNPC X4 modules connected in parallel. This structure follows the gate driver design as well. The paralleling of the gate drivers is made in a slave-master-slave configuration. The master gate driver is fully populated with control cards, one control for each channel, while the slave gate driver doesn't include any control cards. The slave gate driver receives the gate signal via the interconnection cables. The static and dynamic current sharing between the three VINcoMNPC X4 modules will be guaranteed by module design and gate driver design.

4.1 Signal distribution at S-M-S gate drivers

In order to drive an LC09FP70 power module a SLAVE-MASTER-SLAVE (S-M-S) gate driver configuration will be used. The input PWM signals are received by the CTR cards of the MASTER gate driver. INPUT PWM signals are received via fiber optics or 5V electrical signals, the FAULT signals transition in opposite direction is made in a similar way with fiber optics of electrical signals. Figure 6 shows the block diagram of electrical interconnection of the slave-master-slave gate drivers. The current booster PCB has two current boost stages that are connected in parallel to provide a high gate current when necessary. Each VINcoMNPC X4 module has two gate pins, each for half of the nominal module current. A common gate resistor and separated gate resistors

are used for the gates as well, furthermore a common emitter resistor. This way the synchronous switching of the stages can be assured.

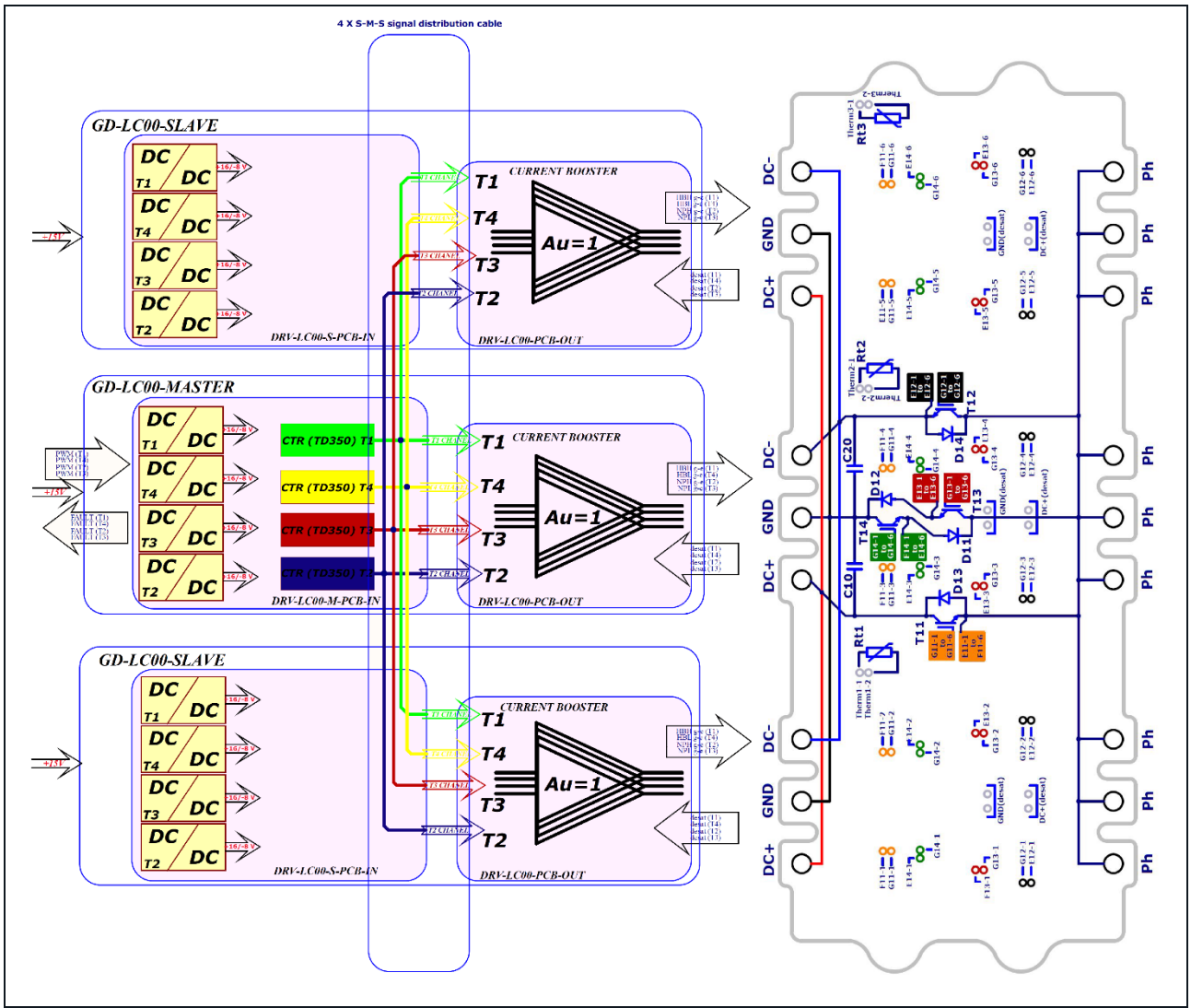


Figure 6: Signal distribution at S-M-S

At figure 7 the parallel connection of the current boosters for one channel is illustrated.

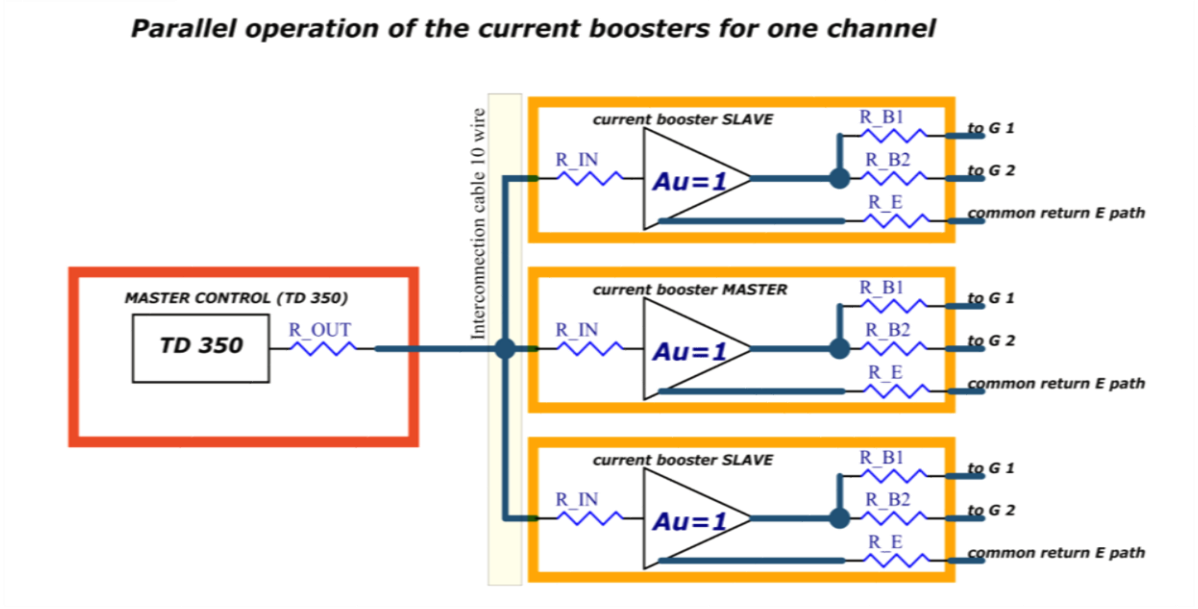


Figure 7: Parallel connection of the current booster

4.2 **Mechanical assembly of the gate drivers**

LC09FP70 gate driver assembled to the VINcoMNPC X12 (LC09FP70) power module is shown at figure 8. The interconnection between the module and gate driver is made with driver pins which are not connected to the power PCB. These pins are the G-E pins and desaturation detection pin.

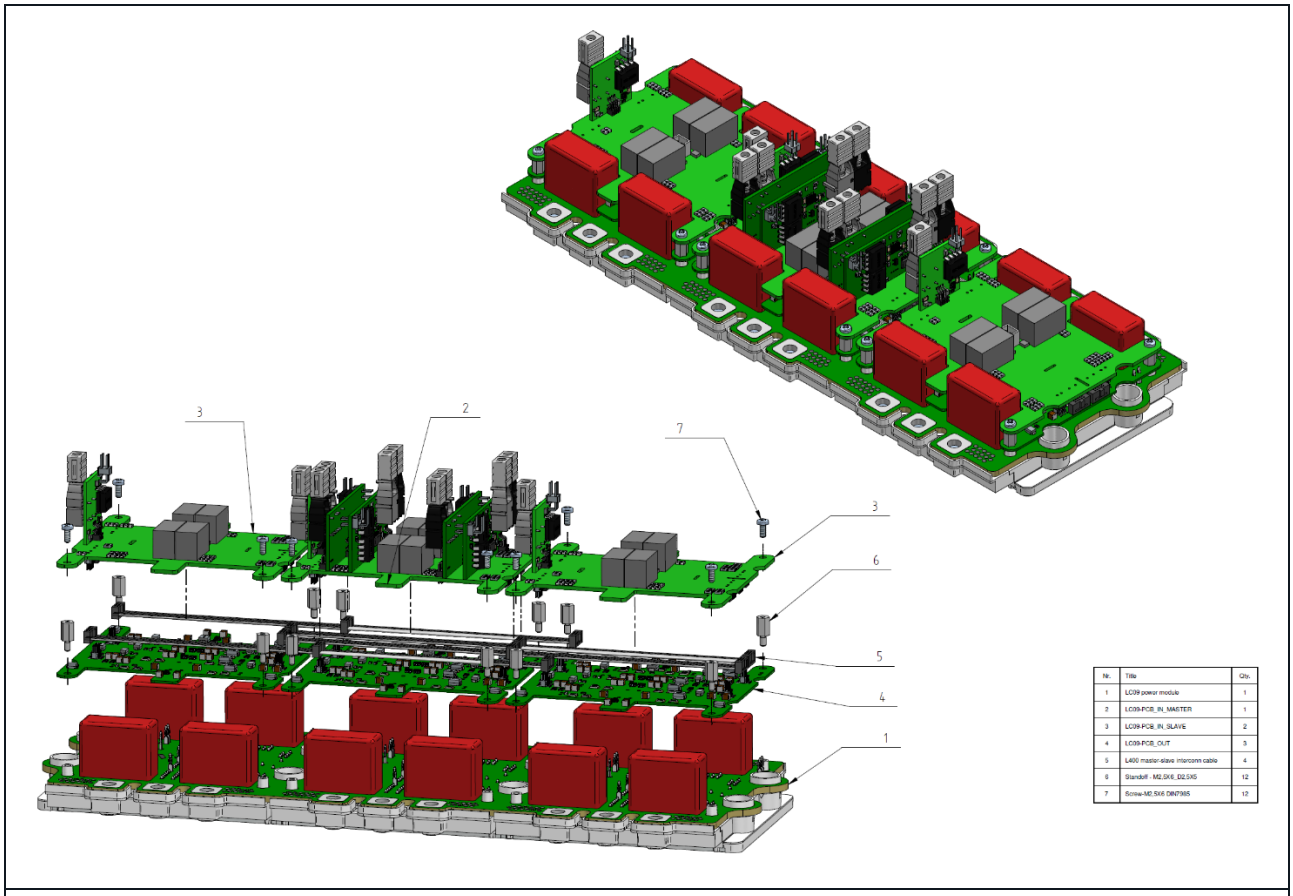


Figure 8: LC09FP70 with S-M-S gate driver

Interconnection of the gate drivers from bottom view:

