Place UZ Logo from Library

Revision

Rev04

Serial

Serial

Serial #

DC-link-Caps

2.5V_REF

DC-link

I_DC_OUT_N
I_DC_OUT_P
V_DC_OUT_N
V_DC_OUT_P

Connectors

I_DC_OUT_N
I_DC_OUT_P
V_DC_OUT_N
V_DC_OUT_P
I_OUT_P[1..3]
I_OUT_N[1..3]
U_OUT_P[1..3]
U_OUT_N[1..3]
PHASE_CONNECTOR_[1..3]

Phase_Measurements
Repeat(PhaseMeasurements,1,3)

I_OUT_P
I_OUT_N
U_OUT_P
U_OUT_N
PHASE_CONNECTOR_

Repeat(I_OUT_P)
Repeat(I_OUT_N)
Repeat(U_OUT_P)
Repeat(U_OUT_N)
Repeat(PHASE_CONNECTOR_)
Repeat(PHASE_)

X1
DigitalCarrierJack

PWM_EN
PWM_H[1..3]
PWM_L[1..3]
OT_H[1..3]
TEMP_H[1..3]

Halfbridges
Repeat(Halfbridge,1,3)

PWM_EN
PWM_H
PWM_L
Repeat(PHASE_)
Repeat(PWM_H)
Repeat(PWM_L)

Temp_Measurements
Repeat(TempMeasurements,1,3)

OT_H
TEMP_H
Repeat(OT_H)
Repeat(TEMP_H)

