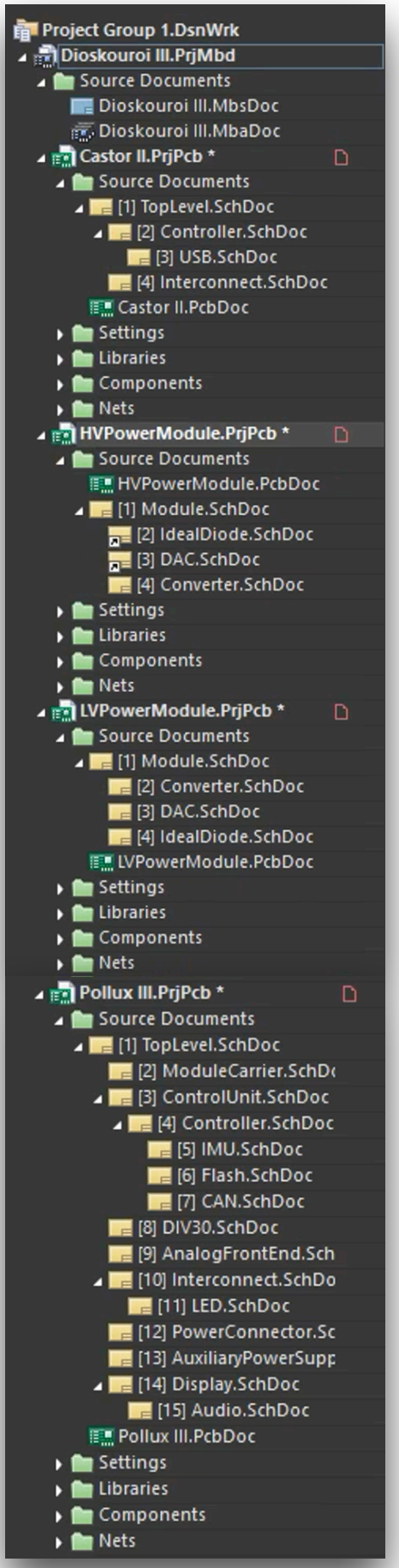
Power Supply V4

Review document

Power Supply V4



Dioskouroi III

Assembly document of all modules. Nothing to review here.

Castor II

PCB and schematics of Castor II, the power supply's 2.4GHz WiFi module. Same design as last year.

HV Power Module

PCB and schematics of the high-voltage power module.

Two 24V buck-boosts were implemented instead of one boost and one buck-boost this year. The converter schematics remains the same. Additionally, an ideal diode was added to the output and a DAC changes the feedback loop's reference to reprogram the output voltage if necessary.
Please review the PCB, IdealDiode and DAC.

LV Power Module

PCB and schematics of the low-voltage power module.

A dual buck controller that nominally provides 5V/15V is used. The converter's design is the same as last year.
The PCB however has completely been redesigned.

Pollux III

PCB and schematics of the power supply's motherboard.

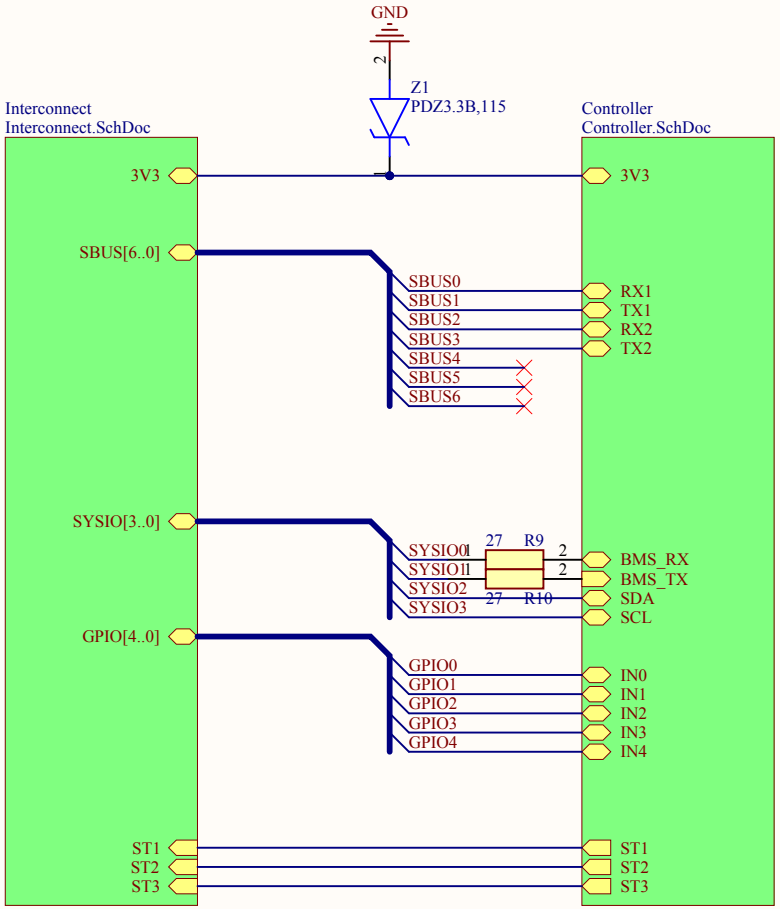
A STM32H7 monitors the power supplies through power monitors and temperature sensors.