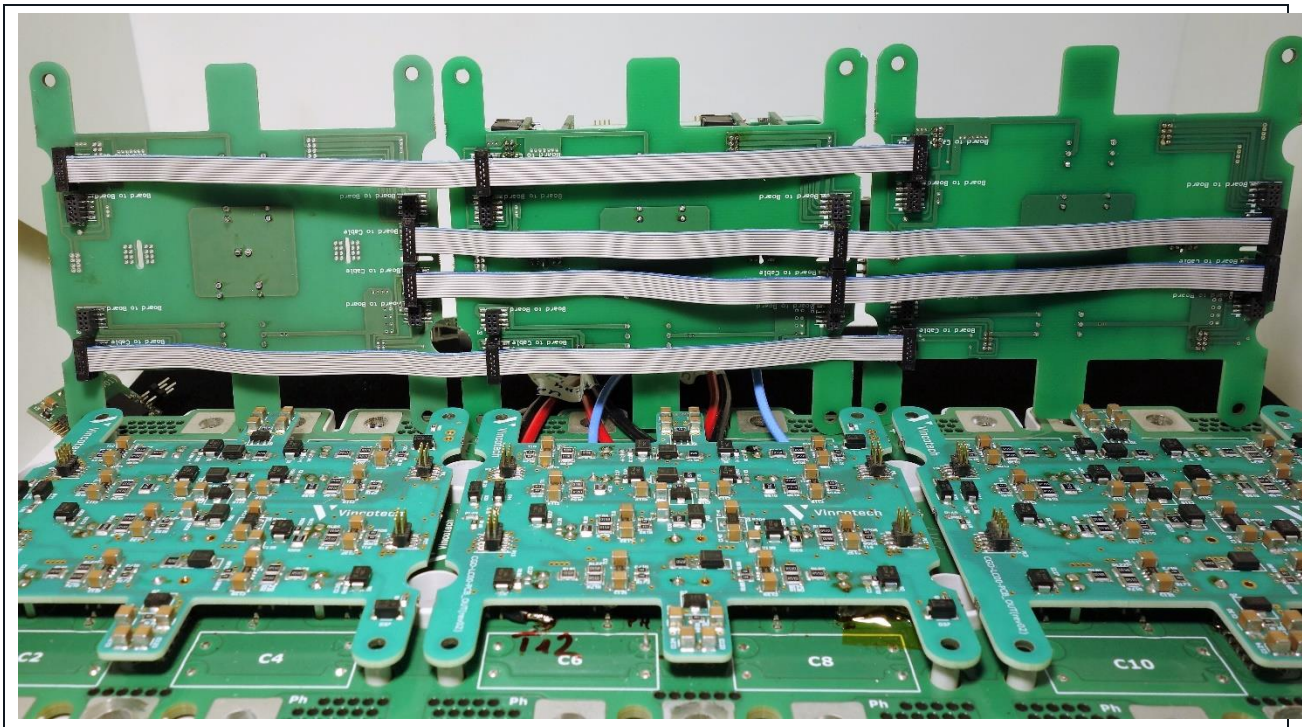


Figure 9: S-M-S interconnection at IN PCB level

4.3 Interconnection cable for S-M-S operation

Channels: HB H ; HB L ; NP H ; NP L					
Pin	Signal HB H	Signal NP H	Signal NP L	Signal HB L	Comment
1	desat	desat	desat	desat	Desaturation protection
2	+16 V	+16 V	+16 V	+16 V	Positive supply
3	out high	out high	out high	out high	Signal for turn on
4	out low	out low	out low	out low	Signal for turn off
5	-8 V	-8 V	-8 V	-8 V	Negative supply
6	V clamp	V clamp	V clamp	V clamp	Miller clamp
7	GND	GND	GND	GND	Ground
8	+5 V	+5 V	+5 V	+5 V	Supply for TH card

Table 2: Signals on Interconnection cables

The signal distribution between the MASTER and SLAVE-s is assured by 4 interconnection S-M-S cables, 10 wires each. Although the DC/DC converters are paralleled (16V, GND, -8V) - to assure if one DC/DC converter is fed, not only the supplied gate driver is functional, also the others are powered up as well - it is very important that gate drivers are externally supplied by +15V at P17 to avoid the overload of the DC/DC converters on IN-PCB card. All the signals between MASTER and SLAVE are connected in parallel, except the NTC signal – please refer to table 2. The NTC temperature is measured at VINco X4 level 3 sensors in total.

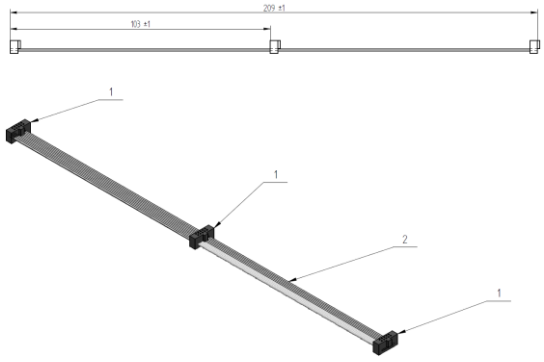


Figure 10: S-M-S interconnection cable

Figure 10 shows the 10 wired interconnection cable. The total length of the cable is 209+/-1 mm, with a symmetrical assembling of the connectors.

5 Features of Driver Board

5.1 Main Features

- Independent drivers for each switch (channel)
- Single 15 V power supply input with 3000VAC isolation
- Gate voltage of -8 V / +16 V
- DC/DC converter / VINcoMNPC X4 /channel
- Non-inverting PWM inputs
- Optical Fiber Input and Output signals
- Optional 5 V Input and Output signals
- Desaturation protection
- Two level turn-off with 11 V intermediate level
- Under voltage lockout
- Fault output signal for each switch
- Isolated PWM coded heatsink temperature sense with thermistor on each VINcoMNPC X4
- Gate drive current of ±20 A peak / VINcoMNPC X4 /channel
- Active Miller clamp
- PCB designed to fulfill the requirements of IEC61800-5-1, pollution degree 2, over voltage category III

5.2 **Electrical parameters**

	MIN	TYP	MAX	UNIT	Rem.
U_{CE} – max for IGBT/FWD			1200	V	
P_{max} – max output power supply			2	W	for each DC/DC converter
U_S – supply voltage for drivers	14,5	15	15,5	V	See note 1
I_S – Input current no load / full load		30/250		mA	for each DC/DC converter
Gate drive supply voltage positive	16,5	17	18	V	$14,5V<V_{in(DC/DC)}<15,5V$
Gate drive supply voltage negative	-7	-8,7	-10	V	$14,5V<V_{in(DC/DC)}<15,5V$
Under voltage lockout	14	14,5	15	V	UVLO top threshold
Under voltage lockout	13	14	14,5	V	UVLO bottom threshold
Desaturation protection		7		V	
f_{sw} – switching frequency		8	16	kHz	See note 2
T_a – Ambient temperature	-25		70	°C	
T_{ST} – Storage temperature	-40		85	°C	
Peak Wavelength of fiber optics R/T		660		nm	
Photosensitivity Spectral Range (S = 80% Smax)	600		780	nm	
Gate drive supply isolation voltage			3000	VAC	1 minutes See note 3

For additional information refer to the datasheet of TD350 from ST

Note 1: The secondary voltage for the gate drive will change with the same ratio.

Note 2: Limited by IGBT losses

Note 3: For conformance with IEC 62109-1 the input supply of the DC-DC converter (15V) should be connected to the inverter neutral potential

Table 3: Electrical parameters

5.3 Channel Assignment

Each IGBT has its own CTR (control card) and current booster stage.