INFO

Project
ProjectRevision
AuthorParam
ProjectDate

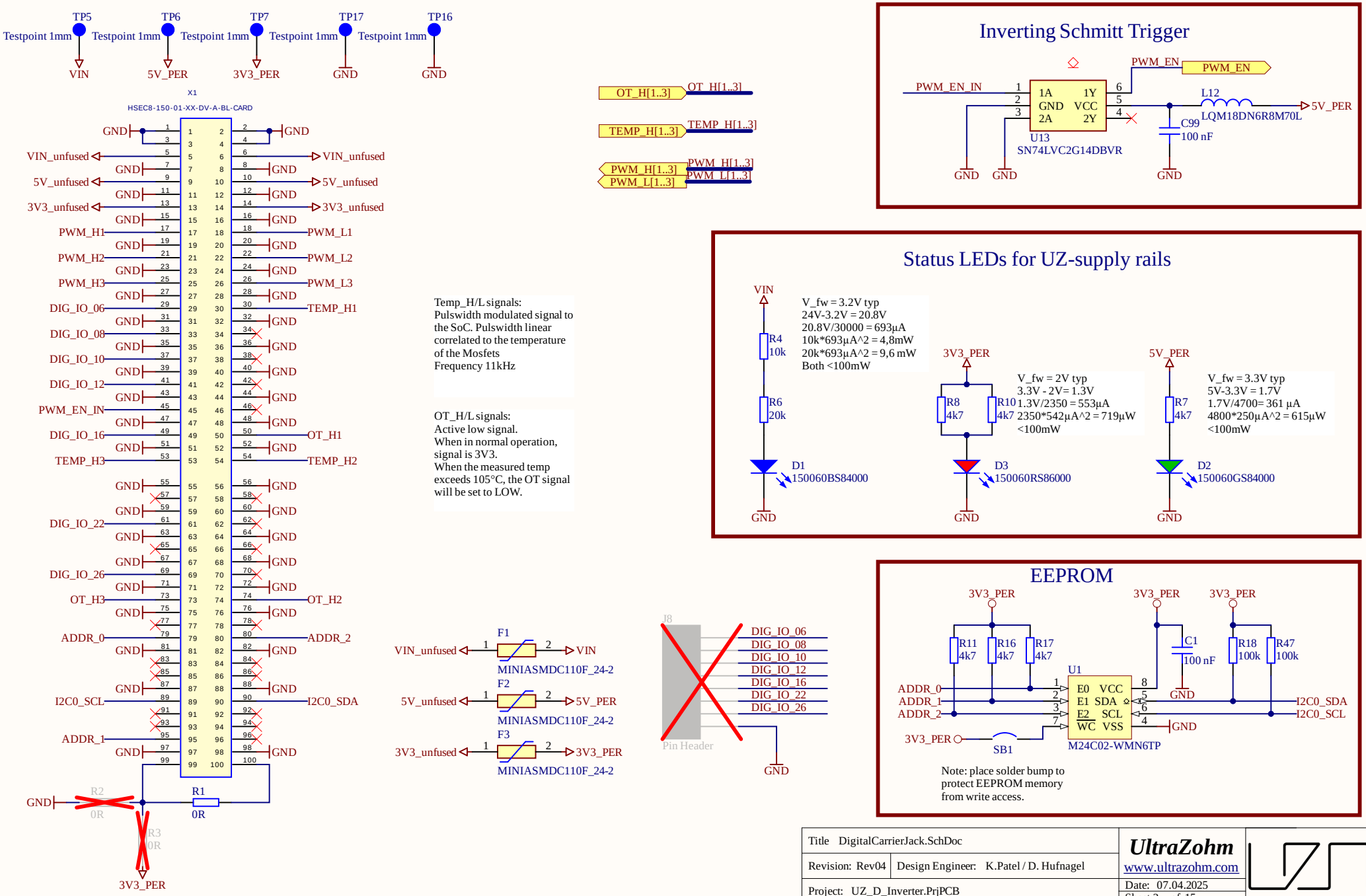
Design Information

LOGO1

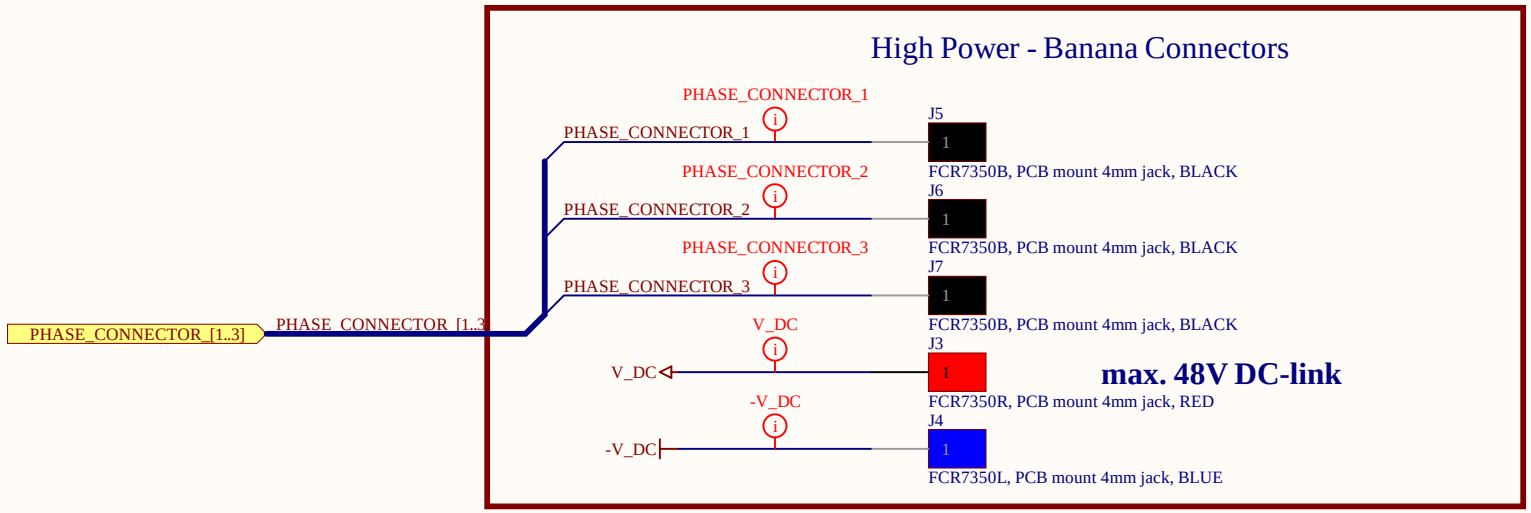
UltraZohm

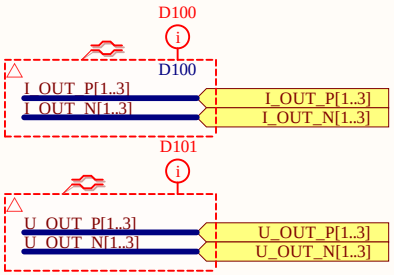
UZ Logo

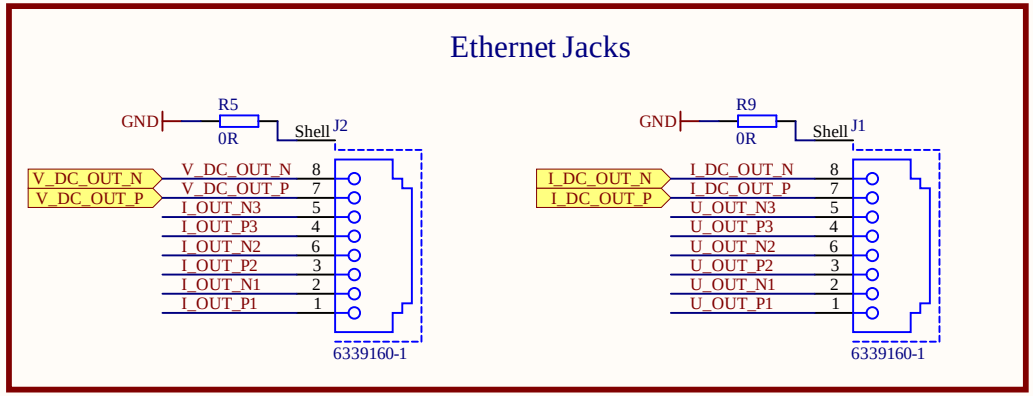
Title TopSheet.SchDoc		UltraZohm	
Revision: Rev04	Design Engineer: K.Patel / D. Hufnagel	www.ultrazohm.com	
Project: UZ_D_Inverter.PrjPCB		Date: 07.04.2025	
		Sheet 1 of 15	



Title DigitalCarrierJack.SchDoc		**UltraZohm** www.ultrazohm.com
Revision: Rev04	Design Engineer: K.Patel / D. Hufnagel	Date: 07.04.2025
Project: UZ_D_Inverter.PrjPCB		Sheet 2 of 15







Title Connectors.SchDoc		UltraZohm	
Revision: Rev04	Design Engineer: K.Patel / D. Hufnagel	www.ultrazohm.com	
Project: UZ_D_Inverter.PrjPCB		Date: 07.04.2025	
		Sheet 3 of 15	

Phase Current Measurement + Single->Diff OPAMP

With 0.5-4.5V bipolar single-ended input at 2.5Vref ->
Gain=2 would lead to a differential signal
with 2.5V VCOM:
Out_N/Out_P:
4.5V/0.5V at -50A
0.5V/4.5V at 50A

Place close to U3 OPAMP

50A max @2mOhm = 1000mV
With fixed 20V/V Gain and 2.5V ref ->
0.5- 4.5V bipolar single-ended

U2 the terminals IN- and IN+ are connected inverted. This is done to improve the PCB-layout. This is fixed, by inverting the inputs at U3 again.

Place close to U2 OPAMP

2V5_REF Place close to U2 REF inputs

Phases

Halfbridges are seen as current "source" for the motor.

Phase Voltage Measurement + Single->Diff OPAMP

Place close to U4 OPAMP

Voltage measurement scaled with voltage divider R22 and R21 :
Max 48V (LowPass max 60V as buffer)
10k||110k->
48V*10k/(10k+110k)=4V
48V/(10k||110k)=5,2mA

Max operation 60V:
60V*10k/(10k+110k)=5V
60V/(10k||110k)=6.5mA

PHASE_CONNECTOR_

Direction towards the connectors and motor

LowPass Filter:
Max Target:
6000rpm at 18 pole pairs
->fg=1800Hz
With LowPass & Feedback Lowpass. Resulting frequency response calculated via LTSpice Simulation ->1.745kHz

All gain resistors match the 10k||110k input resistance of the lowpass filter

Place close to U4 OPAMP

Title Phase_Measurements.SchDoc		UltraZohm www.ultrazohm.com
Revision: Rev04	Design Engineer: K.Patel / D. Hufnagel	Date: 07.04.2025
Project: UZ_D_Inverter.PrjPCB		Sheet 4.1 of 15

Phase Current Measurement + Single->Diff OPAMP

With 0.5-4.5V bipolar single-ended input at 2.5Vref ->
Gain=2 would lead to a differential signal
with 2.5V VCOM:
Out_N/Out_P:
4.5V/0.5V at -50A
0.5V/4.5V at 50A

Place close to U3 OPAMP

50A max @2mOhm = 1000mV
With fixed 20V/V Gain and 2.5V ref ->
0.5- 4.5V bipolar single-ended

U2 the terminals IN- and IN+ are connected inverted. This is done to improve the PCB-layout. This is fixed, by inverting the inputs at U3 again.

Place close to U2 OPAMP

2V5_REF Place close to U2 REF inputs

Phases

Halfbridges are seen as current "source" for the motor.