As space allowed, an IMU, a touch-screen and an audio amplifier were also added to the board.

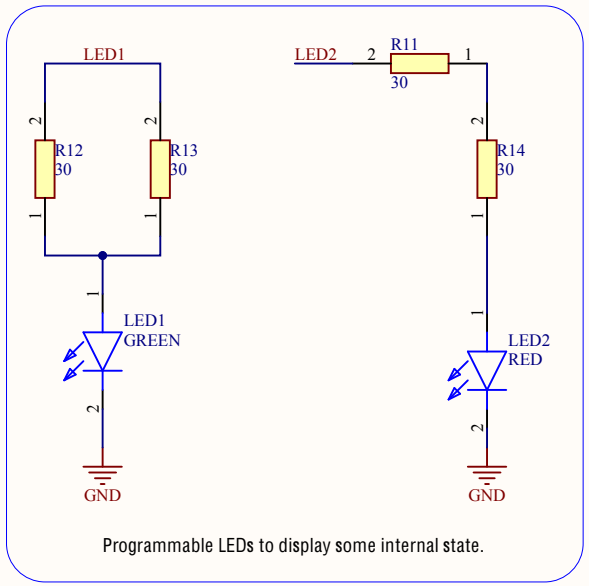
If you can, please review the PCB, Controller, IMU, AuxiliaryPowerSupply, Display and Audio. Some footprints still need to be updated though.