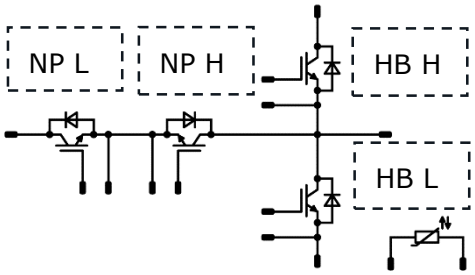


Figure 11: Channel Assignment at schematic level

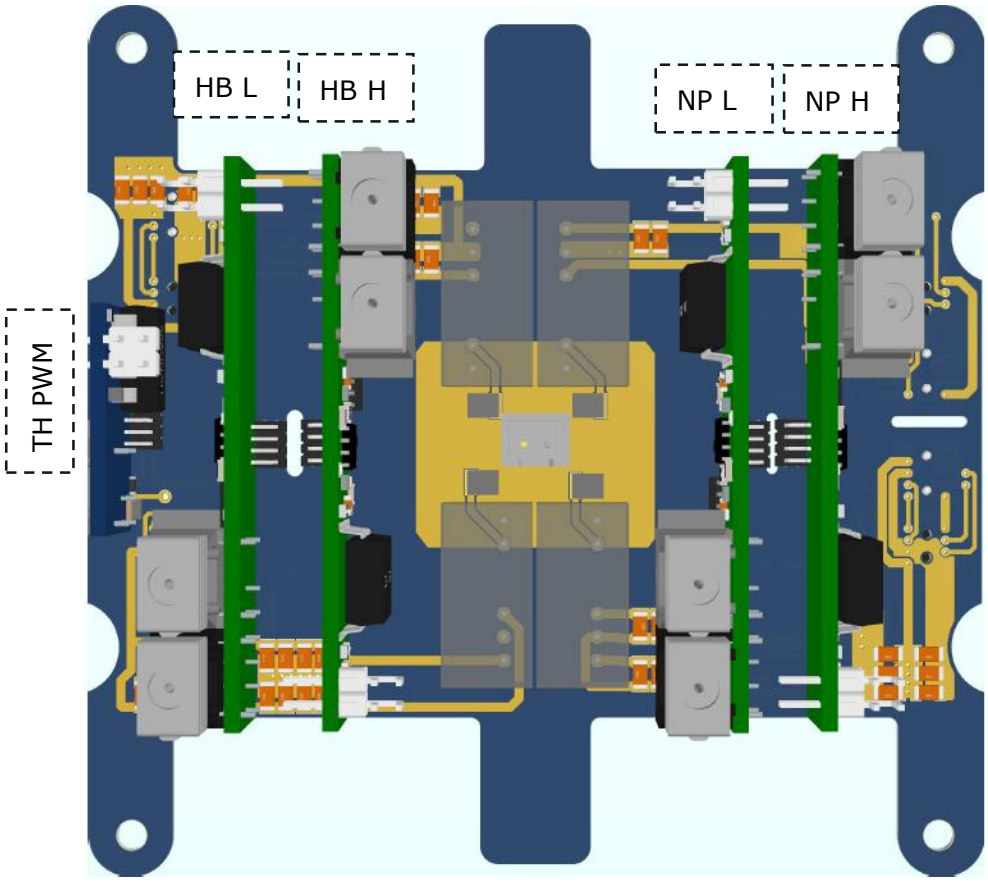


Figure 12: Channel Assignment on IN-PCB

The PWM signal has to be supplied for each CTR card, the FAULT signal of each channel is transmitted by each CTR card.

The PWM signal of the TH (thermal) card transmitted on polymer optical fiber 2,2mm diameter wavelength 650nm. There is also an electrical output with a 2 by 2 pin header connection. Thermal TH card converts the measured NTC value to PWM signal.

6 Description of Electrical Parts

This chapter describes the different electrical parts like input signals, output signals and driver circuits for a better understanding of the gate driver.

Note that there are two version of the gate driver. One equipped with fiber optic inputs and outputs the other with electrical connection. Please make sure to order the correct one.

6.1 Required power supplies

To ensure a correct operation of the evaluation kit one single +15 V power supply for all gate drivers. The +15 V has to be supported through the connector P17. The +15V at P17 has to be supplied at MASTER and SLAVE as well. If the PWM input, FAULT and temperature measurement output are implemented via optical fiber, no additional power supply is required for the CTR cards. In case of 5 V input and output signals all CTR and TH cards have to be supplied with external 5 V from the controller's power rail.

6.2 Input / output signals (fiber optic version)

Each channel needs its own PWM control signal, dedicated receiver U1 (AFBR2529Z) located on CTR card, which receives this control signal. Each switch has its own fault output activated by under voltage lockout or by desaturation. Fault reported through U2 (AFBR1629Z). The output of the temperature is a PWM signal available on U5 (AFBR1629Z) TH-PCB card.

6.3 Input / output signals (electrical version)

Each channel needs its own PWM control signal. Each switch has its own fault output activated by under voltage lockout or by desaturation. The output signal for the temperature measurement is a PWM signal on the TH-PCB card. All the inputs and outputs can be

connected via a 2 by 2 pin header. Controller ground and 5 V should be also provided for each CTR and TH card.

6.4 TH-PCB, temperature measurement

The temperature output is generated with a voltage-controlled pulse width modulator. The temperature measurement is made on each VINcoMNPC X4 module in a result there are a total of three temperature output signals per VINcoMNPC X12. The diagram below shows the duty cycle as a function of the NTC temperature.

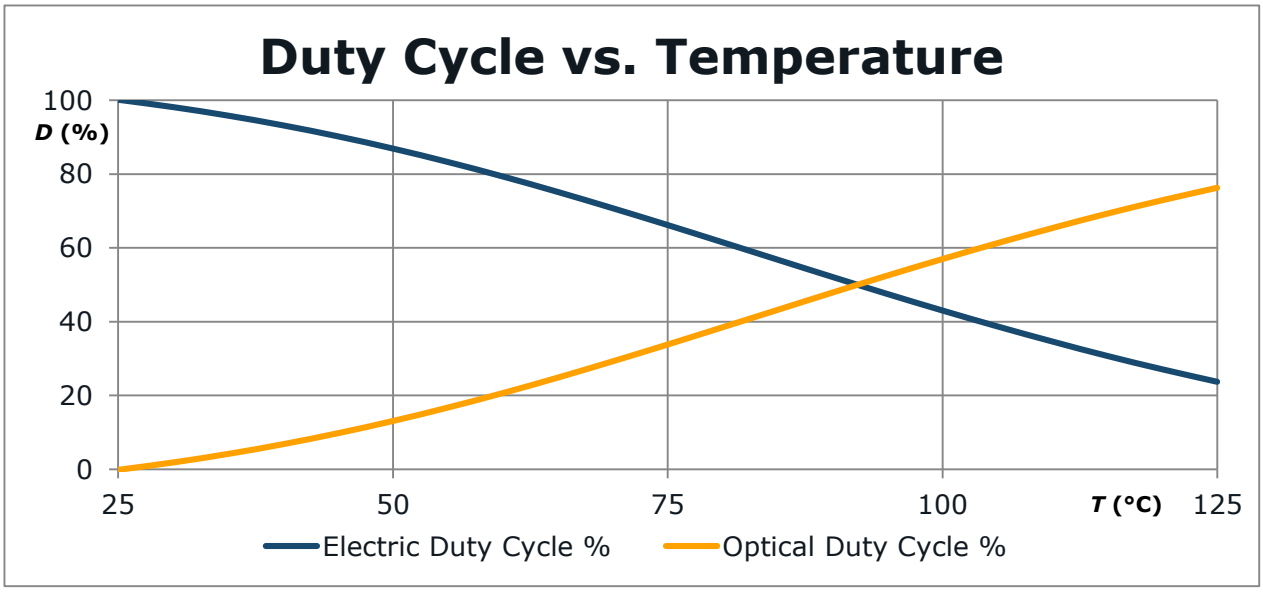


Figure 13: Duty cycle of temperature output

The duty cycle of the PWM signal generated by **LTC6992-1** is directly proportional to the measured module temperature. The fiber optic transmitter is inverting the signal resulting the duty cycle is inverse proportional to the measured module temperature. The optocoupler's output is not inverting, resulting a proportional relationship.

An internal +5 V supply is required to power the **LTC6992-1**. The input of the +5 V voltage regulator is the +16 V rail of the CTR card.

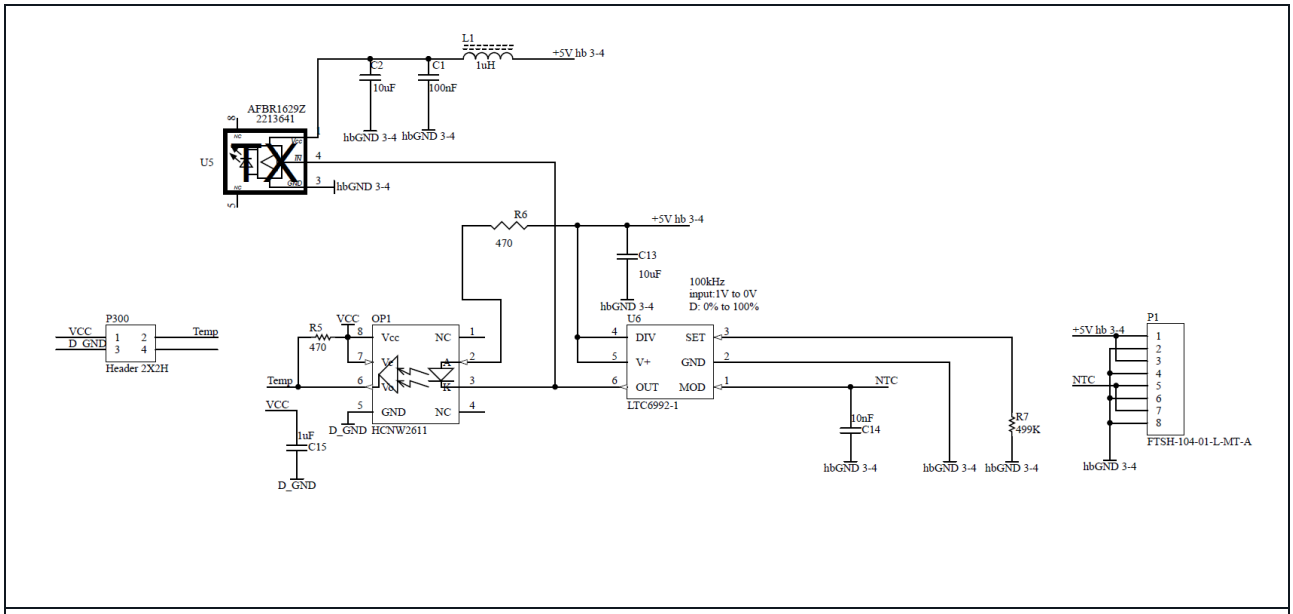


Figure 14: TH-PCB schematic with LTC6992-1 (Voltage-Controlled Pulse Width Modulator)