Phase Voltage Measurement + Single->Diff OPAMP

Place close to U4 OPAMP

Voltage measurement scaled with voltage divider R22 and R21 :
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PHASE_CONNECTOR_
Direction towards the connectors and motor

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Place close to U4 OPAMP

Title Phase_Measurements.SchDoc		UltraZohm www.ultrazohm.com
Revision: Rev04	Design Engineer: K.Patel / D. Hufnagel	Date: 07.04.2025
Project: UZ_D_Inverter.PrjPCB		Sheet 4.2 of 15

Phase Current Measurement + Single->Diff OPAMP

With 0.5-4.5V bipolar single-ended input at 2.5Vref ->
Gain=2 would lead to a differential signal
with 2.5V VCOM:
Out_N/Out_P:
4.5V/0.5V at -50A
0.5V/4.5V at 50A

0.1% R14C 2k
C12C 56 pF
VCOM_1
C24C 100 nF
GND

I_OUT_N R19C 49R9
I_OUT_P R20C 49R9
I_N
I_P
U3C ADA4940-1ARZ-R7
5V_U3
GND
VOCM
DISABLE
VS+
VS-
VCOM_1
0.1% R13C 1k 2V5_REF
R12C 1k 0.1% I_OUT
C11C 56 pF
0.1% R15C 2k
2V5_REF C83C 100 nF GND

Place close to U3 OPAMP
5V_PER L3C LQM18DN6R8M70L 5V_U3 C3C 100 nF GND

2V5_REF Place close to U2 REF inputs
C82C 100 nF GND

50A max @2mOhm = 1000mV
With fixed 20V/V Gain and 2.5V ref ->
0.5- 4.5V bipolar single-ended

U2 the terminals IN- and IN+ are connected inverted. This is done to improve the PCB-layout. This is fixed, by inverting the inputs at U3 again.

2V5_REF
GND
U2C
NC OUT
REF2 VS
GND REF1
IN- IN+
INA241A2IDGKR
I_OUT
5V_U2

Place close to U2 OPAMP
5V_PER L5C LQM18DN6R8M70L 5V_U2 C6C 100 nF GND

Phases
PHASE_
PHASE_
1% R10C 2mR
PHASE_CONNECTOR_
Halfbridges are seen as current "source" for the motor.

Phase Voltage Measurement + Single->Diff OPAMP

Place close to U4 OPAMP
5V_PER L4C LQM18DN6R8M70L 5V_U4 C80C 100 nF GND

U_OUT_N R25C 49R9
U_OUT_P R26C 49R9
U_N
U_P
U4C ADA4940-1ARZ-R7
5V_U4
GND
VOCM
DISABLE
VS+
VS-
VCOM_2
0.1% R130C 10k
R129C 0.1% 110k
C15C 5 % 56 pF
0.1% R24C 110k
R23C 10k 0.1%
5V_U4 C16C 56 pF
R27C 110k 0.1%
R28C 10k 0.1%

VCOM_2
C23C 100 nF GND
Place close to U4 OPAMP

All gain resistors match the 10k||110k input resistance of the lowpass filter

Voltage measurement scaled with voltage divider R22 and R21 :
Max 48V (LowPass max 60V as buffer)
10k||110k->
48V*10k/(10k+110k)=4V
48V/(10k||110k)=5,2mA

Max operation 60V:
60V*10k/(10k+110k)=5V
60V/(10k||110k)=6.5mA

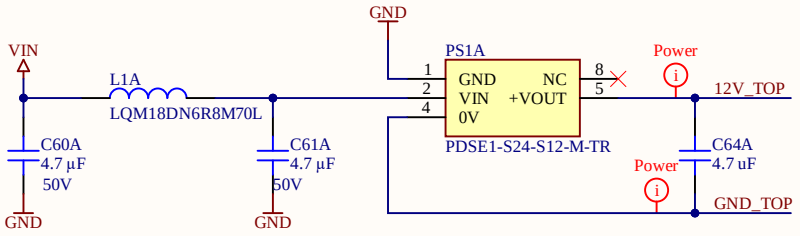
PHASE_CONNECTOR_
Direction towards the connectors and motor

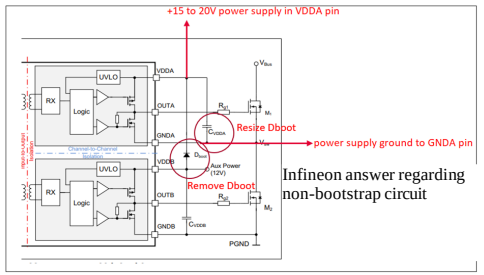
R22C 110k 0.1%
C14C 0.01 µF 10 % 100 VDC GND
R21C 10k 0.1% GND

LowPass Filter:
Max Target:
6000rpm at 18 pole pairs
->fg=1800Hz
With LowPass & Feedback Lowpass. Resulting frequency response calculated via LTSpice Simulation ->1.745kHz

Title Phase_Measurements.SchDoc		UltraZohm www.ultrazohm.com
Revision: Rev04	Design Engineer: K.Patel / D. Hufnagel	
Project: UZ_D_Inverter.PrjPCB		Date: 07.04.2025 Sheet 4.3 of 15

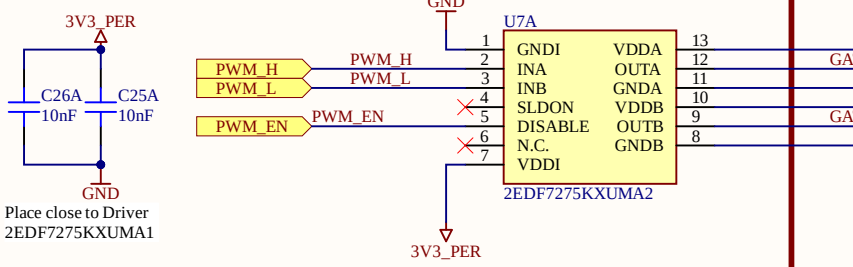
Isolated Top Side Gate Supply



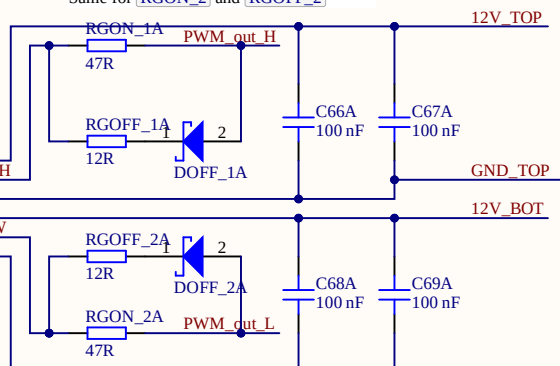


Infineon answer regarding non-bootstrap circuit

Gate Driver



Different values for RGON_1 and RGOFF_1 to facilitate faster turn off.
Same for RGON_2 and RGOFF_2