Castor II

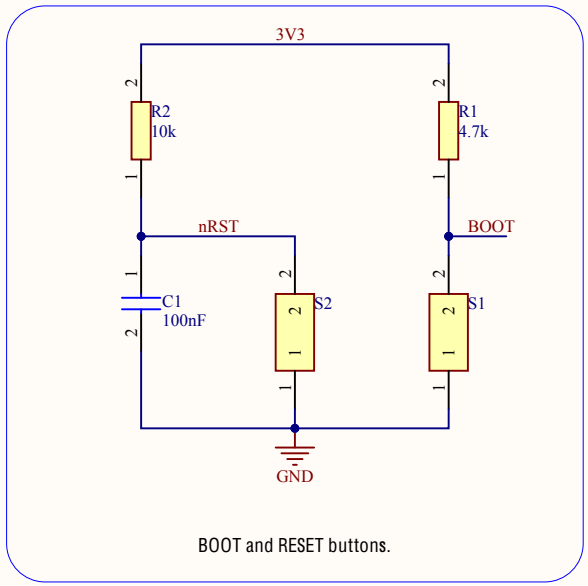
WiFi Module



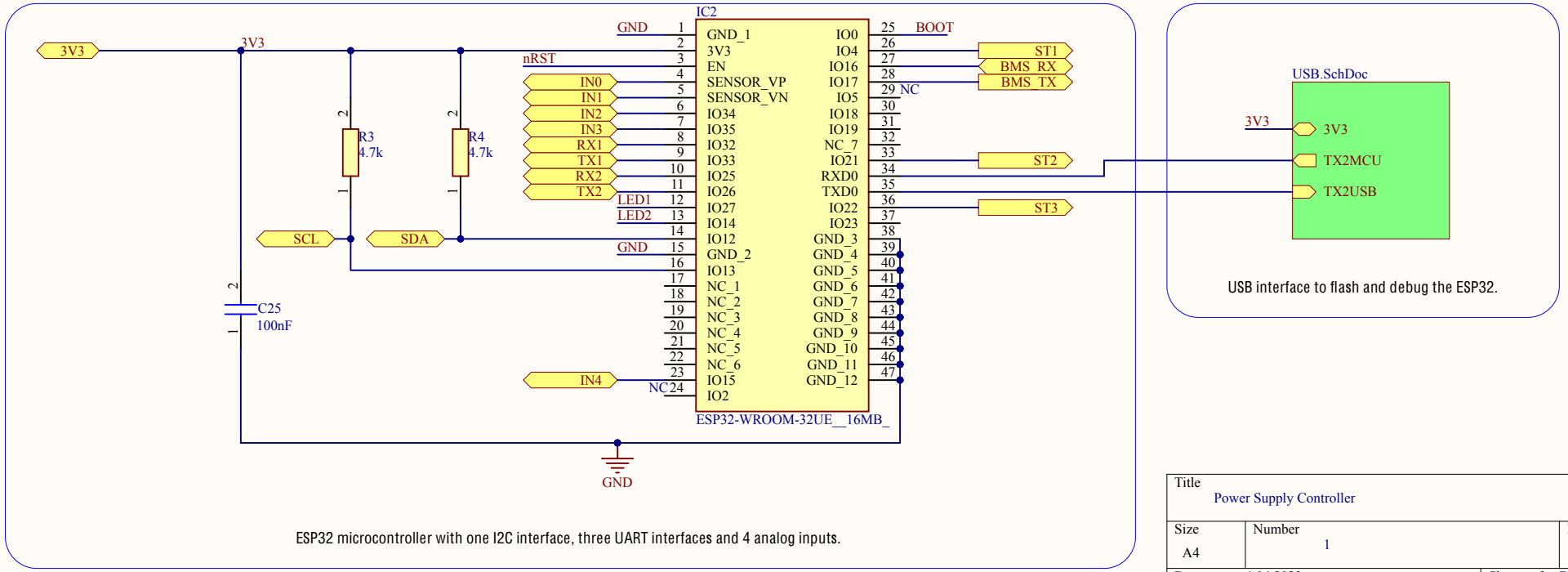
Title	Control Module Top Level		
Size: A4	Number: 1		Revision: 1
Date: 4.04.2023		Sheet of	EPFL Xplore
File: \\..\TopLevel.SchDoc		Drawn By:	Arion Zimmermann



Programmable LEDs to display some internal state.



