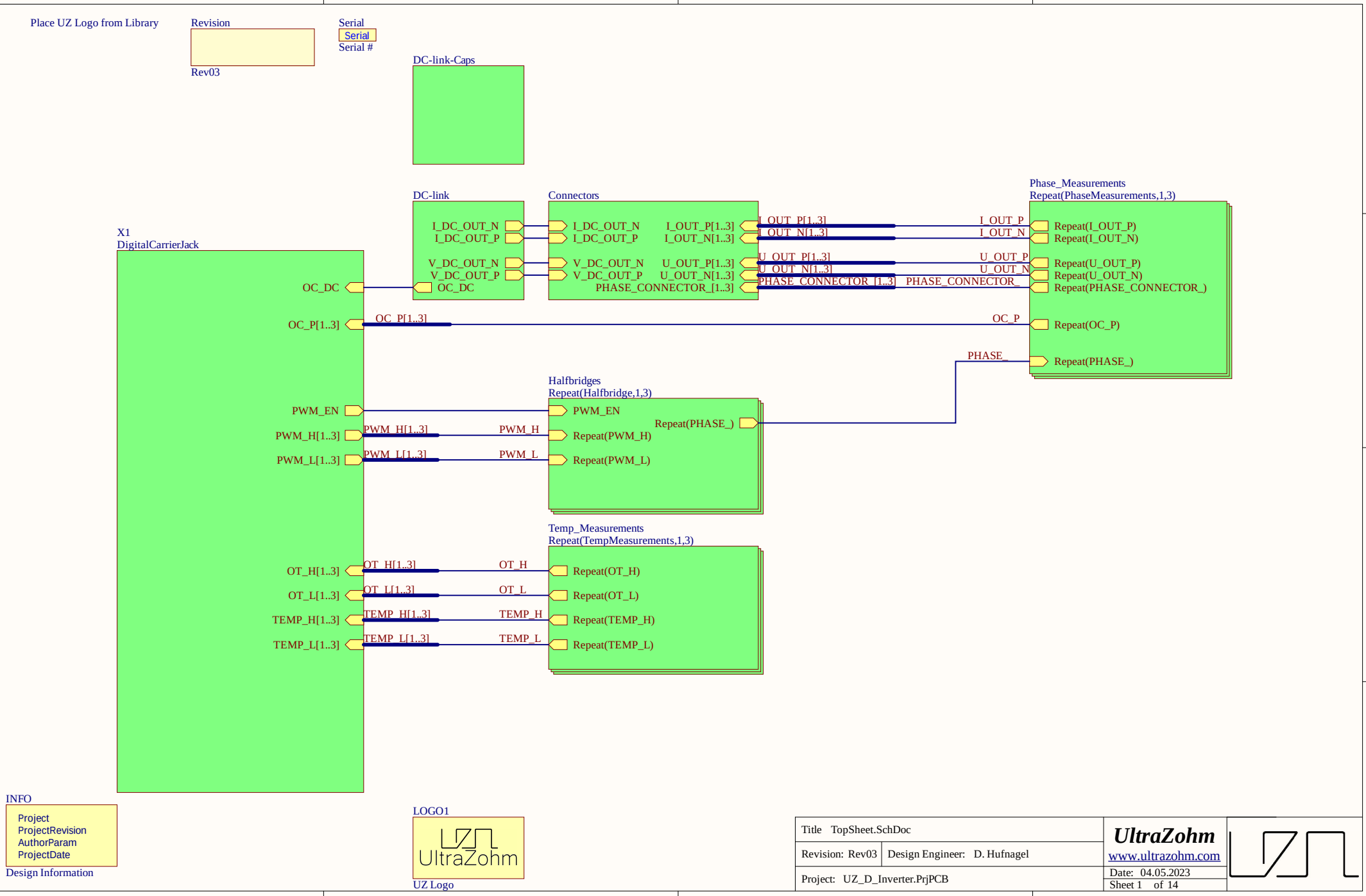
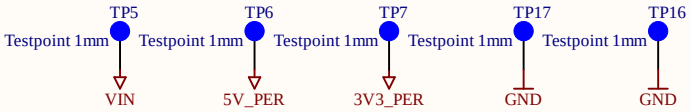
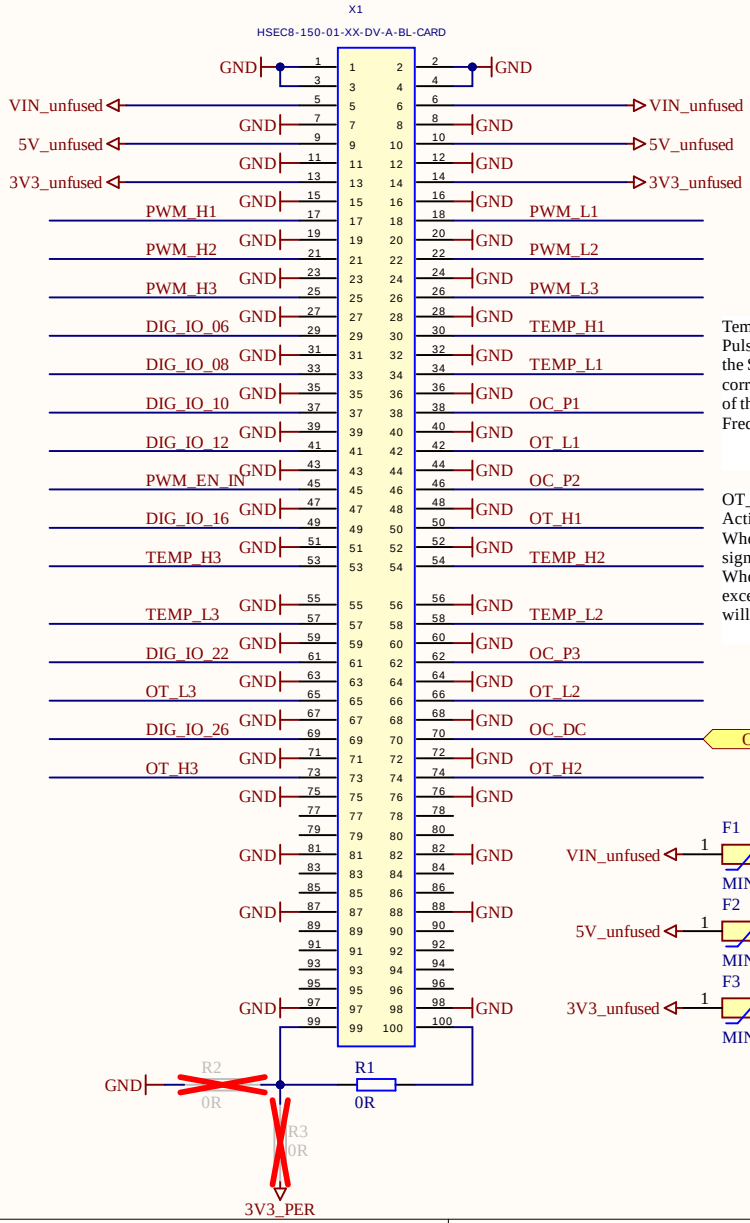
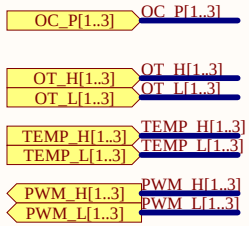

Place UZ Logo from Library
Revision
Rev03
Serial
Serial
Serial #
DC-link-Caps
DC-link
I_DC_OUT_N
I_DC_OUT_P
V_DC_OUT_N
V_DC_OUT_P
OC_DC
Connectors
I_DC_OUT_N
I_DC_OUT_P
V_DC_OUT_N
V_DC_OUT_P
OC_DC
I_OUT_P[1..3]
I_OUT_N[1..3]
U_OUT_P[1..3]
U_OUT_N[1..3]
PHASE_CONNECTOR_[1..3]
Phase_Measurements
Repeat(PhaseMeasurements,1,3)
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_)
X1
DigitalCarrierJack
OC_DC
OC_P[1..3]
OC_P[1..3]
OC_P
Repeat(OC_P)
PHASE_
Repeat(PHASE_)
Halfbridges
Repeat(Halfbridge,1,3)
PWM_EN
PWM_H[1..3]
PWM_L[1..3]
PWM_H[1..3]
PWM_L[1..3]
PWM_H
PWM_L
Repeat(PHASE_)
Repeat(PWM_H)
Repeat(PWM_L)
Temp_Measurements
Repeat(TempMeasurements,1,3)
OT_H[1..3]
OT_L[1..3]
TEMP_H[1..3]
TEMP_L[1..3]
OT_H
OT_L
TEMP_H
TEMP_L
Repeat(OT_H)
Repeat(OT_L)
Repeat(TEMP_H)
Repeat(TEMP_L)
INFO
Project
ProjectRevision
AuthorParam
ProjectDate
Design Information
LOGO1
UltraZohm
UZ Logo
Title TopSheet.SchDoc
Revision: Rev03
Design Engineer: D. Hufnagel
Project: UZ_D_Inverter.PrjPCB
UltraZohm
www.ultrazohm.com
Date: 04.05.2023
Sheet 1 of 14