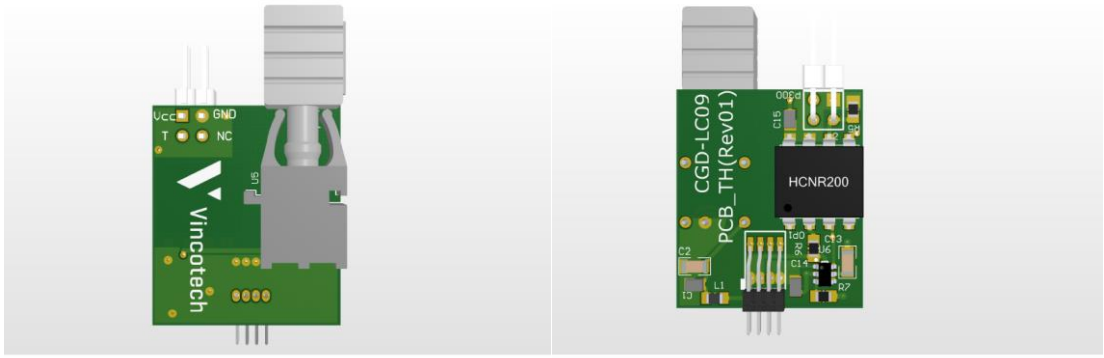


Figure 15: TH-PCB 3D overview

6.5 **IN-PCB, DC/DC power supply**

Upper PCB called IN-PCB has three main functions

- Supply +16/-8 V asymmetric on/off voltage for each channel.
- Makes possible the SLAVE-MASTER-SLAVE operation by utilizing interconnection connectors: fig 16
- Base for the CTR cards (MASTER)

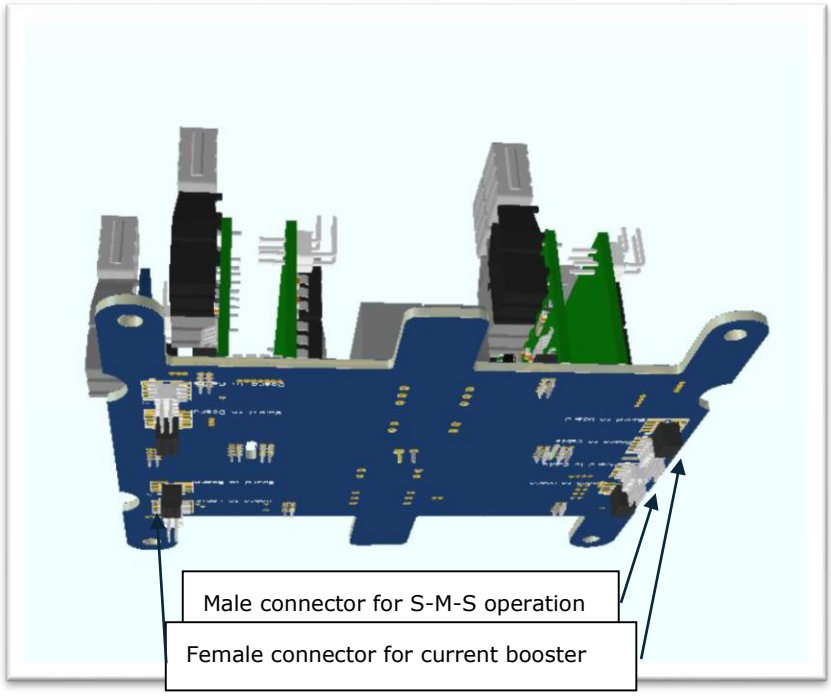


Figure 16: IN-PCB 3D overview

The ON/OFF voltage is supplied by IG136-15, 2W DC/DC converter, with 3000 VACrms isolation voltage. The IN-PCB in case of the MASTER gate driver it is populated with CTR cards while in case of the SLAVE-s there are no CTR-PCB only TH-PCB is populated.

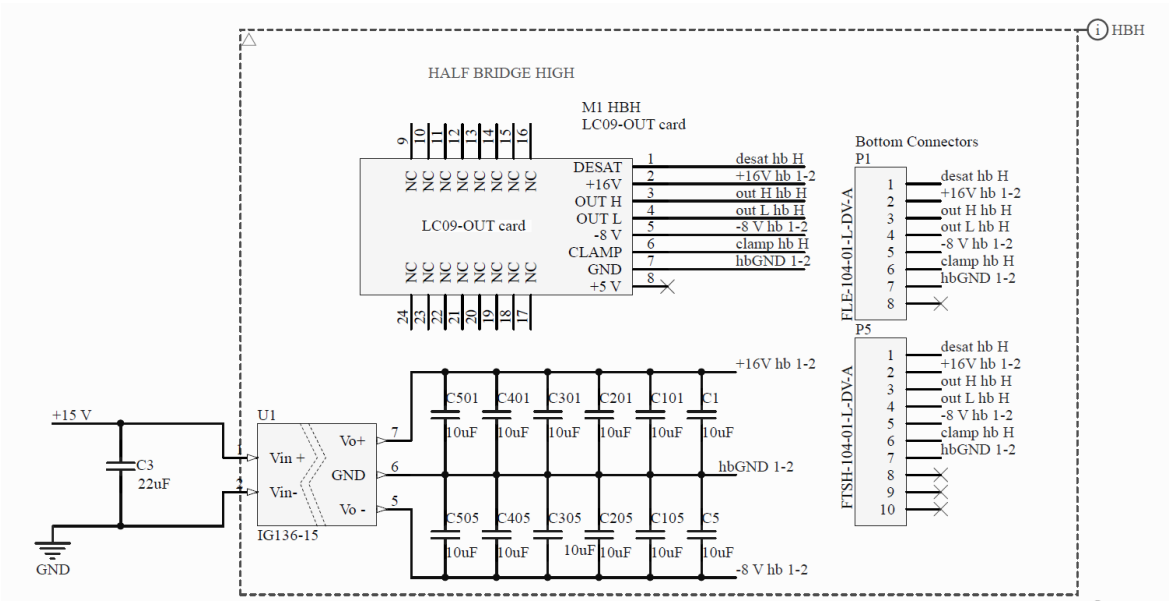


Figure 17: one channel of IN-PCB with CTR card and DC/DC converter.

6.6 CTR-PCB, gate driver IC: TD350

The interface between the control and gate driver can be made with fiber optic interconnection of electrical wireing. Main components of the CTR card: receiver-AFBR2529Z, fault transmitter-AFBR1629Z (fiber version only), HCNW2611-300E opto coupler (electrical version only), gate driver IC-TD350E, +5 V voltage regulator, status LED-s.

Main features of the IGBT gate driver IC (TD350E)

- Active Miller clamp
- Two-level turn-off with adjustable level and delay
- Desaturation detection
- Fault status output
- Negative gate drive capability
- UVLO protection
- 2 kV ESD protection (HBM)

Active Miller clamp: During turn-off, the gate voltage is monitored and the clamp output is activated when gate voltage goes below 2 V (relative to GND). The clamp voltage is VL+3 V max. for a Miller current up to 500 mA. The clamp is disabled when the IN input is triggered again. The current capability of the clamp output is increased by an external PNP bipolar transistor placed on the current booster PCB (bottom PCB).

Two-level turn-off: The two-level turn-off is used to increase the reliability of the application.

During turn-off, gate voltage can be reduced to a programmable level (set by D201 to 11 V) in order to reduce the IGBT current (in the event of overcurrent). This action prevents both dangerous overvoltage across the IGBT and RBSOA problems, especially at short-circuit turn-off. The two-level turn-off (Ta) delay is programmable through an external resistor (R205) and capacitor (C208) for accurate timing use the following equation:

$$T_a[\mu s] = 0.7 \bullet R205[k\Omega] \bullet C208\ [nF] \qquad T_a \text{ is set to 1,5 } \mu s$$

Turn-off delay (T_a) is also used to delay the input signal to prevent distortion of input pulse width.

Start up sequence: In order to have all power rails outputting a stable voltage to the consumers and prevent power up glitches an RC controlled disable transistor is being utilized (Q204). When the inverting fiber receiver has a stable 5V output the gate driver can be enabled. The start-up delay for the TD350 is approximately 15 ms.

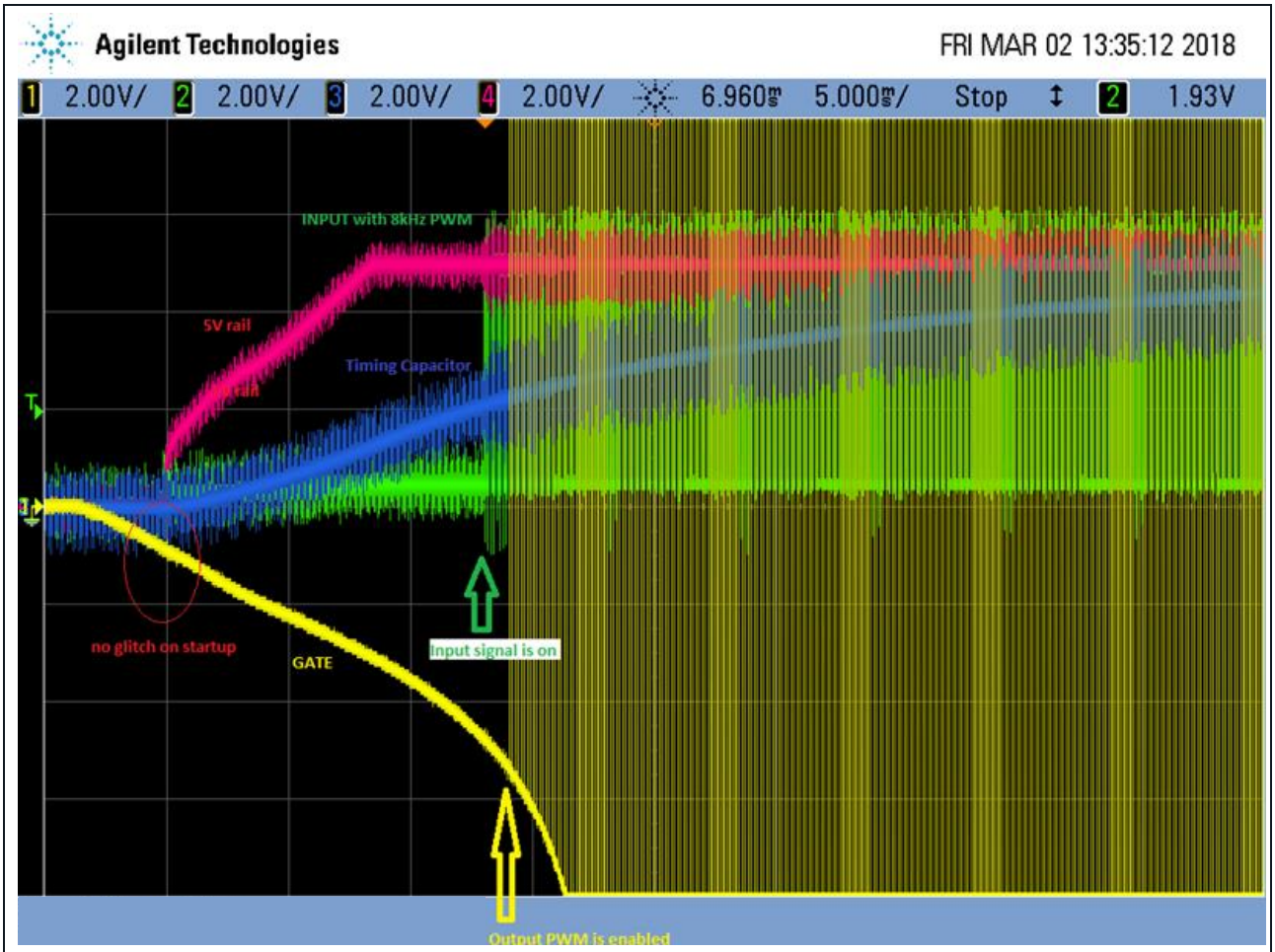


Figure 18: Desaturation event and protection.