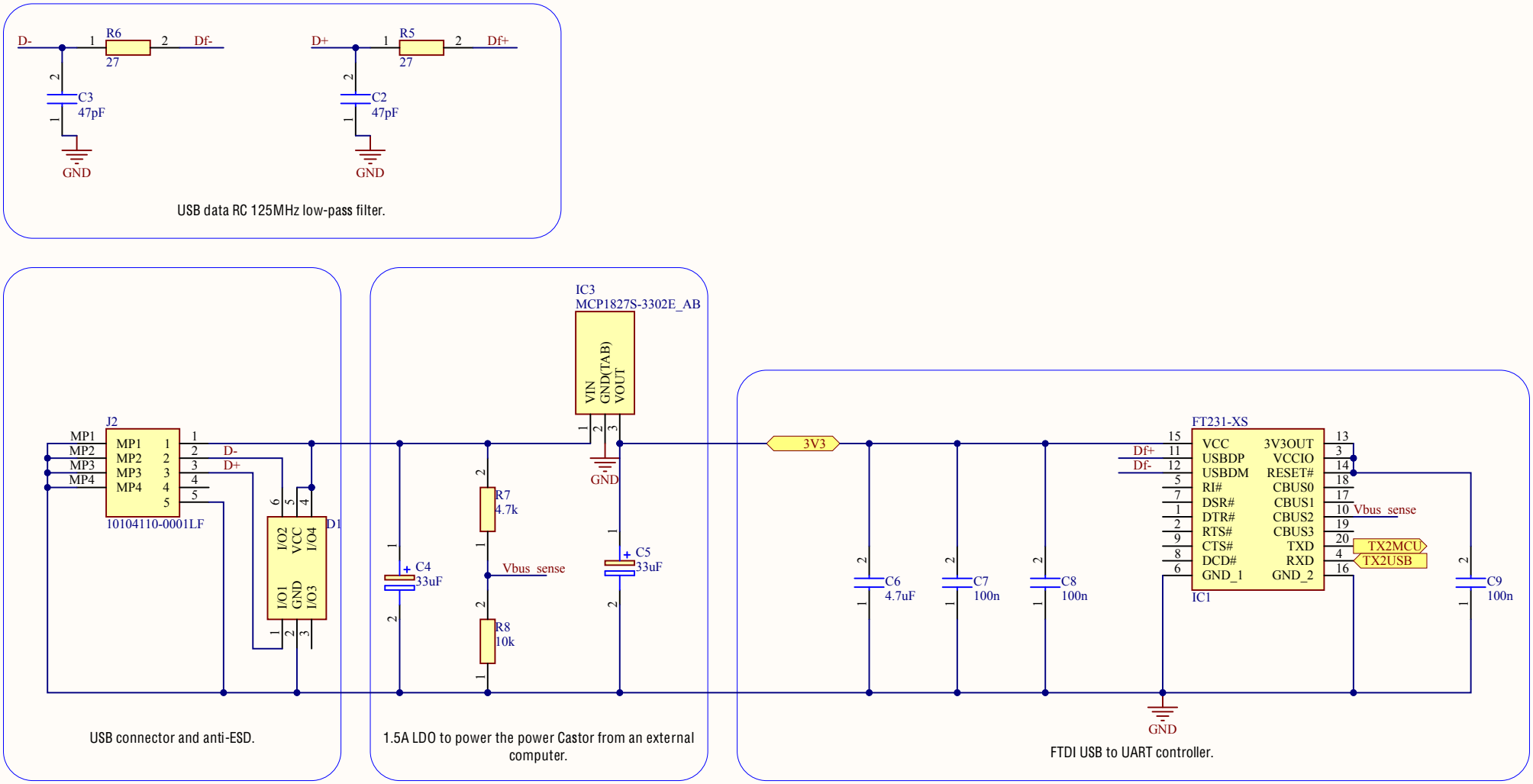
BOOT and RESET buttons.



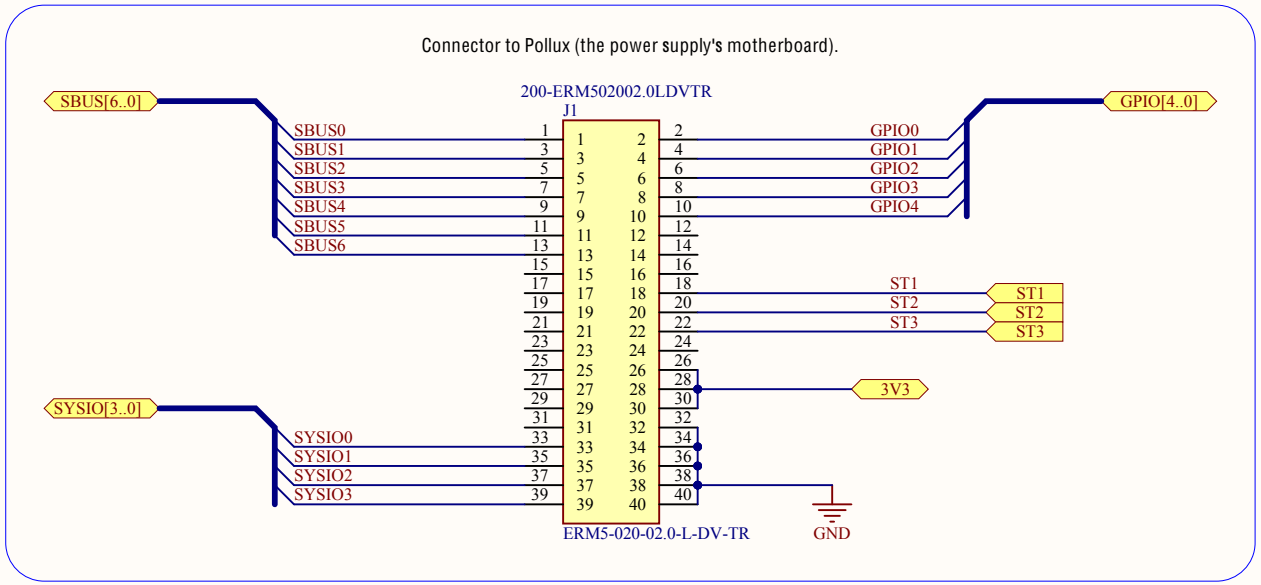
ESP32 microcontroller with one I2C interface, three UART interfaces and 4 analog inputs.