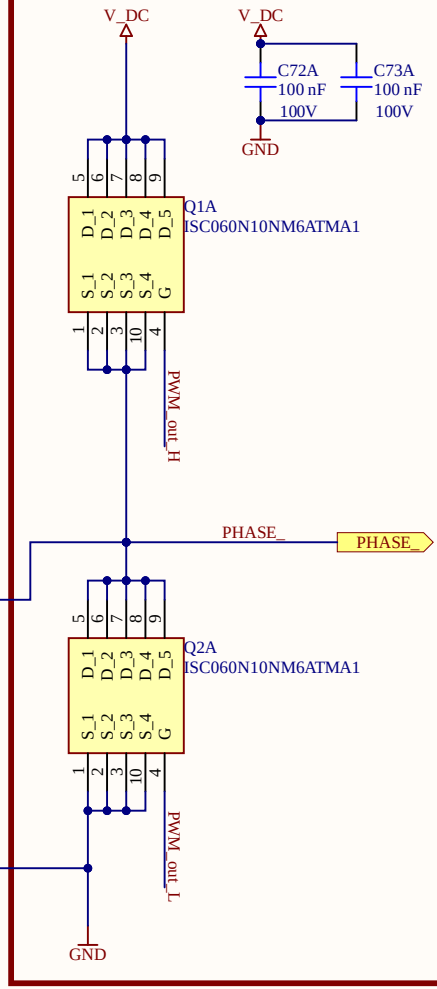


IG_charging_peak <4A
IG_discharging_peak <8A

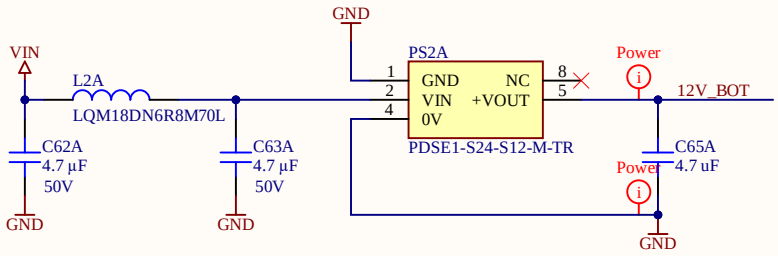
->Max currents:
IG_charging = 12V/(47+0.42)Ohm = 253mA
IG_discharging = 12V/(12+ 0.18)Ohm = 985mA

Datasheet said minimum 20x CISS for output-caps:
2x100nF > 20x2.5nF

MOSFETS

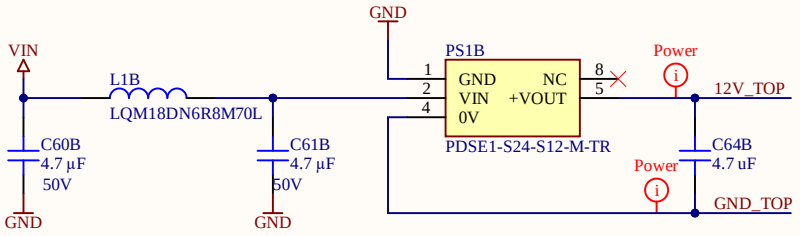


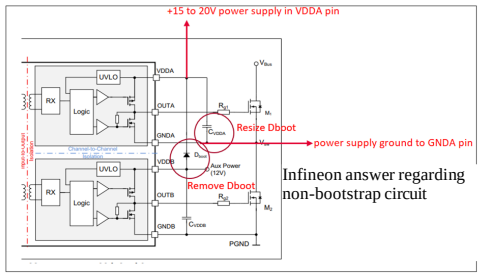
Isolated Bottom Side Gate Supply



Title Halfbridges.SchDoc		**UltraZohm**	
Revision: Rev04	Design Engineer: K.Patel / D. Hufnagel	www.ultrazohm.com	
Project: UZ_D_Inverter.PrjPCB		Date: 07.04.2025	
		Sheet 5.1 of 15	

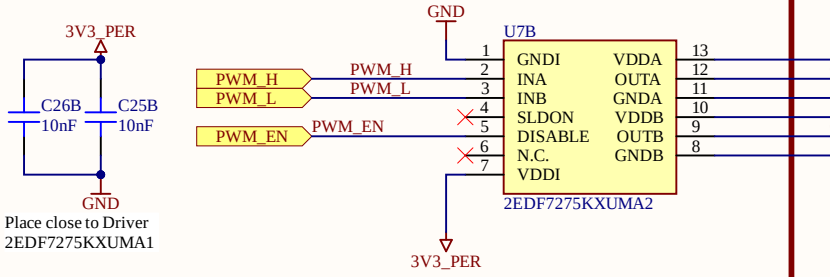
Isolated Top Side Gate Supply



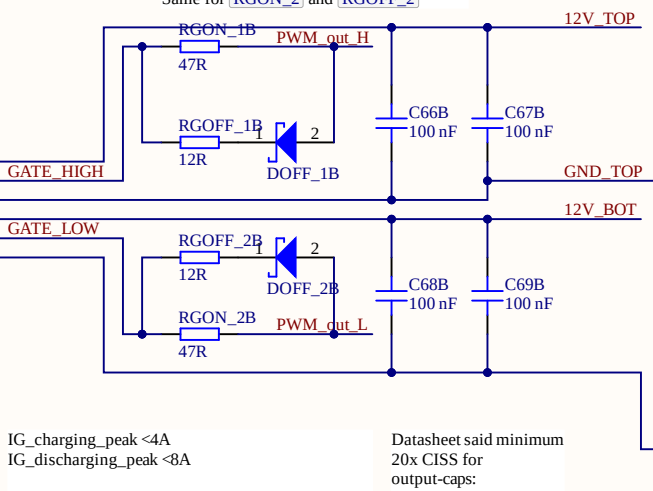


Infineon answer regarding non-bootstrap circuit

Gate Driver



Different values for RGON_1 and RGOFF_1 to facilitate faster turn off.
Same for RGON_2 and RGOFF_2

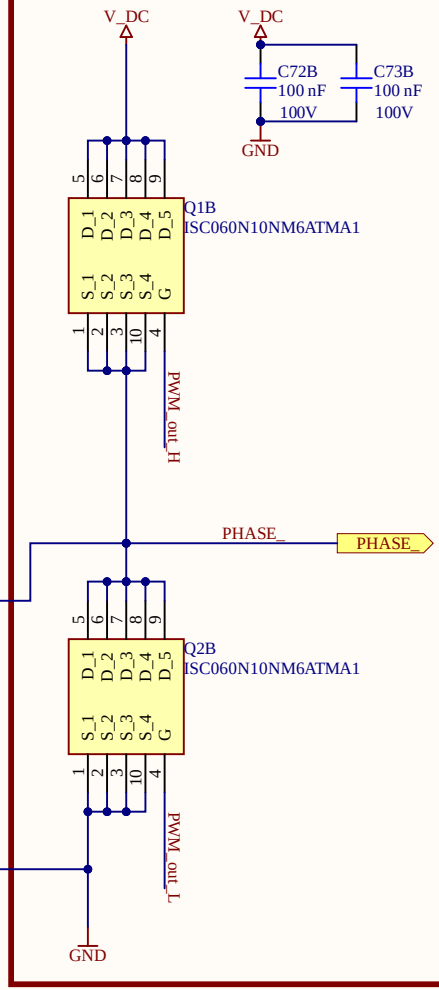


IG_charging_peak <4A
IG_discharging_peak <8A

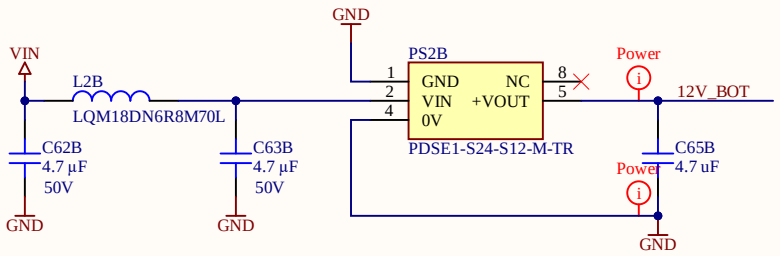
->Max currents:
IG_charging = 12V/(47+0.42)Ohm = 253mA
IG_discharging = 12V/(12+ 0.18)Ohm = 985mA