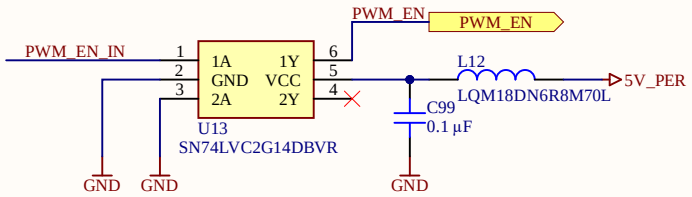




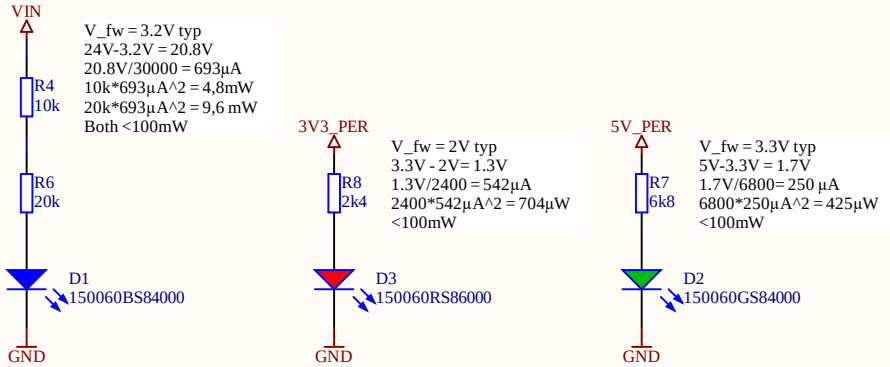
Temp_H/L signals:
Pulswidth modulated signal to the SoC. Pulswidth linear correlated to the temperature of the Mosfets
Frequency 11kHz

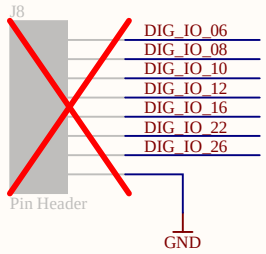
OT_H/L signals:
Active low signal.
When in normal operation, signal is 3V3.
When the measured temp exceeds 105°C, the OT signal will be set to LOW.