USB interface to flash and debug the ESP32.

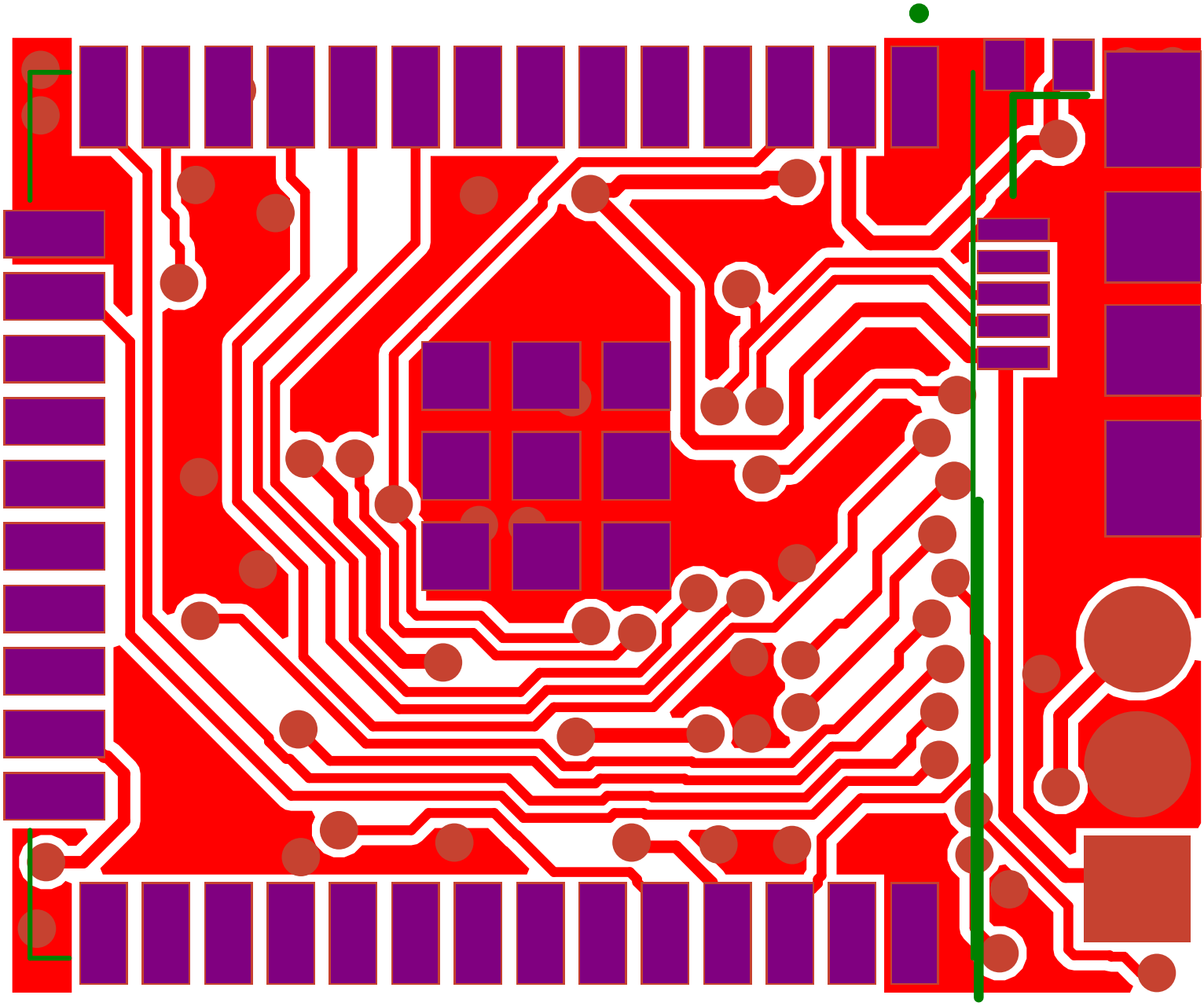
Title: Power Supply Controller		
Size: A4	Number: 1	Revision: 7
Date: 4.04.2023	Sheet of: DC/DC converters	
File: \\..\Controller.SchDoc	Drawn By: Arion Zimmermann	