Desaturation detection: When the desat voltage goes higher than 7 V, the output is driven low (with 2-level turn-off). The FAULT output is activated. The FAULT state is exited at the next falling edge of IN input. A programmable blanking time is used to allow enough time for IGBT saturation. The blanking time is made of an internal 250 µA current source and an external capacitor (C252). The high voltage diode blocks the high voltage during IGBT off-state (a standard 1 kV); the 1 kΩ resistor filters parasitic spikes and also protects the DESAT input.

During operation, the DESAT capacitor is discharged when TD350 output is low (IGBT off).

When the IGBT is turned on, the DESAT capacitor starts charging and desaturation protection is effective after the blanking time (tB)

$$t_s = 7.2[V] * C_{252} / 250[\mu A]$$

When a desaturation event occurs, the fault output is pulled down and TD350 outputs are low (IGBT off) until the IN input signal is released (high level), then activated again (low level).

$$C_{desat} = C_{252} = 470pF$$

The desaturation can be observed on figure 19.

After turn on the current (blue) rises in a relatively linear fashion. After it reaches the critical level the transistor desaturates. Its Voltage (purple) rises to the DC link voltage. For the blanking time the current stays the same. Only a small drop can be observed due to temperature rise. After the blanking time is over the transistor is being switched off with 2-level turn-off. The gate signal (yellow) is reduced to an intermediate level and turned off completely afterwards.

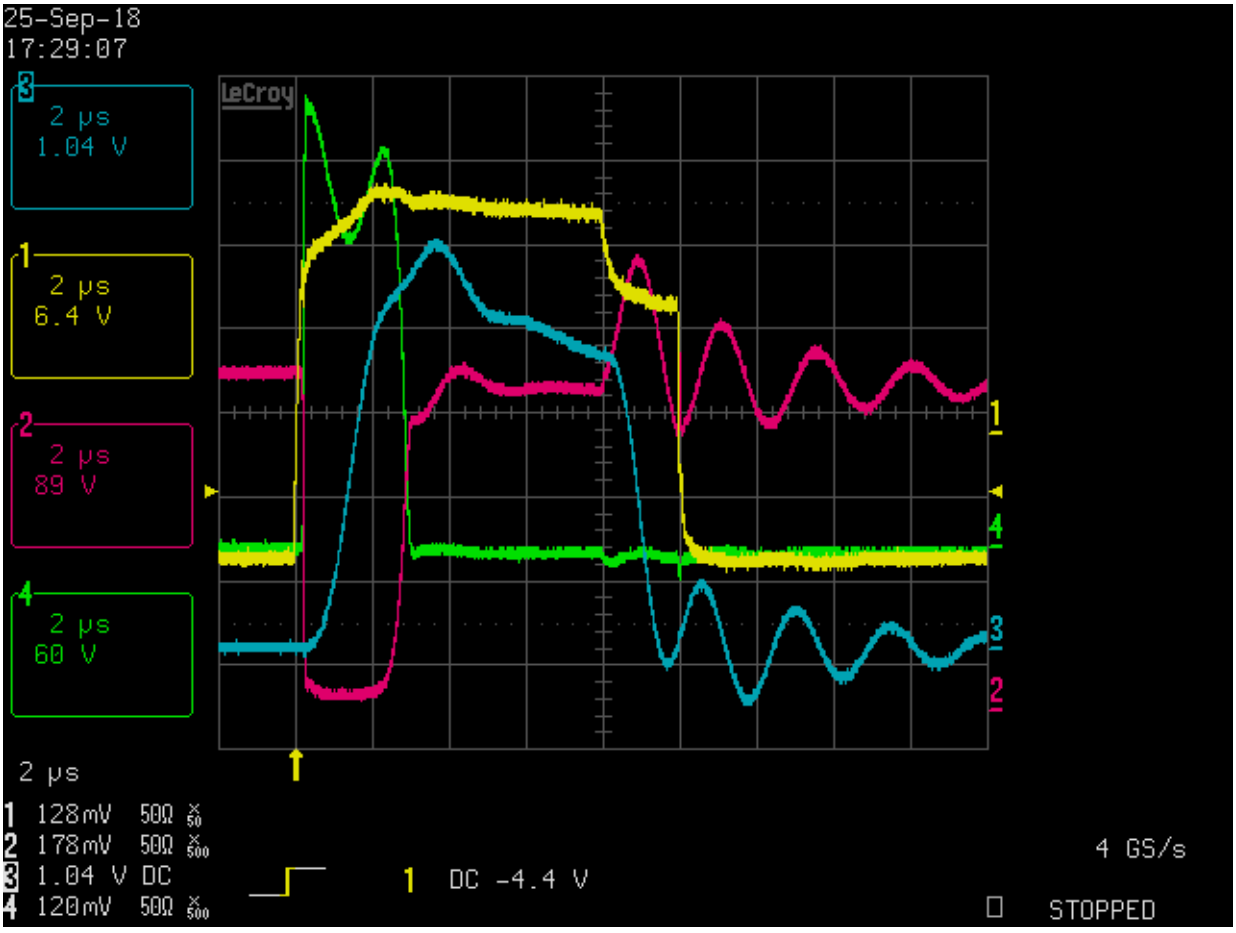


Figure 19: Desaturation event and protection.

Fault status output: the dedicated output pin of the IC is used to signal a fault event (desaturation, UVLO) to a controller. The fault pin drives direct the U201 fiber transmitter or OP201 opto coupler and a red colored LED. When a fault event is detected the red LED will light up.

***Minimum ON time*:** In order to ensure the proper operation of the 2-level turn-off function, the input ON time (Twin) must be greater than the Twinmin value:

$$T_{winmin}=T_a + 2 \bullet R_{del} \bullet C_{208} = 1.5 + 2*0.5*0.47=2\mu s$$

R_{del} is the internal discharge resistor of TD350E 0.5 kΩ (from the datasheet of TD350E)

Input signals smaller than T_a are ignored. Input signals larger than T_{winmin} are transmitted to the output stage after the T_a delay with minimum width distortion ($\Delta Tw = T_{wout} - T_{win}$).

For an input signal width Twin between T_a and T_{winmin}, the output width T_{wout} is reduced below T_{win} (pulse distortion) and the IGBT could be partially turned on. These input signals should be avoided during normal operation.

For more details : http://www.st.com/web/en/resource/technical/document/datasheet/DM00023850.pdf

Schematic of the CTR-PCB:

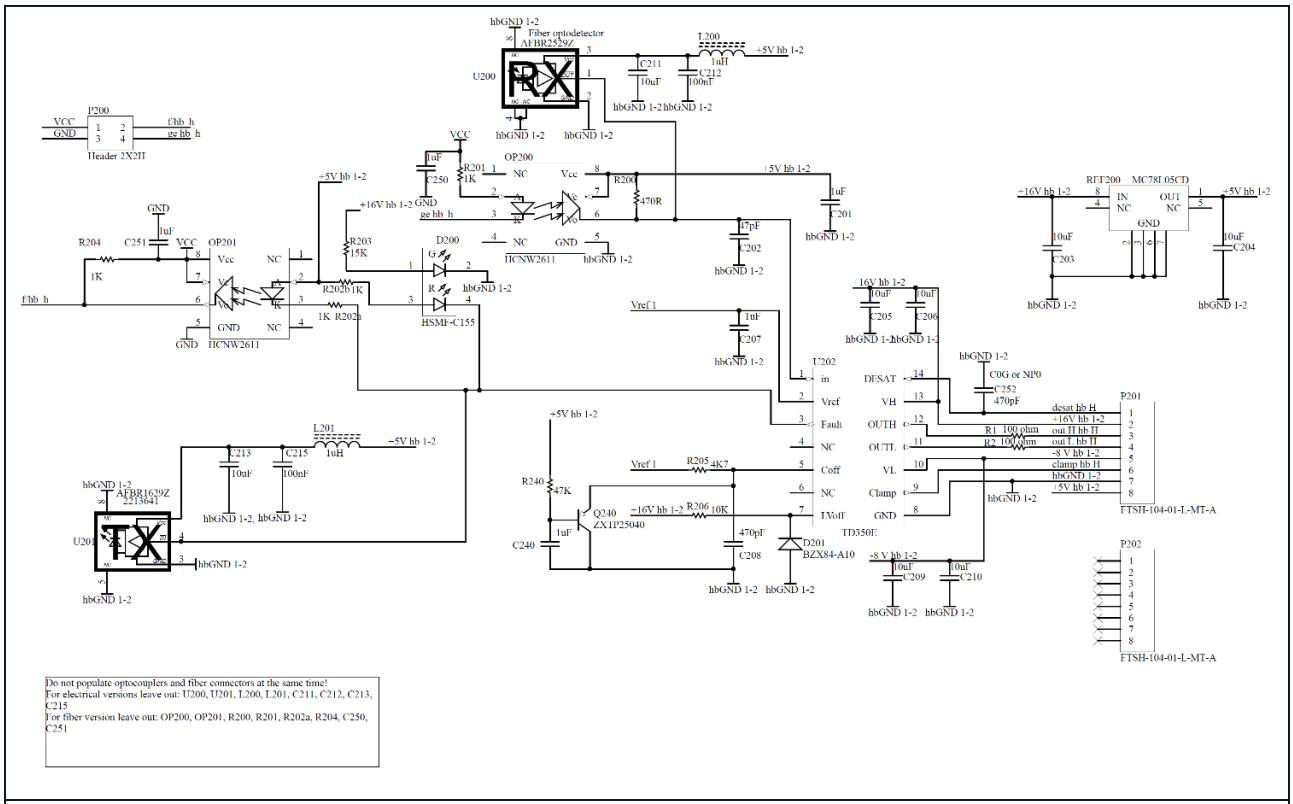


Figure 20: CTR card with TD350E

6.7 **OUT-PCB, current booster**

Main features of the OUT-PCB

- Current booster +/- 20 A current capability / channel / VINcoMNPC X4
- Active voltage clamp, additional PNP transistor for clamp current
- Desaturation detection reporting
- Active voltage clamp

Four independent driver channels are assembled on current booster PCB. The MASTER and SLAVE current boosters are the same and they are connected in parallel as shown in previous chapters. Two current boost IC are connected in parallel per channel (ZXGD3006) to provide high gate current. A common gate resistor as well as separated gate resistors are used for the gates and the common emitter.