Inverting Schmitt Trigger

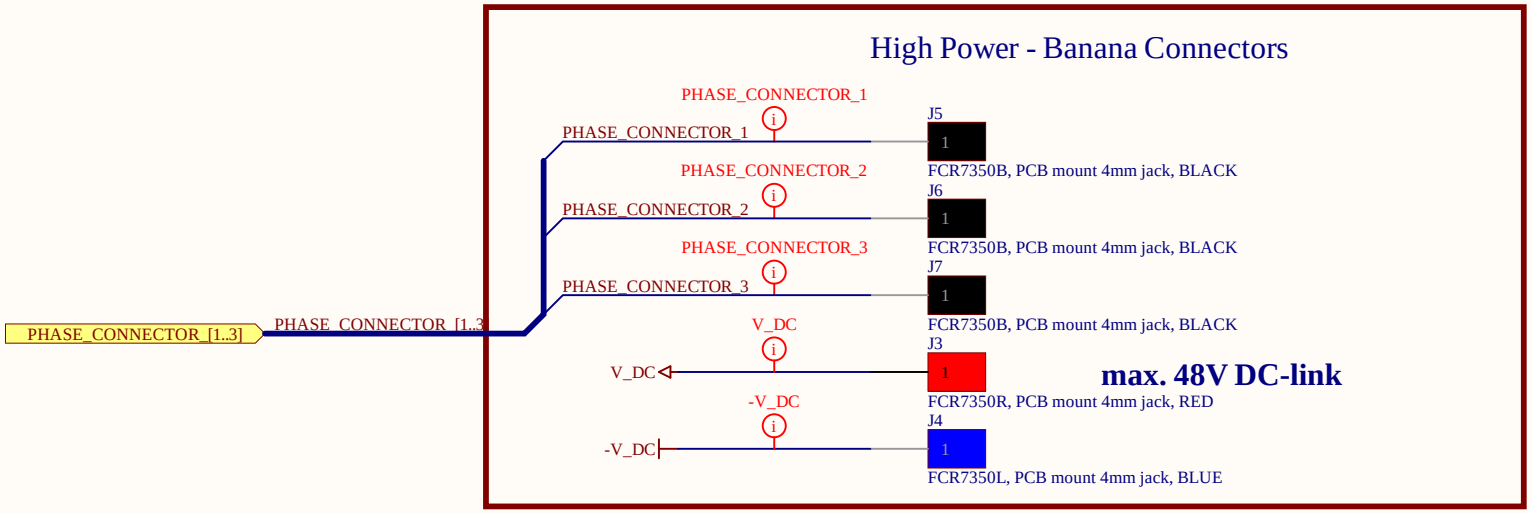


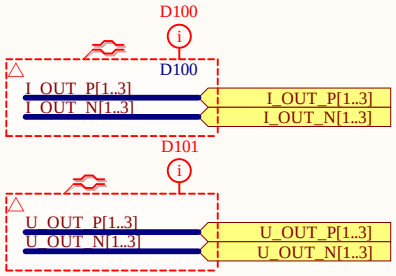
Status LEDs for UZ-supply rails

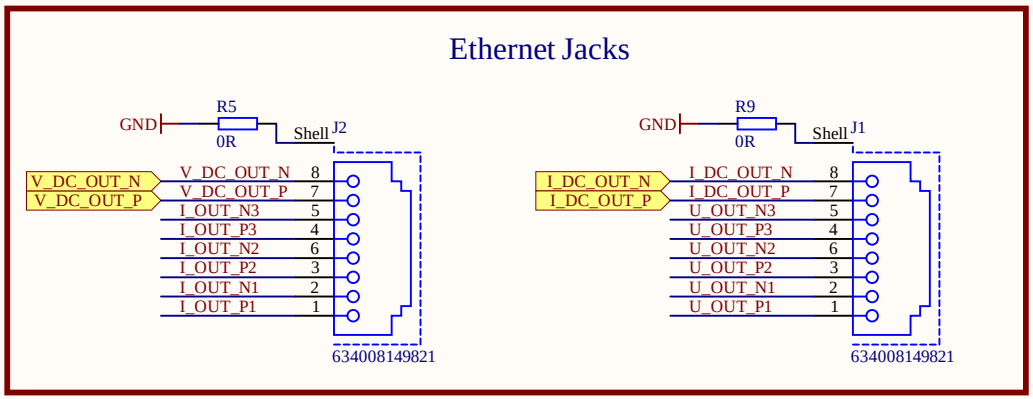




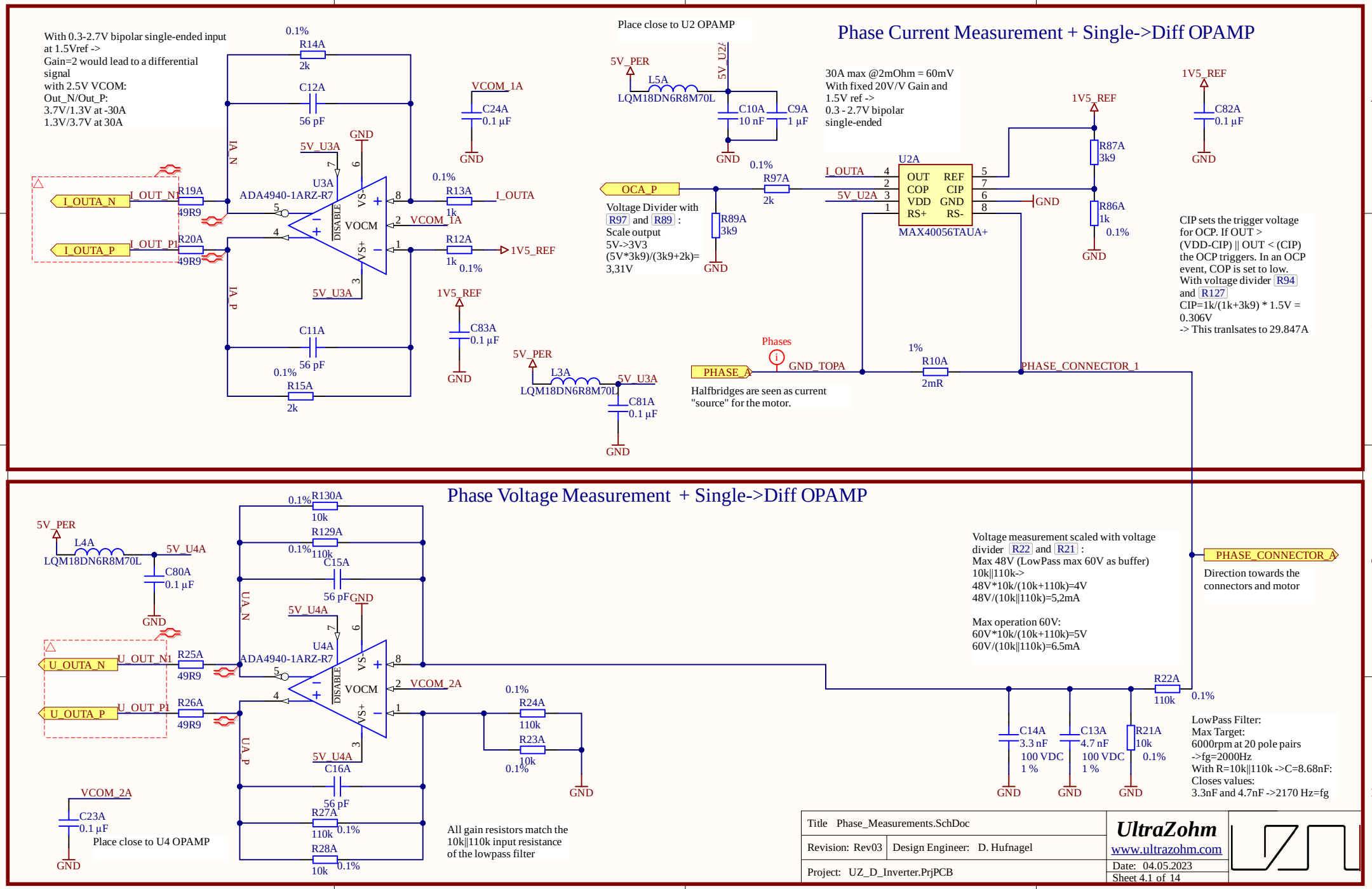
Title DigitalCarrierJack.SchDoc		**UltraZohm**	
Revision: Rev03	Design Engineer: D. Hufnagel	www.ultrazohm.com	
Project: UZ_D_Inverter.PrjPCB		Date: 04.05.2023	
		Sheet 2 of 14	







Title Connectors.SchDoc		UltraZohm www.ultrazohm.com	
Revision: Rev03	Design Engineer: D. Hufnagel		
Project: UZ_D_Inverter.PrjPCB		Date: 04.05.2023	Sheet 3 of 14


Phase Current Measurement + Single->Diff OPAMP
With 0.3-2.7V bipolar single-ended input at 1.5Vref ->
Gain=2 would lead to a differential signal
with 2.5V VCOM:
Out_N/Out_P:
3.7V/1.3V at -30A
1.3V/3.7V at 30A
I_OUTA_N
I_OUTA_P
I_OUT_N1
I_OUT_P1
R19A
R20A
49R9
R14A
2k
C12A
56 pF
R15A
C11A
IA_N
IA_P
U3A
ADA4940-1ARZ-R7
VOCM
VCOM_1A
C24A
0.1 µF
R13A
1k
R12A
I_OUTA
1V5_REF
C83A
5V_U3A
GND
Place close to U2 OPAMP
5V_PER
L5A
LQM18DN6R8M70L
C10A
10 nF
C9A
1 µF
30A max @2mOhm = 60mV
With fixed 20V/V Gain and
1.5V ref ->
0.3 - 2.7V bipolar
single-ended
OCA_P
R97A
2k
R89A
3k9
Voltage Divider with
R97 and R89 :
Scale output
5V->3V3
(5V*3k9)/(3k9+2k)=
3,31V
U2A
MAX40056TAUA+
I_OUTA
5V_U2A
R87A
3k9
R86A
1k
CIP sets the trigger voltage for OCP. If OUT > (VDD-CIP) || OUT < (CIP) the OCP triggers. In an OCP event, COP is set to low.
With voltage divider R94 and R127
CIP=1k/(1k+3k9) * 1.5V = 0.306V
-> This tranlsates to 29.847A
C82A
L3A
C81A
Phases
PHASE_A
GND_TOPA
R10A
2mR
PHASE_CONNECTOR_1
Halfbridges are seen as current "source" for the motor.
Phase Voltage Measurement + Single->Diff OPAMP
L4A
C80A
R130A
10k
R129A
110k
C15A
56 pF
U4A
R25A
R26A
U_OUTA_N
U_OUTA_P
U_OUT_N1
U_OUT_P1
UA_N
UA_P
R24A
R23A
C16A
R27A
R28A
VCOM_2A
C23A
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
R22A
C14A
3.3 nF
100 VDC
1 %
C13A
4.7 nF
R21A
10k
PHASE_CONNECTOR_A
Direction towards the connectors and motor
LowPass Filter:
Max Target:
6000rpm at 20 pole pairs
->fg=2000Hz
With R=10k||110k ->C=8.68nF:
Closes values:
3.3nF and 4.7nF ->2170 Hz=fg
Title Phase_Measurements.SchDoc
Revision: Rev03
Design Engineer: D. Hufnagel
Project: UZ_D_Inverter.PrjPCB
UltraZohm
www.ultrazohm.com
Date: 04.05.2023
Sheet 4.1 of 14

Phase Current Measurement + Single->Diff OPAMP

With 0.3-2.7V bipolar single-ended input at 1.5Vref ->
Gain=2 would lead to a differential signal
with 2.5V VCOM:
Out_N/Out_P:
3.7V/1.3V at -30A
1.3V/3.7V at 30A

I_OUTB_N
I_OUTB_P
R19B 49R9
R20B 49R9
I_OUT_N2
I_OUT_P2
IB_N
IB_P
U3B ADA4940-1ARZ-R7
VOCM
DISABLE
VS-
VS+
5V_U3B
GND
R14B 2k
C12B 56 pF
C11B 56 pF
R15B 2k
0.1%
VCOM_1B
C24B 0.1 µF
R13B 1k
R12B 1k
I_OUTB
1V5_REF
C83B 0.1 µF

Place close to U2 OPAMP

5V_PER
L5B LQM18DN6R8M70L
C10B 10 nF
C9B 1 µF
5V_U2B

30A max @2mOhm = 60mV
With fixed 20V/V Gain and
1.5V ref ->
0.3 - 2.7V bipolar
single-ended

OCB_P
R97B 2k
R89B 3k9
Voltage Divider with R97 and R89 :
Scale output
5V->3V3
(5V*3k9)/(3k9+2k)=
3,31V

U2B MAX40056TAUA+
OUT REF
COP CIP
VDD GND
RS+ RS-
I_OUTB
5V_U2B
R87B 3k9
R86B 1k
0.1%

CIP sets the trigger voltage for OCP. If OUT > (VDD-CIP) || OUT < (CIP) the OCP triggers. In an OCP event, COP is set to low.
With voltage divider R94 and R127
CIP=1k/(1k+3k9) * 1.5V = 0.306V
-> This tranlsates to 29.847A

5V_PER
L3B LQM18DN6R8M70L
5V_U3B
C81B 0.1 µF

Phases
PHASE_B
GND_TOPB
R10B 2mR 1%
PHASE_CONNECTOR_2

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

Phase Voltage Measurement + Single->Diff OPAMP

5V_PER
L4B LQM18DN6R8M70L
5V_U4B
C80B 0.1 µF

U_OUTB_N
U_OUTB_P
R25B 49R9
R26B 49R9
U_OUT_N2
U_OUT_P2
UB_N
UB_P
U4B ADA4940-1ARZ-R7
VOCM
DISABLE
VS-
VS+
VCOM_2B
R130B 10k
R129B 110k
C15B 56 pF
C16B 56 pF
R27B 110k
R28B 10k
R24B 110k
R23B 10k
0.1%

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_B
Direction towards the connectors and motor