Datasheet said minimum 20x CISS for output-caps:
2x100nF > 20x2.5nF

MOSFETS

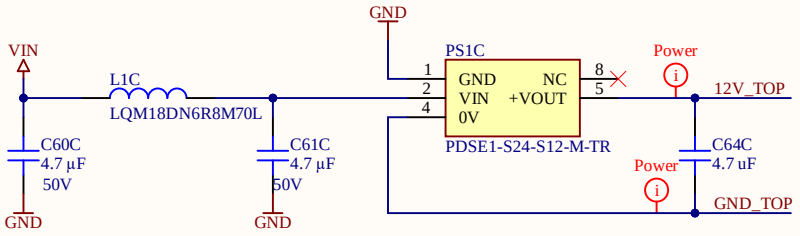


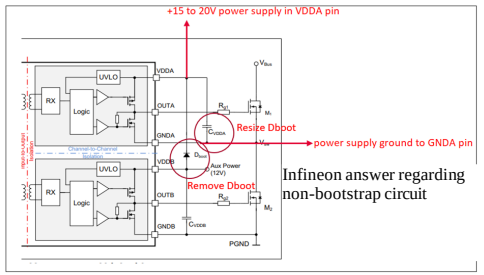
Isolated Bottom Side Gate Supply



Title Halfbridges.SchDoc		**UltraZohm**	
Revision: Rev04	Design Engineer: K.Patel / D. Hufnagel	www.ultrazohm.com	
Project: UZ_D_Inverter.PrjPCB		Date: 07.04.2025	
		Sheet 5.2 of 15	

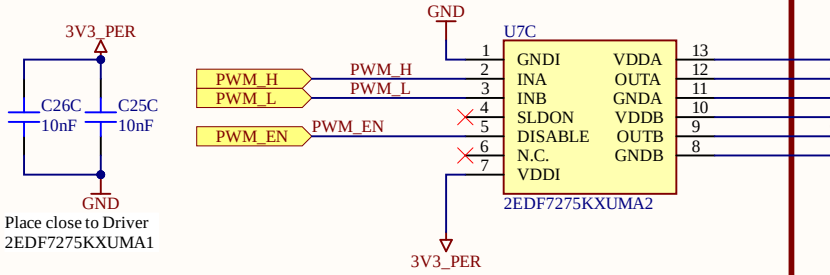
Isolated Top Side Gate Supply



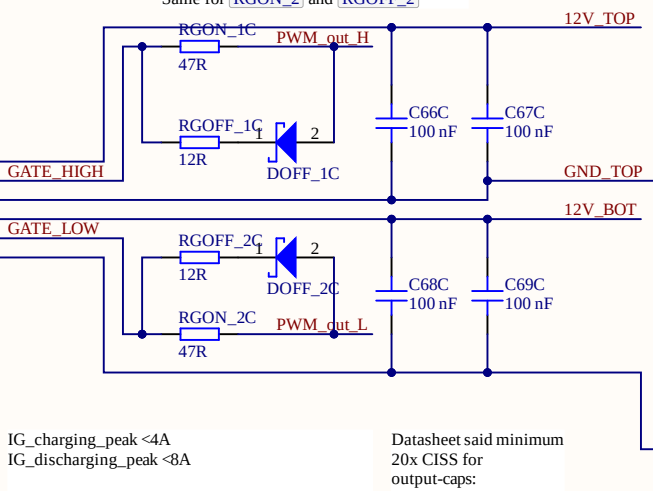


Infineon answer regarding non-bootstrap circuit

Gate Driver



Different values for RGON_1 and RGOFF_1 to facilitate faster turn off.
Same for RGON_2 and RGOFF_2

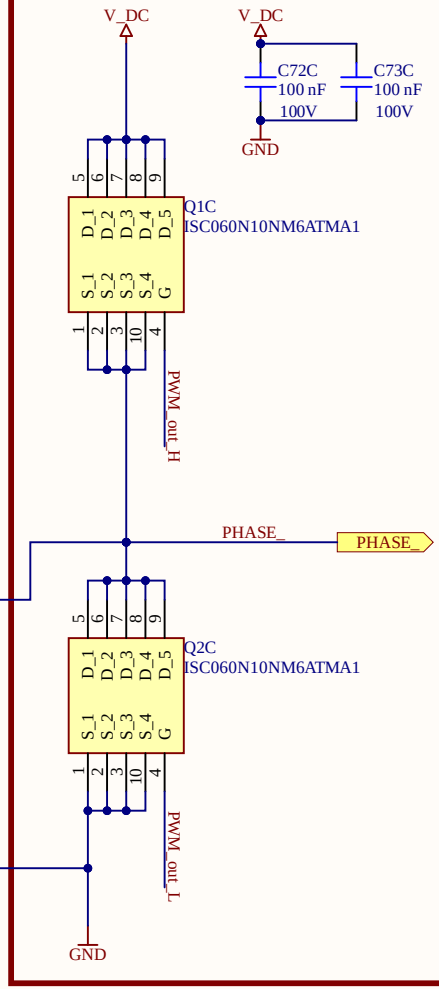


IG_charging_peak <4A
IG_discharging_peak <8A

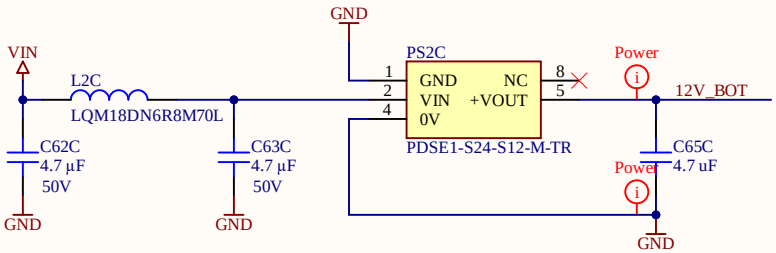
->Max currents:
IG_charging = 12V/(47+0.42)Ohm = 253mA
IG_discharging = 12V/(12+ 0.18)Ohm = 985mA