The schematic of one channel is shown in the next figure:

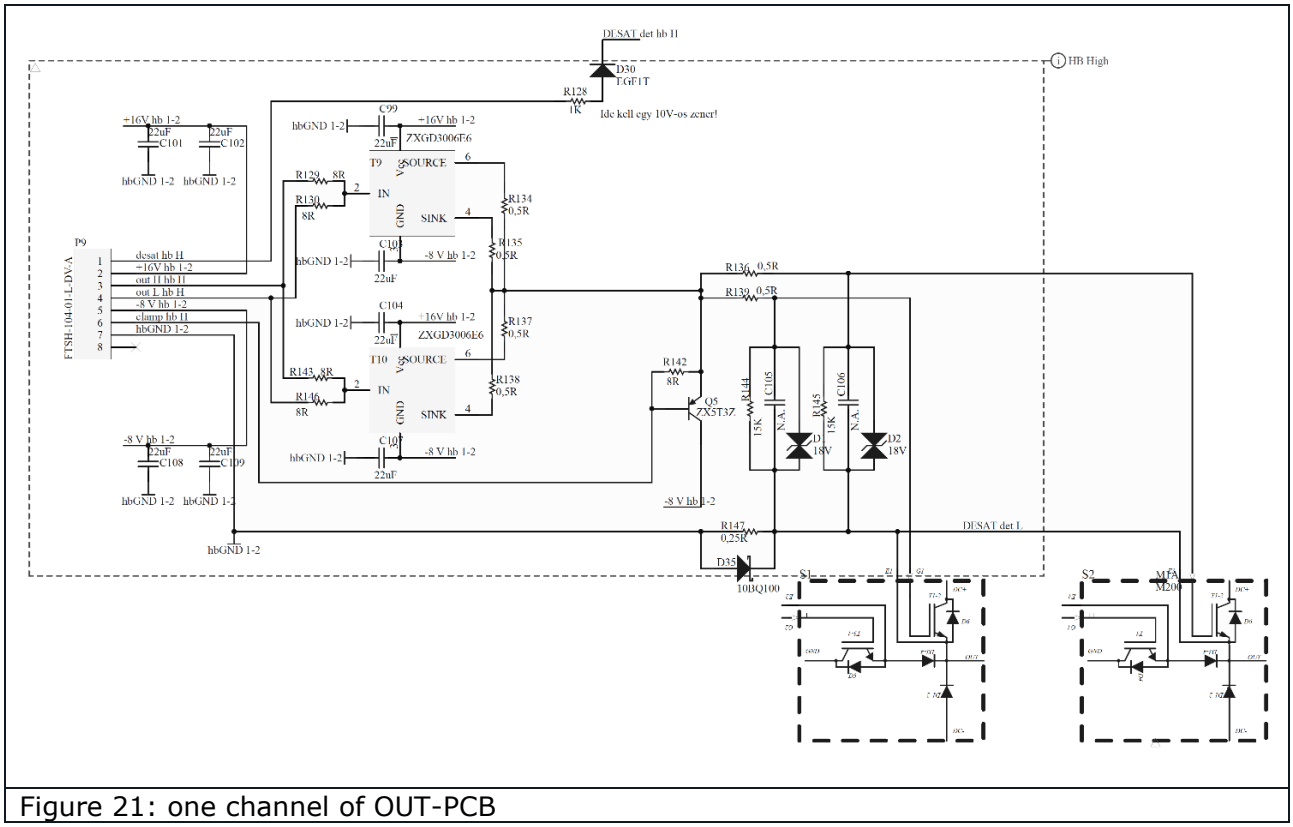


Figure 21: one channel of OUT-PCB

Pin assignment for the male connectors on OUT-PCB

Connector: HB H ; HB L ; NP H ; NP L					
PIN	Chanel HBH	Chanel NPH	Chanel NPL	Chanel HBL	comment
1	desat	desat	desat	desat	Desaturation protection
2	+16 V	+16 V	+16 V	+16 V	Positive supply
3	out high	out high	out high	out high	Signal for turn on/off
4	V clamp	V clamp	V clamp	V clamp	Active voltage clamp
5	-8 V	-8 V	-8 V	-8 V	Negative supply
6	clamp	clamp	clamp	clamp	Miller clamping
7	GND	GND	GND	GND	Ground
8	n.c.	n.c.	n.c.	NTC	not connected / NTC