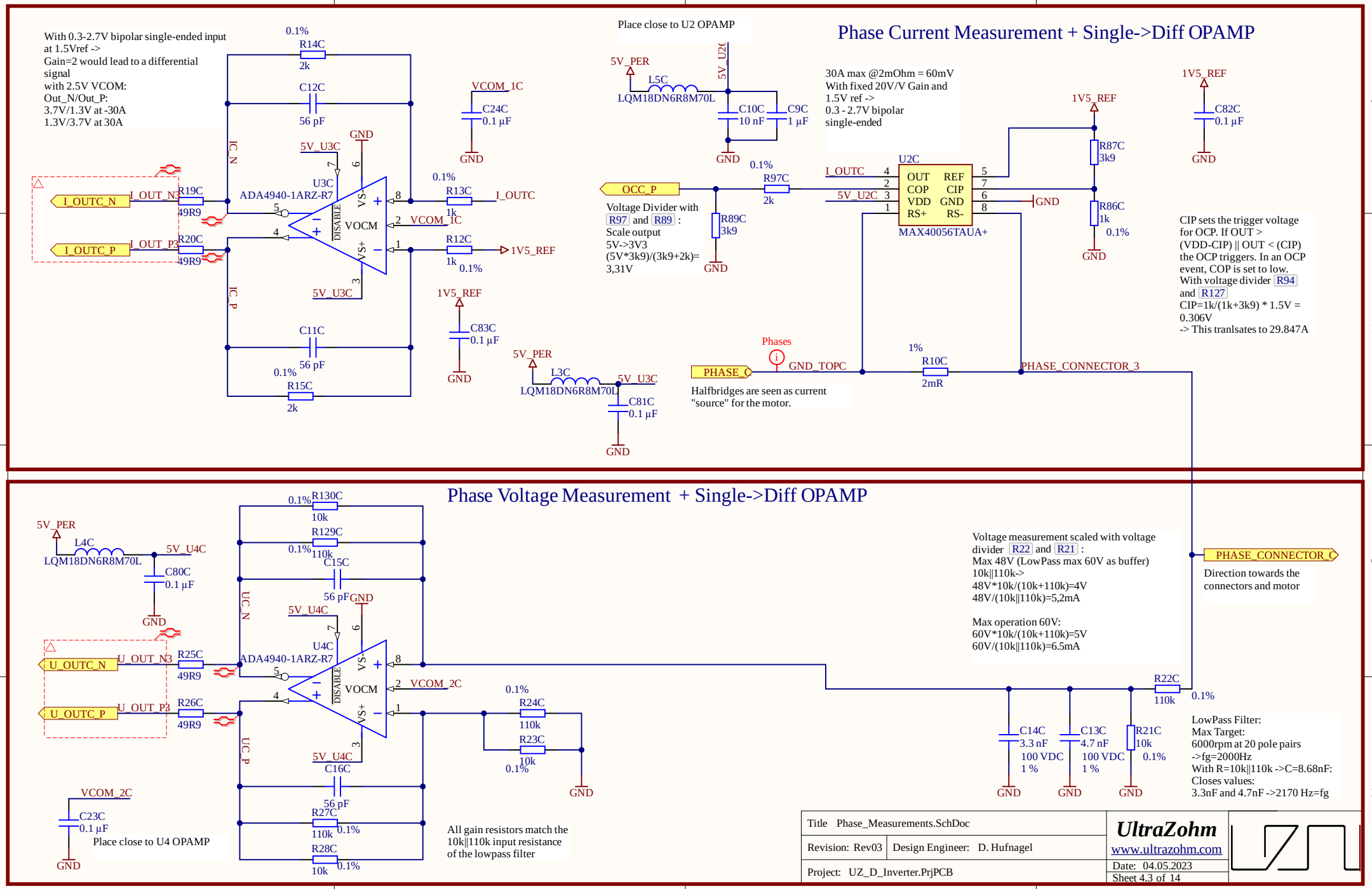
R22B 110k 0.1%
C14B 3.3 nF 100 VDC 1 %
C13B 4.7 nF 100 VDC 1 %
R21B 10k 0.1%

LowPass Filter:
Max Target:
6000rpm at 20 pole pairs
->fg=2000Hz
With R=10k||110k ->C=8.68nF:
Closes values:
3.3nF and 4.7nF ->2170 Hz=fg

C23B 0.1 µF
Place close to U4 OPAMP

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

Title Phase_Measurements.SchDoc		UltraZohm www.ultrazohm.com
Revision: Rev03	Design Engineer: D. Hufnagel	Date: 04.05.2023
Project: UZ_D_Inverter.PrjPCB		Sheet 4.2 of 14


Phase Current Measurement + Single->Diff OPAMP
With 0.3-2.7V bipolar single-ended input at 1.5Vref ->
Gain=2 would lead to a differential signal
with 2.5V VCOM:
Out_N/Out_P:
3.7V/1.3V at -30A
1.3V/3.7V at 30A
I_OUTC_N
I_OUTC_P
I_OUT_N3
I_OUT_P3
R19C
R20C
49R9
U3C
ADA4940-1ARZ-R7
VOCM
DISABLE
VS-
VS+
IC_N
IC_P
R14C
2k
C12C
56 pF
C11C
56 pF
R15C
2k
0.1%
VCOM_1C
C24C
0.1 µF
R13C
1k
R12C
1k
I_OUTC
1V5_REF
C83C
0.1 µF
5V_U3C
GND
Place close to U2 OPAMP
5V_PER
L5C
LQM18DN6R8M70L
C10C
10 nF
C9C
1 µF
30A max @2mOhm = 60mV
With fixed 20V/V Gain and
1.5V ref ->
0.3 - 2.7V bipolar
single-ended
OCC_P
R97C
2k
R89C
3k9
Voltage Divider with
R97 and R89 :
Scale output
5V->3V3
(5V*3k9)/(3k9+2k)=
3,31V
U2C
MAX40056TAUA+
OUT
COP
VDD
RS+
REF
CIP
GND
RS-
I_OUTC
5V_U2C
R87C
3k9
R86C
1k
C82C
0.1 µF
CIP sets the trigger voltage for OCP. If OUT > (VDD-CIP) || OUT < (CIP) the OCP triggers. In an OCP event, COP is set to low.
With voltage divider R94 and R127
CIP=1k/(1k+3k9) * 1.5V = 0.306V
-> This tranlsates to 29.847A
Phases
PHASE_C
GND_TOPC
R10C
2mR
1%
PHASE_CONNECTOR_3
L3C
LQM18DN6R8M70L
C81C
0.1 µF
Halfbridges are seen as current "source" for the motor.
Phase Voltage Measurement + Single->Diff OPAMP
5V_PER
L4C
LQM18DN6R8M70L
5V_U4C
C80C
0.1 µF
U_OUTC_N
U_OUTC_P
U_OUT_N3
U_OUT_P3
R25C
R26C
49R9
U4C
ADA4940-1ARZ-R7
VOCM
DISABLE
VS-
VS+
UC_N
UC_P
R130C
10k
R129C
110k
C15C
56 pF
C16C
56 pF
R27C
110k
R28C
10k
R24C
110k
R23C
10k
0.1%
VCOM_2C
C23C
0.1 µF
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_C
Direction towards the connectors and motor
R22C
110k
C14C
3.3 nF
100 VDC
1 %
C13C
4.7 nF
100 VDC
1 %
R21C
10k
LowPass Filter:
Max Target:
6000rpm at 20 pole pairs
->fg=2000Hz
With R=10k||110k ->C=8.68nF:
Closes values:
3.3nF and 4.7nF ->2170 Hz=fg
Title Phase_Measurements.SchDoc
Revision: Rev03
Design Engineer: D. Hufnagel
Project: UZ_D_Inverter.PrjPCB
UltraZohm
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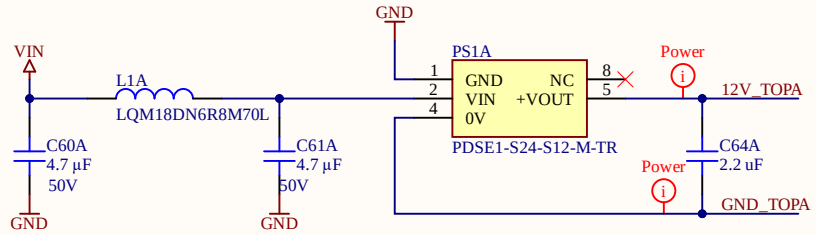
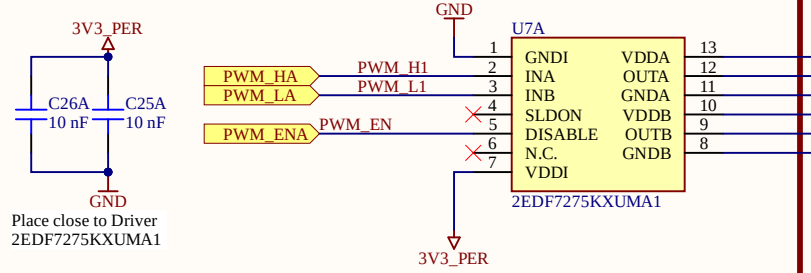
Date: 04.05.2023
Sheet 4.3 of 14