Datasheet said minimum 20x CISS for output-caps:
2x100nF > 20x2.5nF

MOSFETS



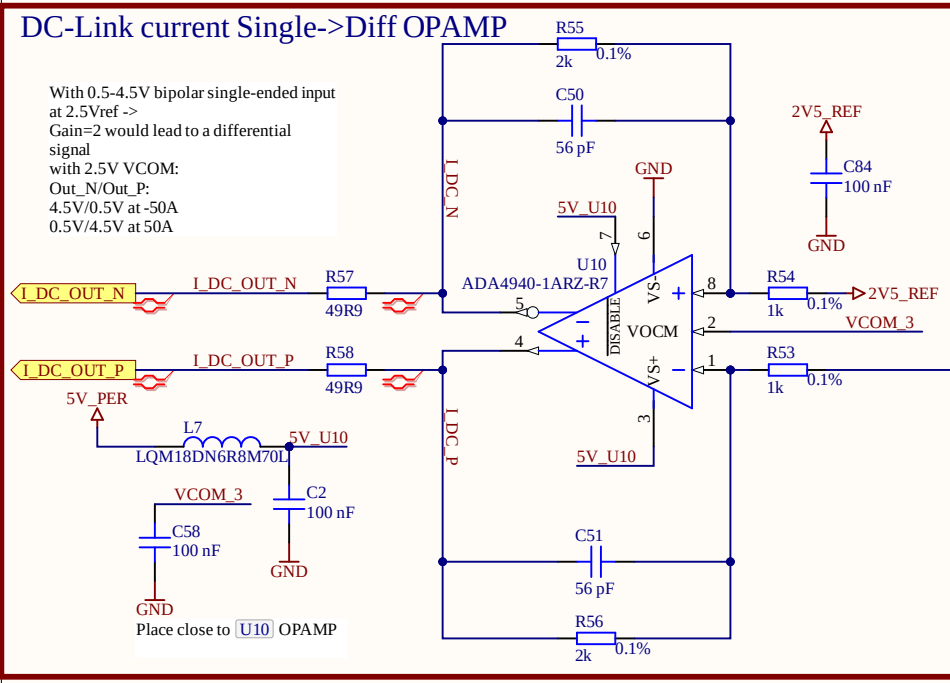
Isolated Bottom Side Gate Supply



Title Halfbridges.SchDoc		UltraZohm	
Revision: Rev04	Design Engineer: K.Patel / D. Hufnagel	www.ultrazohm.com	
Project: UZ_D_Inverter.PrjPCB		Date: 07.04.2025	
		Sheet 5.3 of 15	

DC-Link current Single->Diff OPAMP

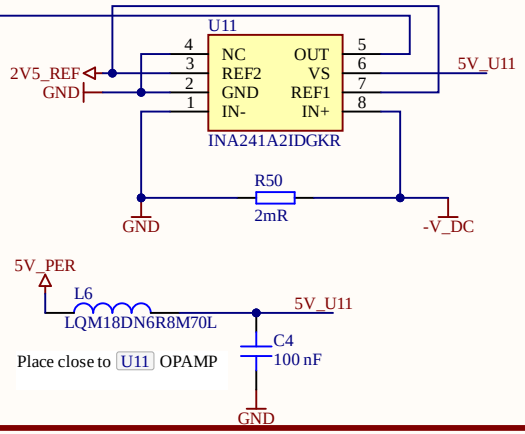
With 0.5-4.5V bipolar single-ended input at 2.5Vref ->
Gain=2 would lead to a differential signal
with 2.5V VCOM:
Out_N/Out_P:
4.5V/0.5V at -50A
0.5V/4.5V at 50A

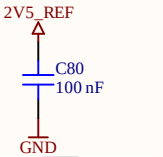


DC-Link current measurement

50A max @2mOhm = 1000mV
With fixed 20V/V Gain and 2.5V ref ->
0.5- 4.5V bipolar single-ended

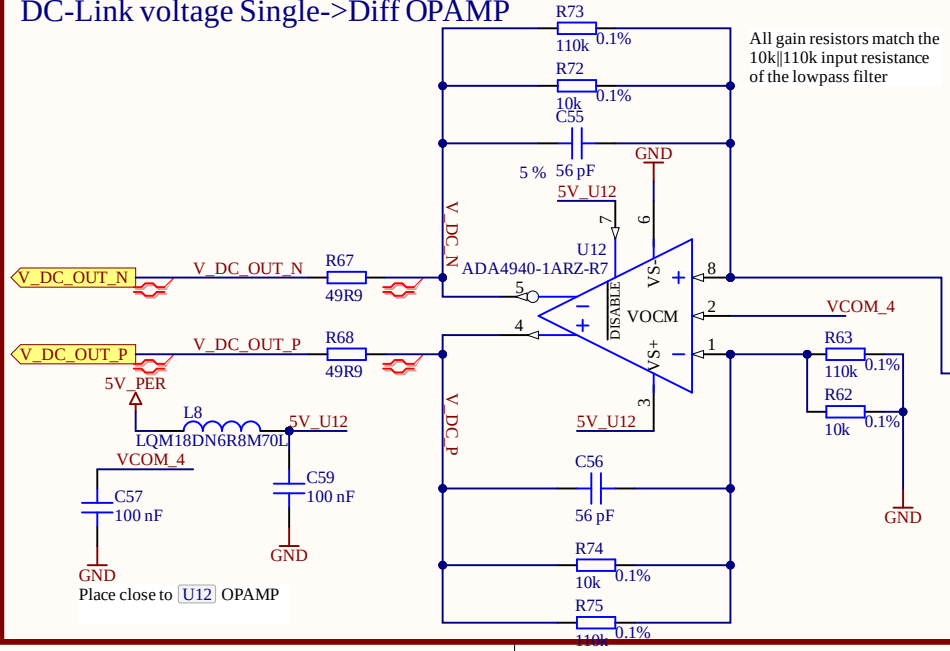
U11 the terminals IN- and IN+ are connected inverted. This is done to improve the PCB-layout. This is fixed, by inverting the inputs at U10 again.