Table 4: Signals at OUT-PCB

7 Schematics

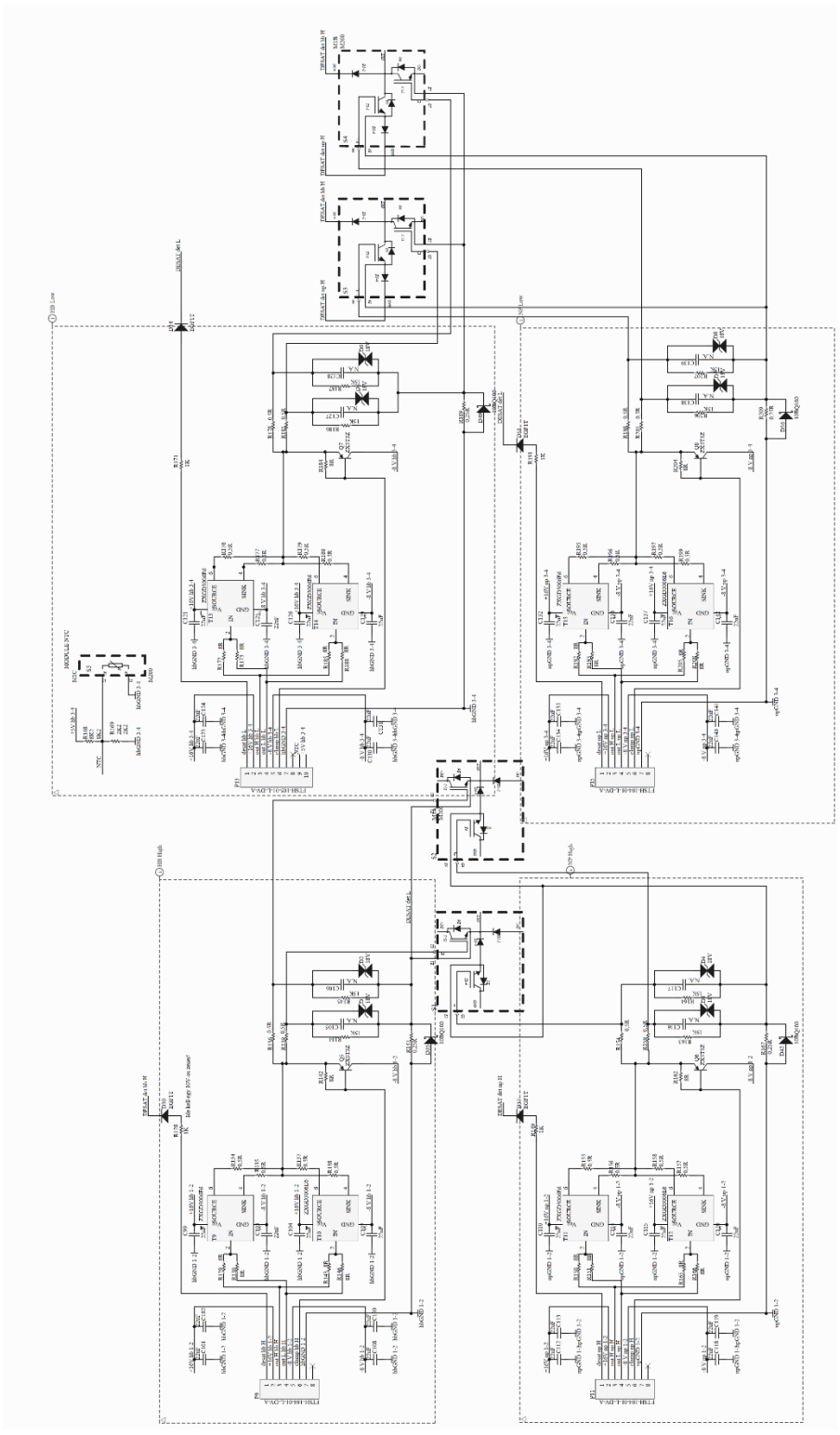


Figure 22: OUT-PCB CURRENT BOOSTER

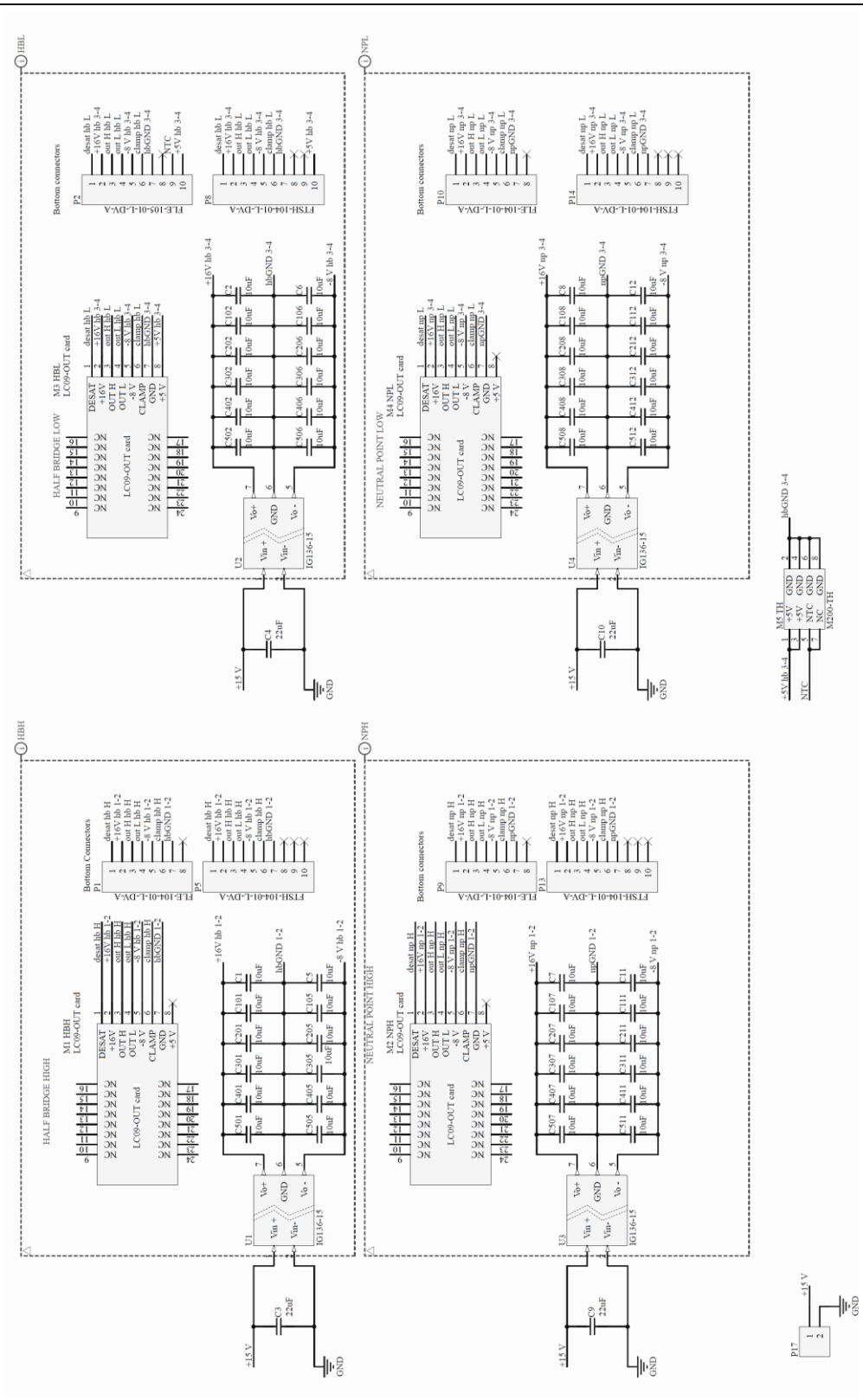


Figure 23: IN-PCB-MASTER

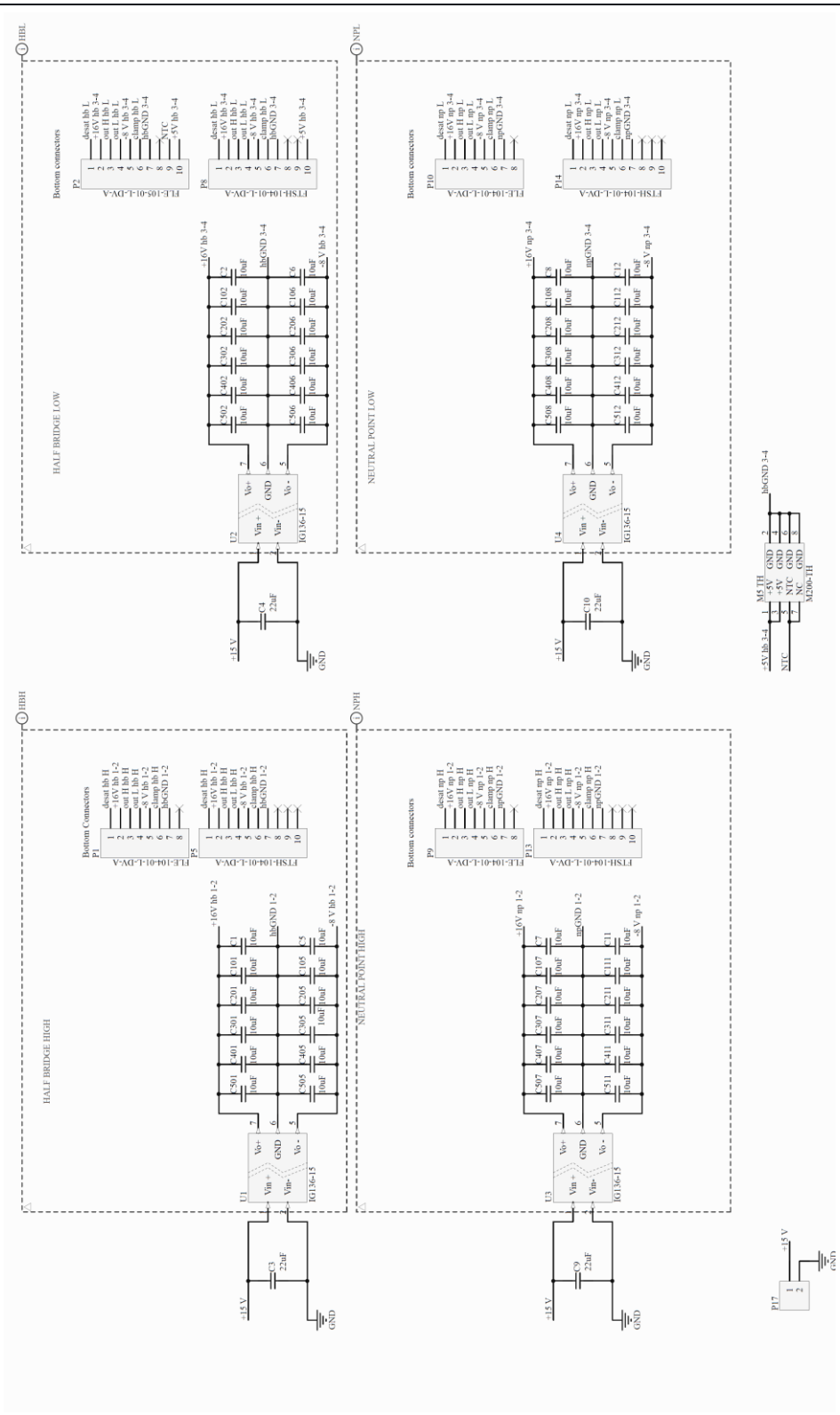


Figure 24: IN-PCB-SLAVE

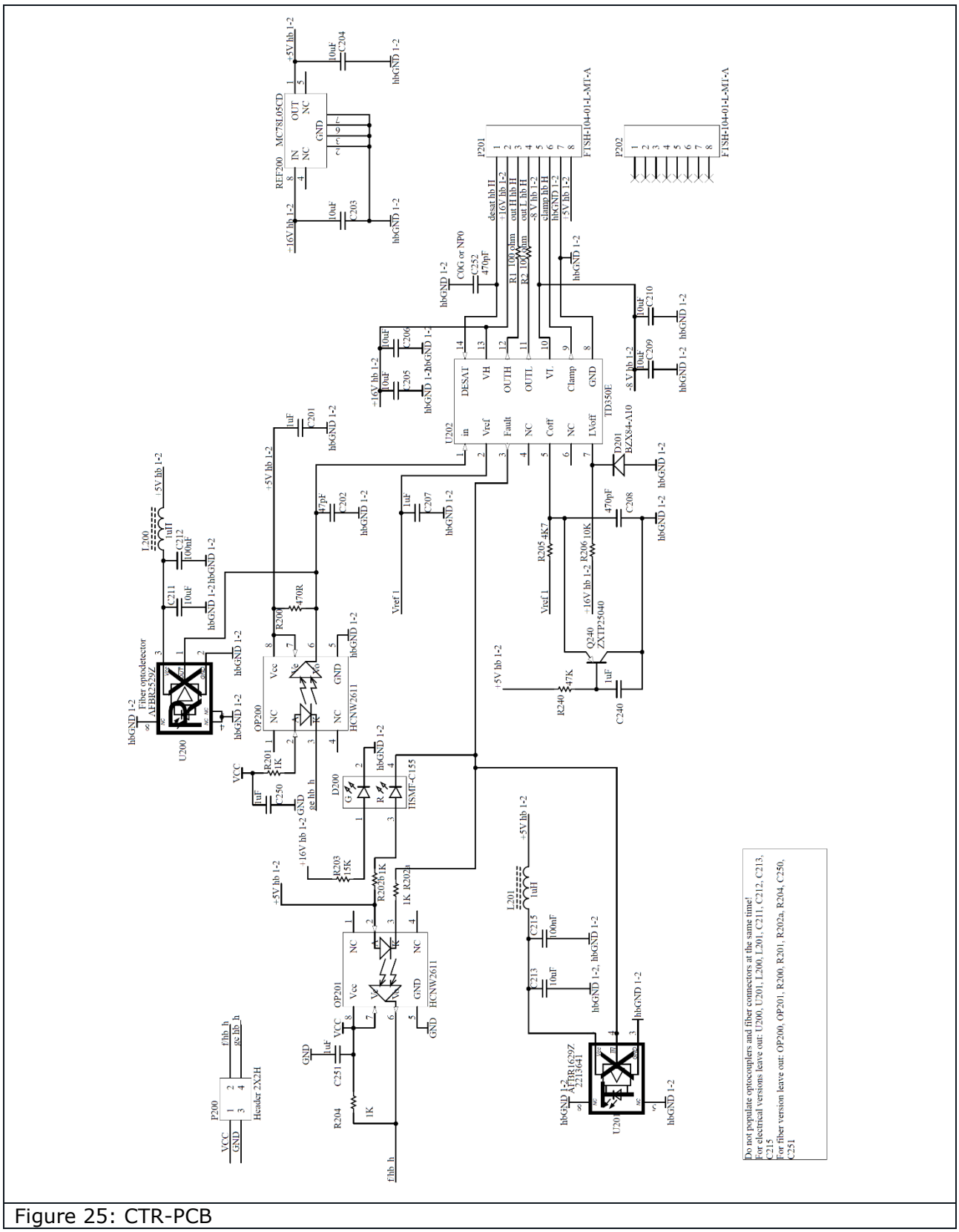


Figure 25: CTR-PCB

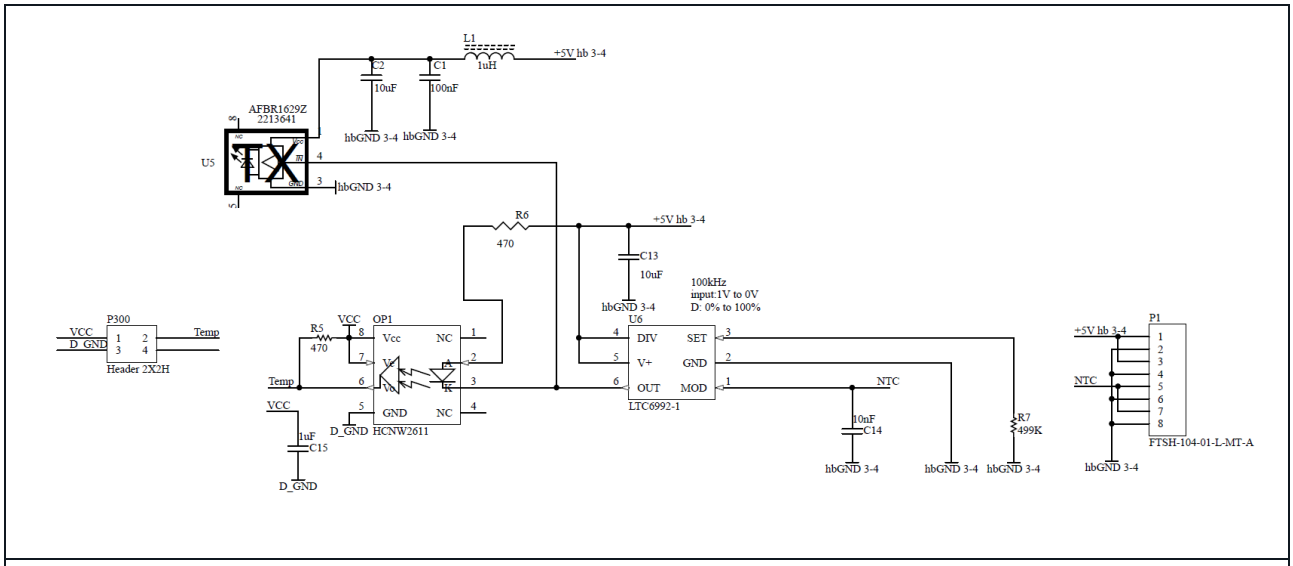


Figure 26: TH-PCB

8 Ordering numbers

Vincotech offer the LC09FP70 gate driver solution as a ready to use kit, including the input DC connector (+15V) screws and standoffs for assembling. Table 5 shows the ordering numbers for an S-M-S gate driver suitable for LC09FP70.

Ordering number	BOM	Quantity	Obs.
GD-LC09-KIT	GD-LC09-Master	1	including input power connector, fiber optics connector, screws and standoffs
	GD-LC09-Slave	2	including input power connector, screws and standoffs
	GD-L400-SMS-CONN	4	

Table 5: Ordering numbers for an LC09 gate driver

9 BOM

9.1 BOM CTR-PCB

Description	Material group	Quantity	Un	Layout position
CGD-LC09-PCB_CTR(Rev03)	PCB	1	PC	
C-1uF-25V-10%-X7R-0805	Cap. below 500V	3	PC	C201, C207, C240
C-10uF-25V-10%-X7R-1206	Cap. below 500V	8	PC	C203, C204, C205, C206, C209, C210, C211, C213
C-100nF-50V-10%-X7R-0805	Cap. below 500V	2	PC	C212, C215
C-47pF-100V-NPO-0805	Cap. below 500V	1	PC	C202
C-470pF-50V-5%-COG-0805	Cap. below 500V	2	PC	C208, C252
LED-HSMF-C155-(Red/Green)-SMD-PM; SAMPLE	LEDs	1	PC	D200
DI-BZX84C10-SOT23	Diode zener	1	PC	D201
CONNECTOR-8PIN-1.27mm-MT-PM; SAMPLE	Connectors	2	PC	P201, P202
R-100R-1%-TK100-0805	Resistors	2	PC	R1, R2
R-1K-1%-TK100-0805	Resistors	1	PC	R202_B
R-4K7-1%-0805	Resistors	1	PC	R205
R-47K-1%-TK100-0805	Resistors	1	PC	R240
R-10K-1%-TK100-0805	Resistors	1	PC	R206
ZXTP25040DFH-PNP-SOT23	Transiostors	1	PC	Q240
MC78L05ACDR2G; Sample	IC	1	PC	REF200
AFBR-2529Z_RX	IC	1	PC	U200
AFBR-1629Z_TX	IC	1	PC	U201
IC-TD350ID-SO14-PM;Sample	IC	1	PC	U202
L-1uH+-5%-0805	Inductor	1	PC	L200, L201

9.2 **BOM TH-PCB**

Description	Material group	Quantity	Un	Layout position
CGD-LC09-PCB_TH(Rev01)	PCB	1	PC	
C-10uF-25V-10%-X7R-1206	Cap. below 500V	2	PC	C2, C13
C-1uF-25V-10%-X7R-0805	Cap. below 500V	1	PC	C15
C-10nF-50V-10%-X7R-0805	Cap. below 500V	1	PC	C14
CONNECTOR-8PIN-1.27mm-MT	Connector	1	PC	P1
L-1uH+-5%-0805	Inductor	1	PC	L1
C-100nF-50V-10%-X7R-0805	Cap. below 500V	1	PC	C1
R-470R-1%-TK100-0805	Resistors	2	PC	R5, R6
R-499K-1%-TK100-0805	Resistors	1	PC	R7
MC78L05ACDR2G	IC	1	PC	REF1
HCNW2611-300E-DIP8	Optoelectronics	1	PC	OP1
CONNECTOR-4PIN/2ROWS-2.54mm	Connector	1	PC	P300
AFBR-1629Z_TX	IC	1	PC	U5
IC-LTC6992CS6-1-SOT363-6L	IC	1	PC	U6

9.3 **BOM IN-PCB MASTER (SLAVE)**