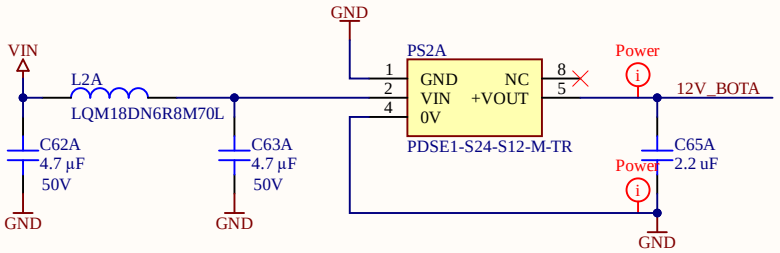
Isolated Top Side Gate Supply

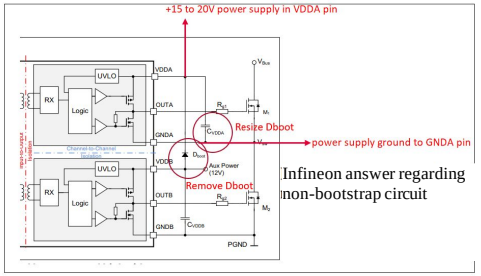


Gate Driver



Isolated Bottom Side Gate Supply





Infineon answer regarding non-bootstrap circuit

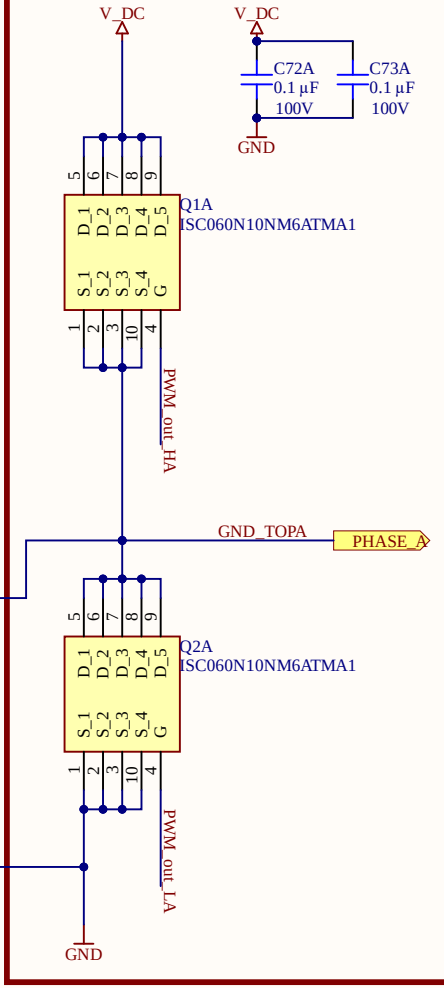
GATE_HIGHA
GATE_LOWA
RG1A
47R
RG2A
47R
PWM_out_HA
PWM_out_LA
12V_TOPA
GND_TOPA
12V_BOTA
C66A
0.1 µF
C67A
0.1 µF
C68A
0.1 µF
C69A
0.1 µF

IG_charging_peak <4A
IG_discharging_peak <8A

->Max currents:
IG_charging = 12V/(47+0.42)Ohm = 253mA
IG_discharging = 12V/(47 + 0.18)Ohm = 254mA

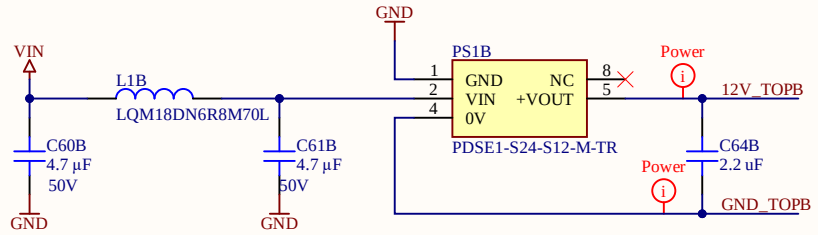
Datasheet said minimum 20x CISS for output-caps:
2x100nF > 20x2.5nF

MOSFETS

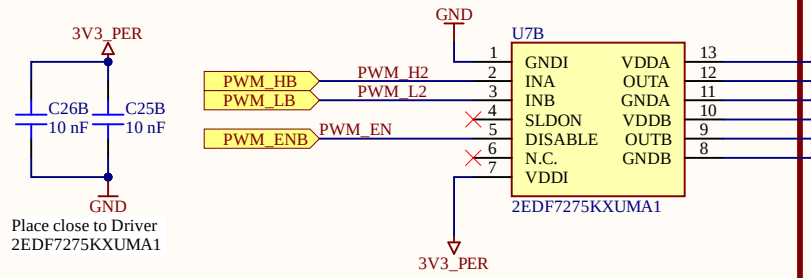


Title Halfbridges.SchDoc		UltraZohm www.ultrazohm.com	
Revision: Rev03	Design Engineer: D. Hufnagel		
Project: UZ_D_Inverter.PrjPCB		Date: 04.05.2023	Sheet 5.1 of 14

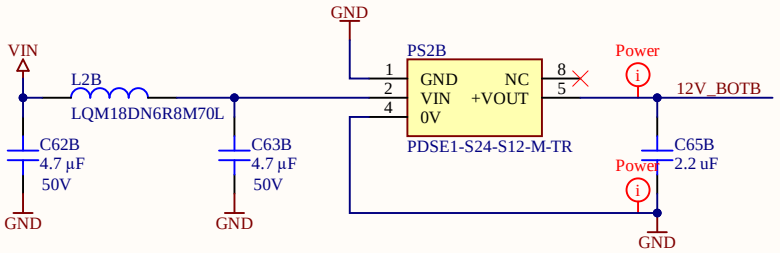
Isolated Top Side Gate Supply

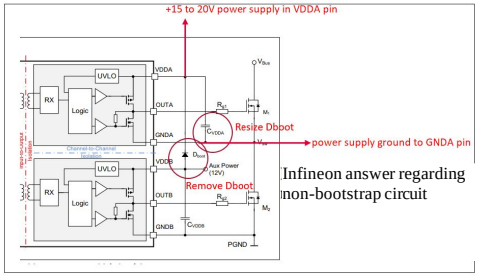


Gate Driver



Isolated Bottom Side Gate Supply





Infineon answer regarding non-bootstrap circuit

GATE_HIGHB
RG1B
47R
PWM_out_HB
GATE_LOWB
RG2B
47R
PWM_out_LB

C66B 0.1 µF
C67B 0.1 µF
C68B 0.1 µF
C69B 0.1 µF

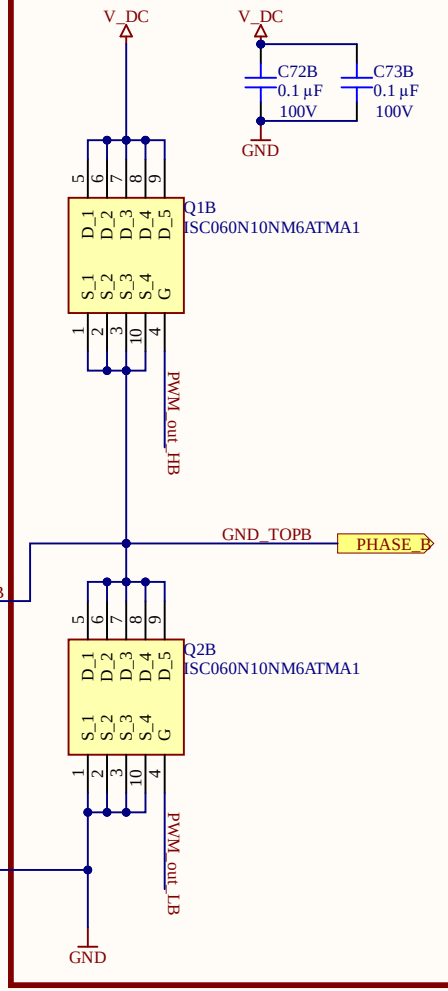
12V_TOPB
GND_TOPB
12V_BOTB

IG_charging_peak <4A
IG_discharging_peak <8A

->Max currents:
IG_charging = 12V/(47+0.42)Ohm = 253mA
IG_discharging = 12V/(47 + 0.18)Ohm = 254mA