DC-Link voltage Single->Diff OPAMP

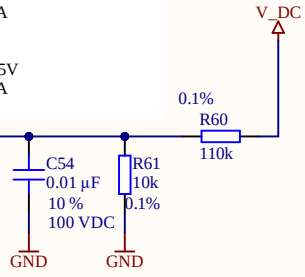
All gain resistors match the 10k||110k input resistance of the lowpass filter



DC-Link Voltage lowpass

Voltage measurement scaled with voltage divider R60 and R61 :
Max 48V (LowPass max 60V as buffer)
10k||110k->
48V*10k/(10k+110k)=4V
48V/(10k||110k)=5,2mA

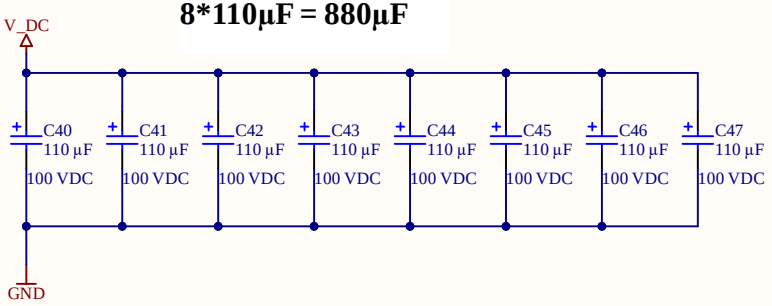
Max operation 60V:
60V*10k/(10k+110k)=5V
60V/(10k||110k)=6.5mA

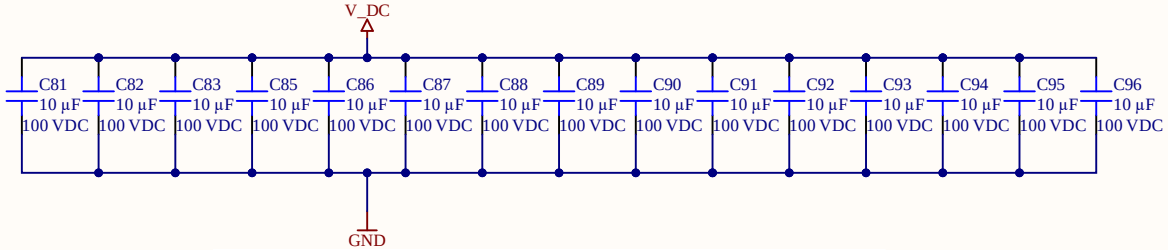


LowPass Filter:
Max Target:
6000rpm at 18 pole pairs
->fg=1800Hz
With LowPass & Feedback Lowpass. Resulting frequency response calculated via LTSpice Simulation ->1.745kHz

Title DC-link.SchDoc		UltraZohm	
Revision: Rev04	Design Engineer: K.Patel / D. Hufnagel	www.ultrazohm.com	
Project: UZ_D_Inverter.PrjPCB		Date: 07.04.2025	
		Sheet 6 of 15	

8*110µF = 880µF



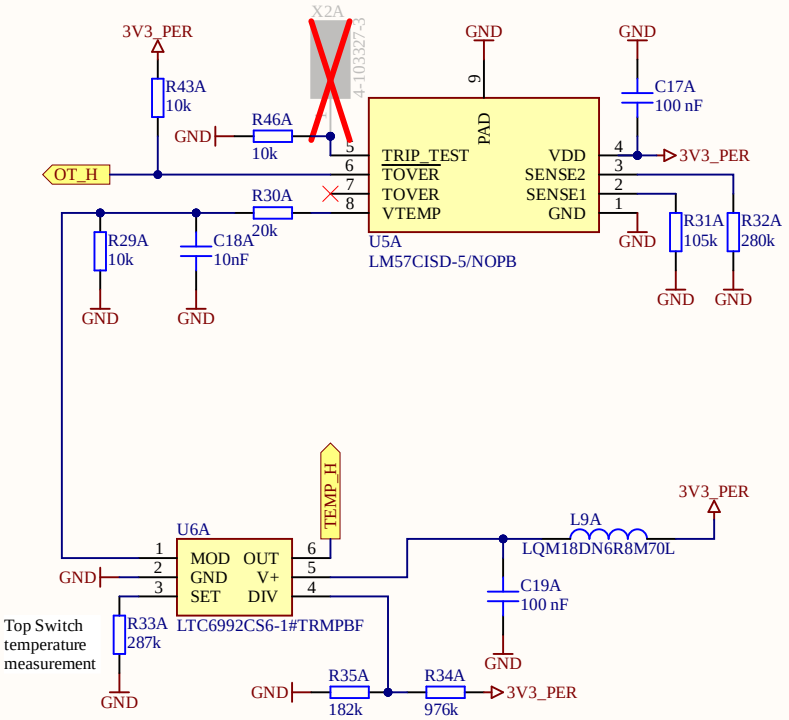


Additional MLCC caps with low internal R
15*10µF = 150µF

Total DC-Link capacitance
880µF + 150µF = 1030 µF

Title DC-Link-Caps.SchDoc		UltraZohm www.ultrazohm.com
Revision: Rev04	Design Engineer: K.Patel / D. Hufnagel	
Project: UZ_D_Inverter.PrjPCB		Date: 07.04.2025 Sheet 7 of 15

Top MOSFET Temp Measurement

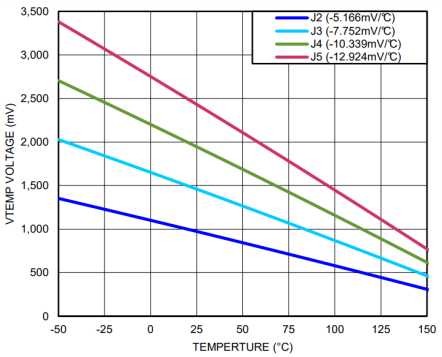


R_SENSE1 (R31) = 105k
R_SENSE2 (R32) = 280k is Gain
->J4 ->Leads to:
1.11V@105°C
2.00V@20°C

/TOVER trips at 105°C

VTEMP has voltage divider with 20k/10k:
MOD input voltages->
1.11V * 10/(10+20) = 0.37V@105°C
2.00V * 10/(10+20) = 0.67V@20°C

MOD input should be between 0.14V and 0.9V



Title Temp_Measurements.SchDoc		UltraZohm	
Revision: Rev04	Design Engineer: K.Patel / D. Hufnagel	www.ultrazohm.com	
Project: UZ_D_Inverter.PrjPCB		Date: 07.04.2025	
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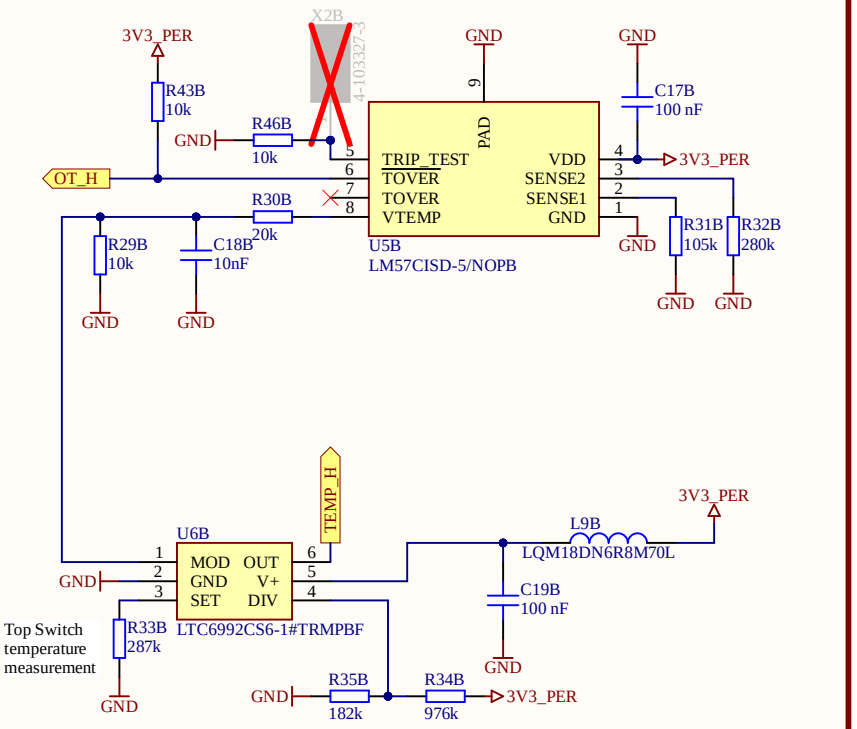
Top MOSFET Temp Measurement