Description	Material group	Quantity	Un	Layout position
CGD-M200-PCB_IN(Rev06)	PCB	1	PC	
DRV-LC09-PCB_CTRF(Rev53) Fiber version	SemiFinished Good	4	PC	HBH CTR, NPH CTR, NPL CTR, HBL CTR-MASTER NA-SLAVE
DRV-LC09-PCB_CTRE(Rev53) Electric version	SemiFinished Good	4	PC	HBH CTR, NPH CTR, NPL CTR, HBL CTR-MASTER NA-SLAVE
DRV-LC09-PCB_TH(Rev51)	SemiFinished Good	1	PC	TH

C-10uF-25V-10%-X7R-1206	Cap. below 500V	48	PC	C1, C2, C5, C6, C7, C8, C11, C12, C101, C102, C105, C106, C107, C108, C111, C112, C201, C202, C205, C206, C207, C208, C211, C212, C301, C302, C305, C306, C307, C308, C311, C312, C401, C402, C405, C406, C407, C408, C411, C412, C501, C502, C505, C506, C507, C508, C511, C512
C-22uF-25V-10%-X7R-1210	Cap. below 500V	4	PC	C3,C4,C9,C10
CONNECTOR-8PIN-1.27mm-FLE8-PM	Connector	3	PC	P1,P9,P10
CONNECTOR-10PIN-1.27mm-FLE10	Connector	1	PC	P2
CONNECTOR-10PIN-1.27mm-FTSH10	Connector	4	PC	P5, P8, P12, P14
CONNECTOR-2PIN-2.5mm-HDR1X2-PM	Connector	1	PC	P17
IC-IGC136-15W	IC	4	PC	U1, U2, U3, U4

9.4 **BOM OUT-PCB**

Description	Material group	Quantity	Un	Layout position
CGD-LC09-PCB_OUT(Rev02)	PCB	1	PC	
C-22uF-25V-10%-X7R-1210	Capacitor	32	PC	C99,C101-C104,C107-C110,C112-C115,C118-C121,C123-C126,C129-C132,C134-C137,C140-C142
DI-EGF1T-E3/67A-DO214BA	Diode	4	PC	D30,D37,D44,D51
DI-VS-10BQ100PBF-SMB	Diode	4	PC	D35,D42,D49,D56
CONNECTOR-8PIN-1.27mm-SMD-FTSH8	Connector	3	PC	P9,P11,P15
CONNECTOR-10PIN-1.27mm-	Connector	1	PC	P13

SMD-FTSH10				
TR-ZX5T3ZTA-SOT89-PM	Transistor	4	PC	Q5-Q8
TR-ZXGD3006E6-SOT23-6	IC	8	PC	T9-T16
R-1K-1%-TK100-0805	Resistor	4	PC	R128,R149,R171,R191
R-8R2-5%-TK200-0805	Resistor	20	PC	R129,R130,R142,R143,R146, R150,R151,R162,R165,R166, R172,R173,R184,R185,R188, R192,R193,R204,R205,R208
R-15K-1%-TK100-0805	Resistor	8	PC	R144,R145,R163,R164,R186, R187,R206,R207
R-R025-5%-1210	Resistor	4	PC	R147,R167,R189,R209
R-R510-1%-TK100-1210	Resistor	24	PC	R134-R139,R154-R159,R176-R181,R195-R199,R201
R-8K2-0.1%-TK25-0805	Resistor	1	PC	R168
DI-P6SMB18CA-18V-600W-SMB	Diode	8	PC	D1-D8
R-2K2-0.1%-TK25-0805	Resistor	8	PC	R5-6;R21-22;R27-28;R43-44
R-15K-1%-TK100-0805-PM; SAMPLE	Resistor	1	PC	R169
C-100nF-50V-10%-X7R-0805	Cap. below 500V	8	PC	C105,C106,C116,C117,C127, C128,C138,C139

10 Conclusion

With a proper parallel connection of the current boosters the current capability of the gate driver can be increased in order to serve the higher current rated Vincotech power modules, meanwhile the equal current sharing between the paralleled power modules is kept equal. To maintain this balanced current the customer has to pay a special attention to a symmetrical connection of the input-output wiring.