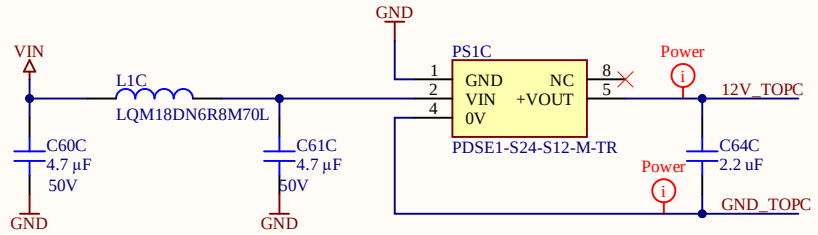
Datasheet said minimum 20x CISS for output-caps:
2x100nF > 20x2.5nF

MOSFETS

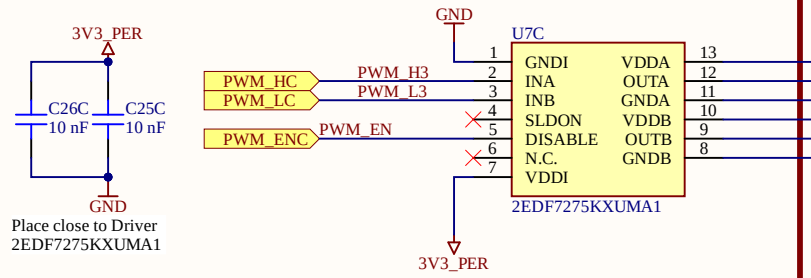


Title Halfbridges.SchDoc		UltraZohm www.ultrazohm.com	
Revision: Rev03	Design Engineer: D. Hufnagel		
Project: UZ_D_Inverter.PrjPCB		Date: 04.05.2023	Sheet 5.2 of 14

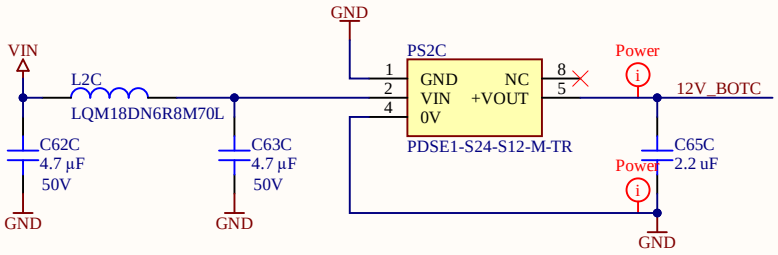
Isolated Top Side Gate Supply

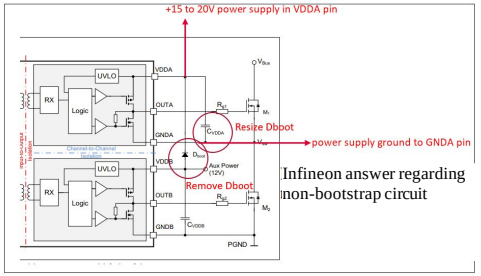


Gate Driver



Isolated Bottom Side Gate Supply





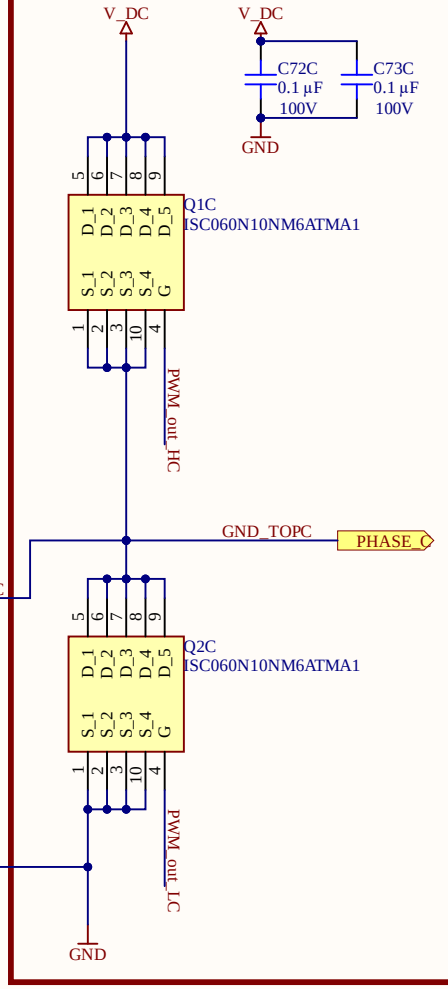
Infineon answer regarding non-bootstrap circuit

IG_charging_peak <4A
IG_discharging_peak <8A

->Max currents:
IG_charging = 12V/(47+0.42)Ohm = 253mA
IG_discharging = 12V/(47 + 0.18)Ohm = 254mA

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

MOSFETS



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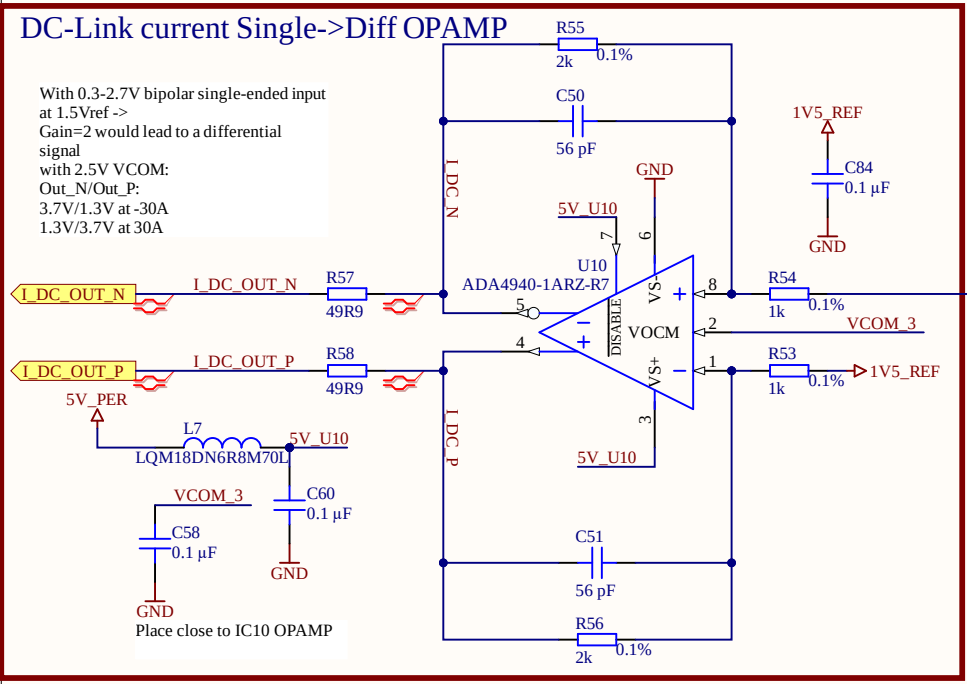
Revision: Rev03	Design Engineer: D. Hufnagel	Date: 04.05.2023
Project: UZ_D_Inverter.PrjPCB		Sheet 5.3 of 14

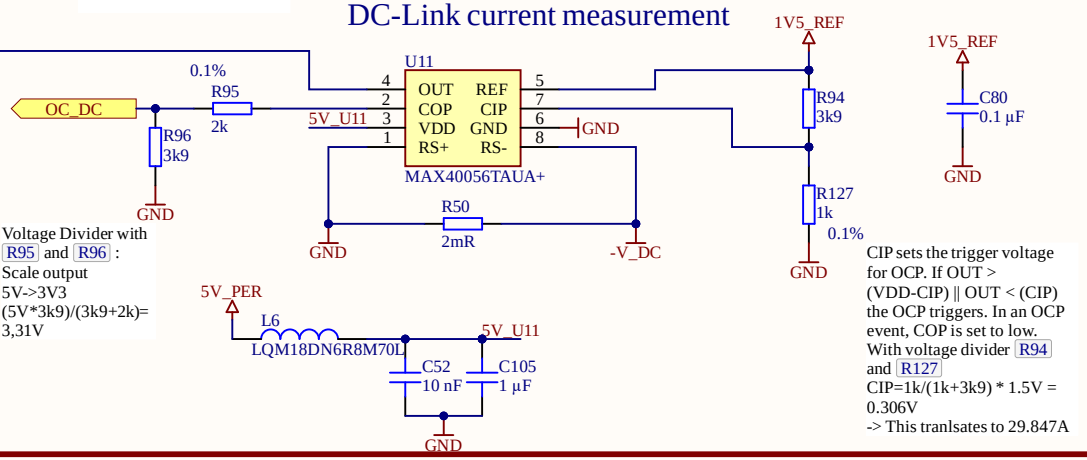
DC-Link current Single->Diff OPAMP

With 0.3-2.7V bipolar single-ended input
at 1.5Vref ->
Gain=2 would lead to a differential signal
with 2.5V VCOM:
Out_N/Out_P:
3.7V/1.3V at -30A
1.3V/3.7V at 30A