R_SENSE1 (R31) = 105k
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2.00V@20°C

/TOVER trips at 105°C

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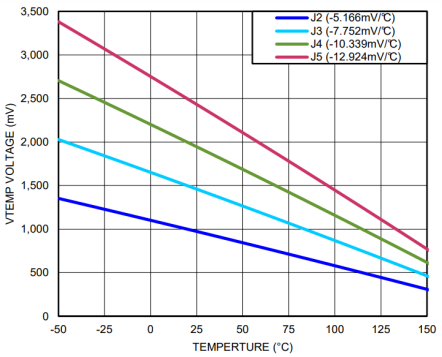
2.00V * 10/(10+20) = 0.67V@20°C

MOD input should be between 0.14V and 0.9V



Title Temp_Measurements.SchDoc		UltraZohm	
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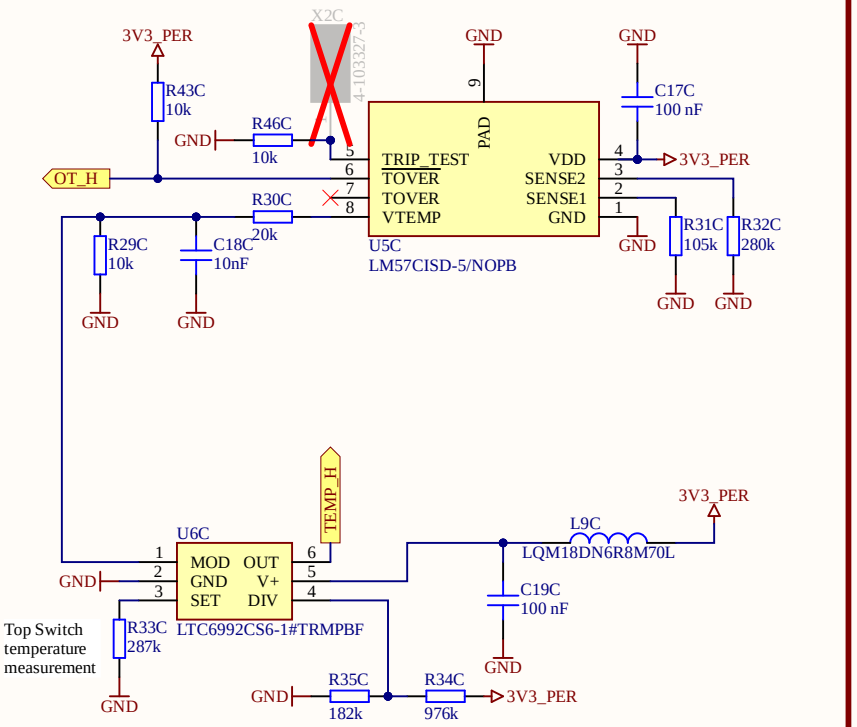
Top MOSFET Temp Measurement



R_SENSE1 (R31) = 105k
R_SENSE2 (R32) = 280k is Gain
->J4 ->Leads to:
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2.00V@20°C

/TOVER trips at 105°C

VTEMP has voltage divider with 20k/10k:
MOD input voltages->
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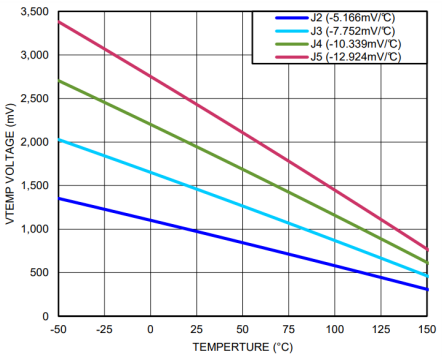
MOD input should be between 0.14V and 0.9V



Title Temp_Measurements.SchDoc		UltraZohm	
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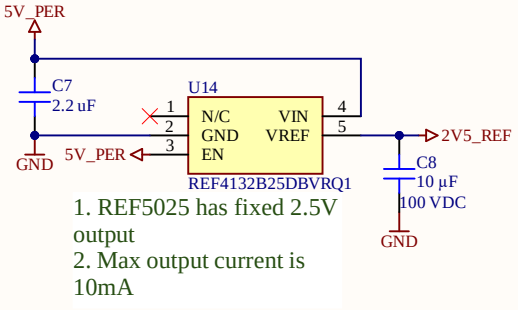

1. REF5025 has fixed 2.5V output
2. Max output current is 10mA

12.1 Layout Guidelines

Figure 31 illustrates an example of a PCB layout for a data acquisition system using the REF4132-Q1. Some key considerations are:

- Connect low-ESR, 0.1-µF ceramic bypass capacitors at V_{IN}, V_{REF} of the REF4132-Q1.
- Decouple other active devices in the system per the device specifications.
- Using a solid ground plane helps distribute heat and reduces electromagnetic interference (EMI) noise pickup.
- Place the external components as close to the device as possible. This configuration prevents parasitic errors (such as the Seebeck effect) from occurring.
- Do not run sensitive analog traces in parallel with digital traces. Avoid crossing digital and analog traces if possible, and only make perpendicular crossings when absolutely necessary.

12.2 Layout Example

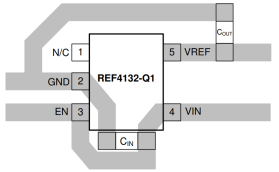

Figure 31. Layout Example

10.2.1 Design Requirements

A detailed design procedure is described based on a design example. For this design example, use the parameters listed in Table 2 as the input parameters.

Table 2. Design Example Parameters

DESIGN PARAMETER	VALUE
Input voltage V_{IN}	5 V
Output voltage V_{OUT}	2.5 V
REF4132-Q1 input capacitor	1 µF
REF4132-Q1 output capacitor	10 µF

Title 2.5V_REF.SchDoc		UltraZohm www.ultrazohm.com	
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