DC-Link current measurement

30A max @2mOhm = 60mV
With fixed 20V/V Gain and
1.5V ref ->
0.3 - 2.7V bipolar
single-ended

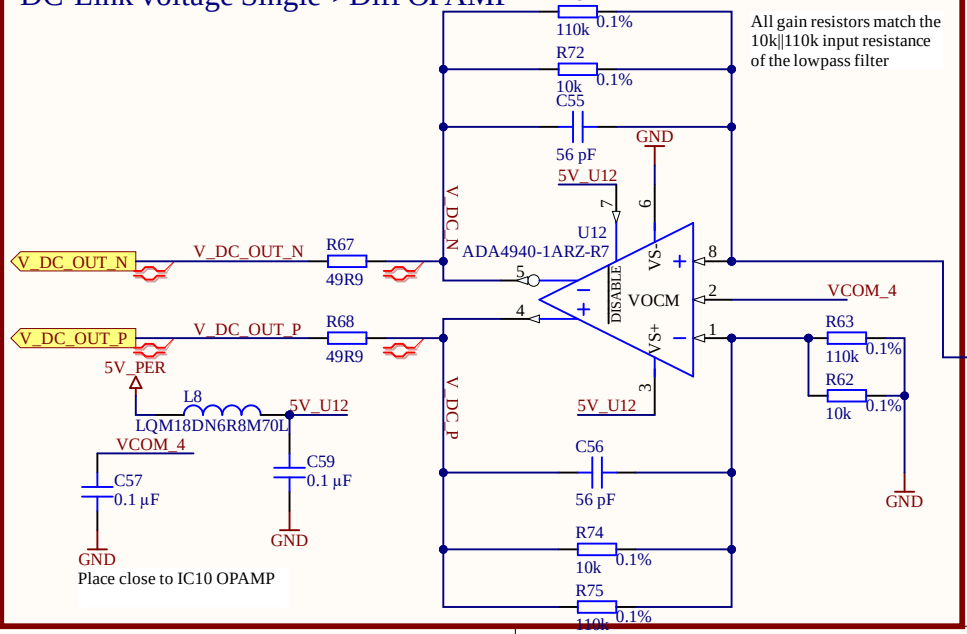


Voltage Divider with R95 and R96 :
Scale output
5V->3V3
(5V*3k9)/(3k9+2k)=
3,31V

CIP sets the trigger voltage for OCP. If OUT > (VDD-CIP) || OUT < (CIP) the OCP triggers. In an OCP event, COP is set to low.
With voltage divider R94 and R127
CIP=1k/(1k+3k9) * 1.5V = 0.306V
-> This tranlsates to 29.847A

DC-Link voltage Single->Diff OPAMP

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

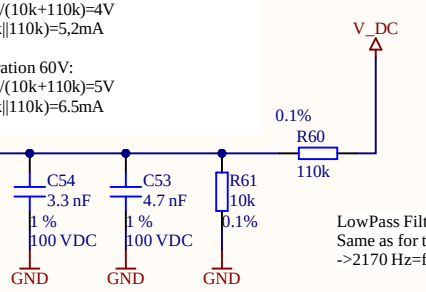


Place close to IC10 OPAMP

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

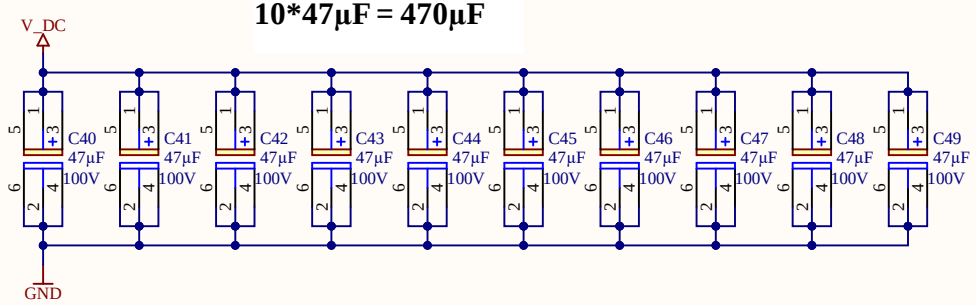
Max operation 60V:
60V*10k/(10k+110k)=5V
60V/(10k||110k)=6.5mA

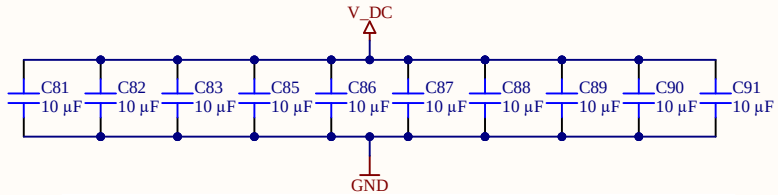


LowPass Filter:
Same as for the phases
->2170 Hz=fg

Title DC-link.SchDoc		UltraZohm	
Revision: Rev03	Design Engineer: D. Hufnagel	www.ultrazohm.com	
Project: UZ_D_Inverter.PrjPCB		Date: 04.05.2023	
		Sheet 6 of 14	

10*47µF = 470µF





Additional MLCC caps with low internal R
10*10µF = 100µF

Total DC-Link capacitance
470µF + 100µF = 570 µF

Title DC-Link-Caps.SchDoc		***UltraZohm***	
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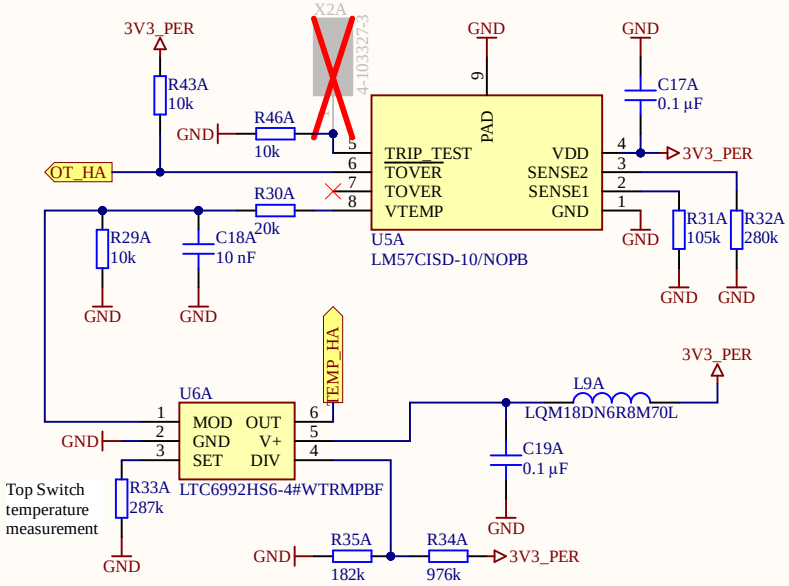
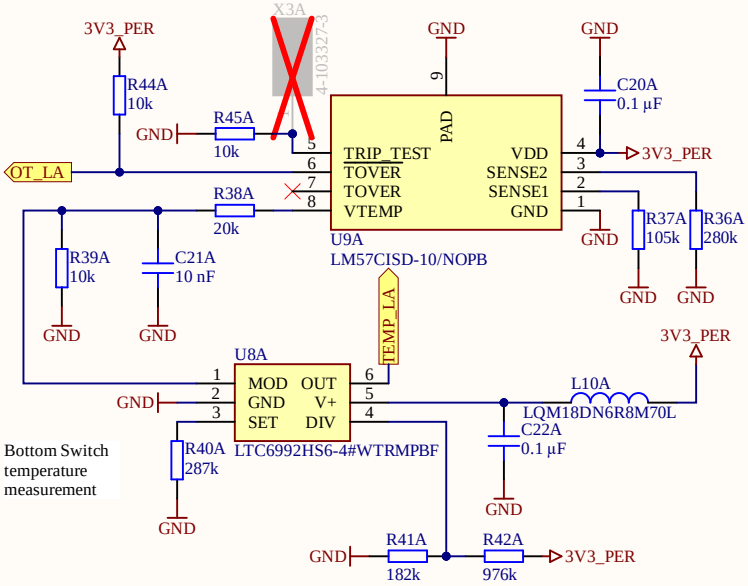
Project: UZ_D_Inverter.PrjPCB		Date: 04.05.2023	
		Sheet 7 of 14	

Top MOSFET Temp Measurement



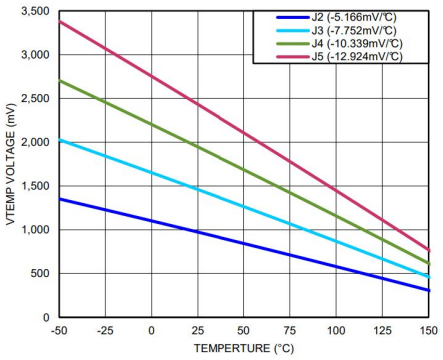
Bottom MOSFET Temp Measurement



R_SENSE1 (R31 / R37) = 105k
R_SENSE2 (R32 / R36) = 280k
is Gain
->J4 ->Leads to:
1.11V@105°C
2.00V@20°C

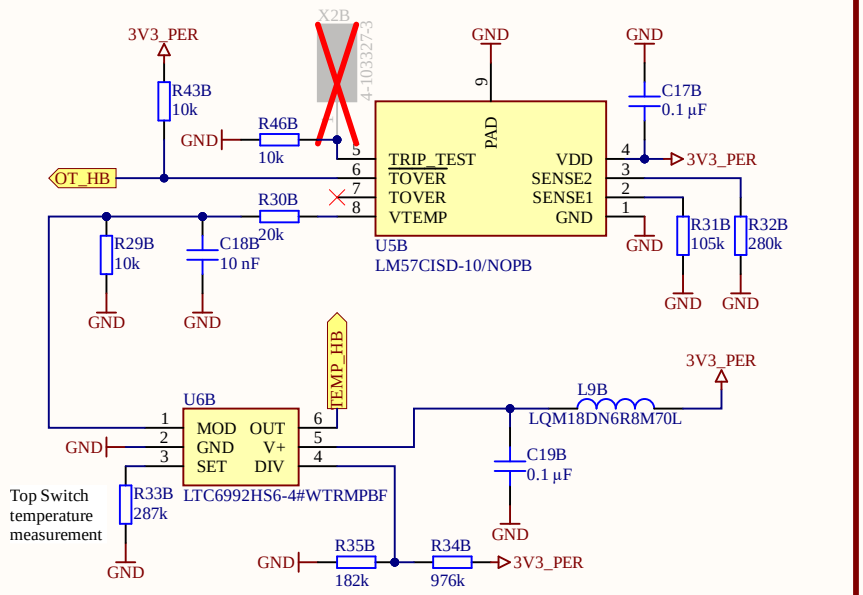
VTEMP has voltage divider with 20k/10k:
MOD input voltages->
1.11V * 10/(10+20) = 0.37V@105°C
2.00V * 10/(10+20) = 0.67V@20°C

MOD input should be between 0.14V and 0.9V

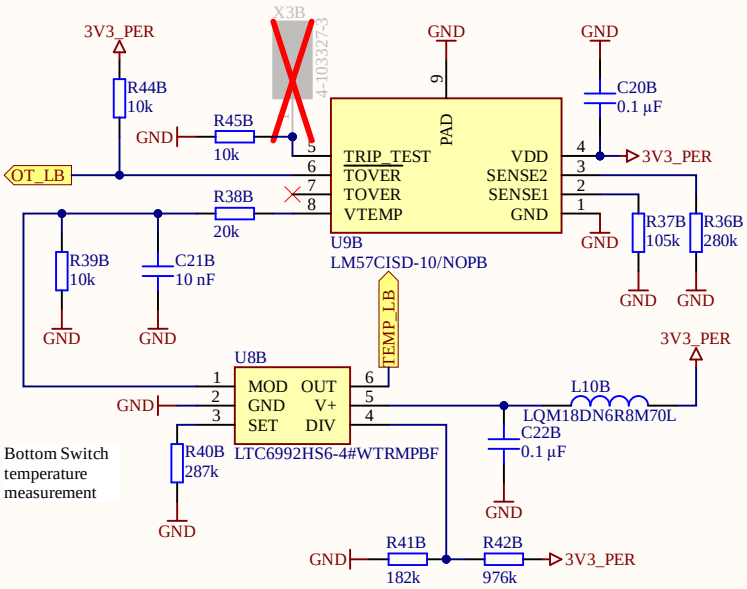


Title Temp_Measurements.SchDoc		UltraZohm	
Revision: Rev03	Design Engineer: D. Hufnagel	www.ultrazohm.com	
Project: UZ_D_Inverter.PrjPCB		Date: 04.05.2023	
		Sheet 8.1 of 14	

Top MOSFET Temp Measurement



Bottom MOSFET Temp Measurement



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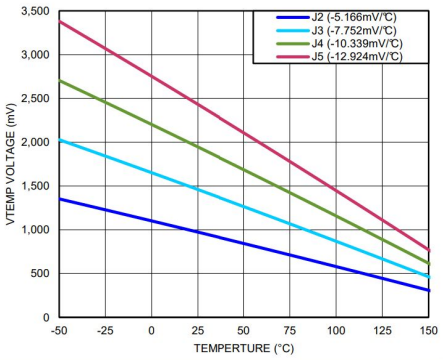

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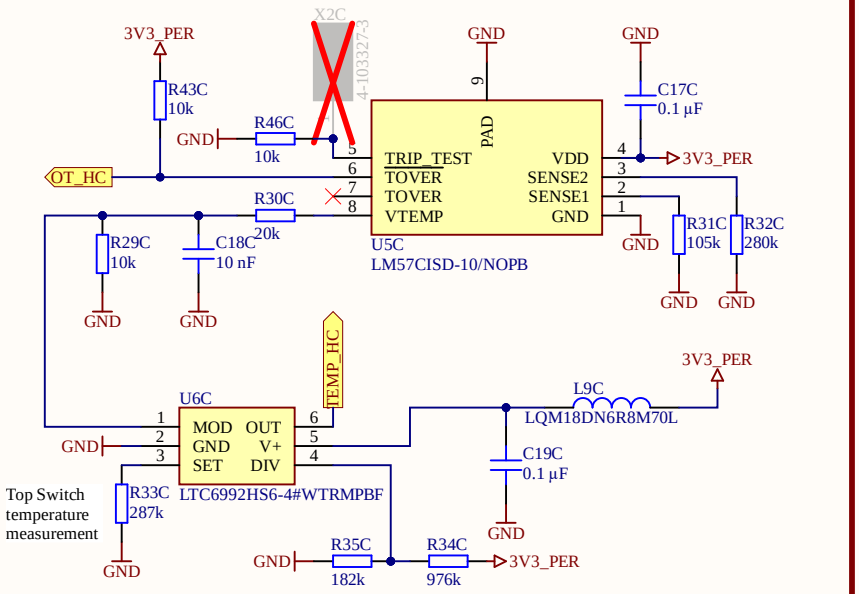
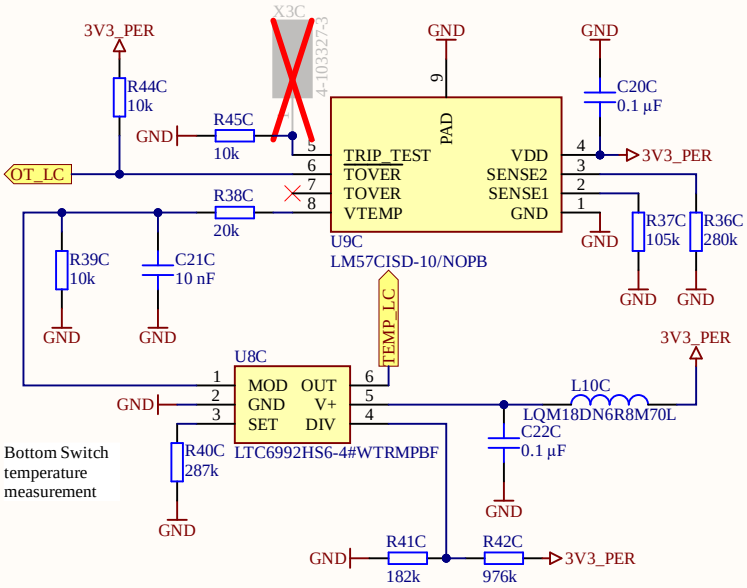
Revision: Rev03	Design Engineer: D. Hufnagel	Date: 04.05.2023
Project: UZ_D_Inverter.PrjPCB		Sheet 8.2 of 14

Top MOSFET Temp Measurement



Bottom MOSFET Temp Measurement



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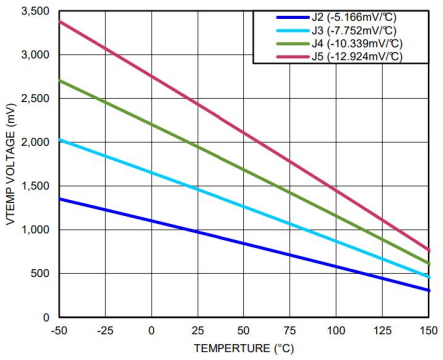

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Project: UZ_D_Inverter.PrjPCB		Date: 04.05.2023	
		Sheet 8.3 of 14	