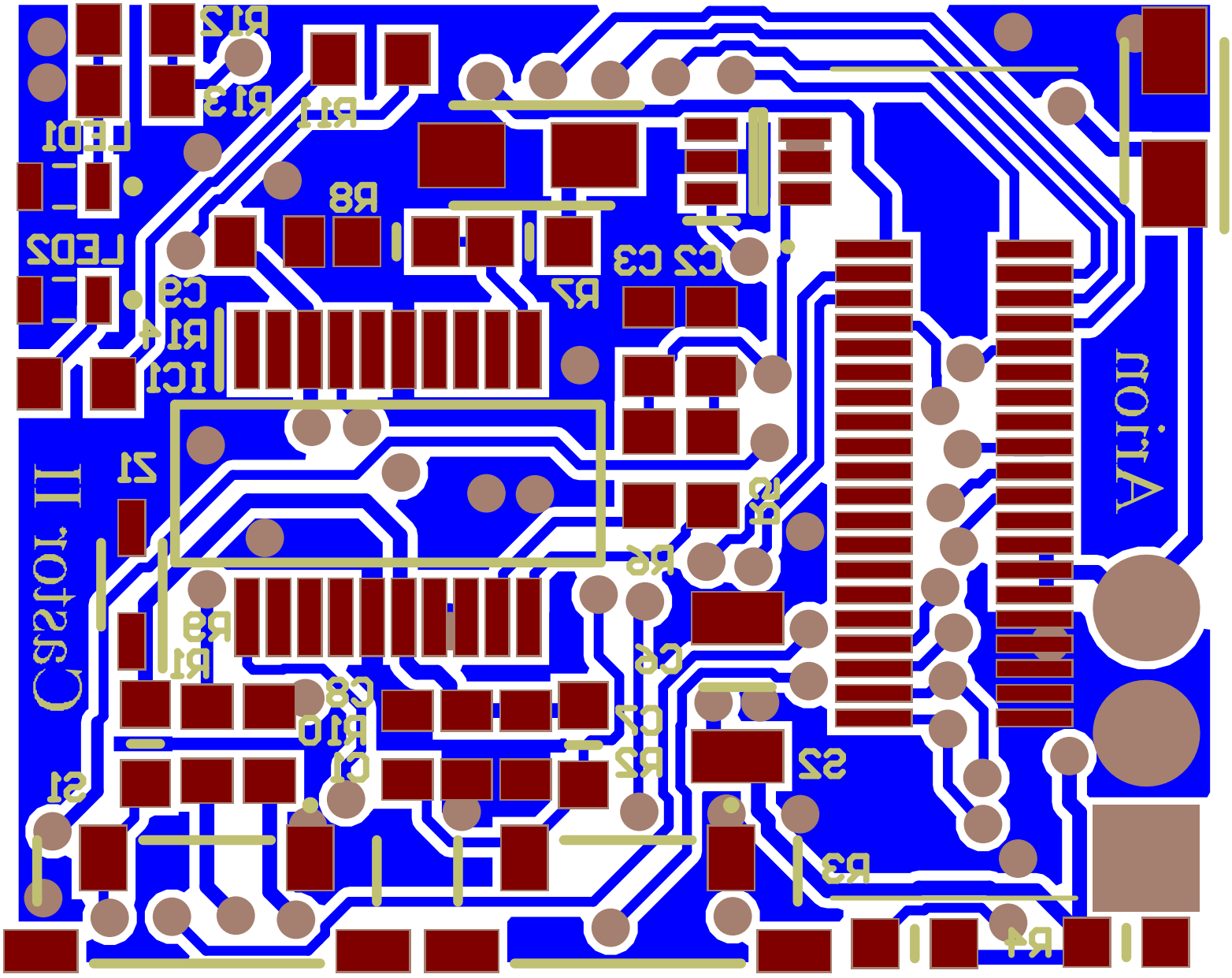


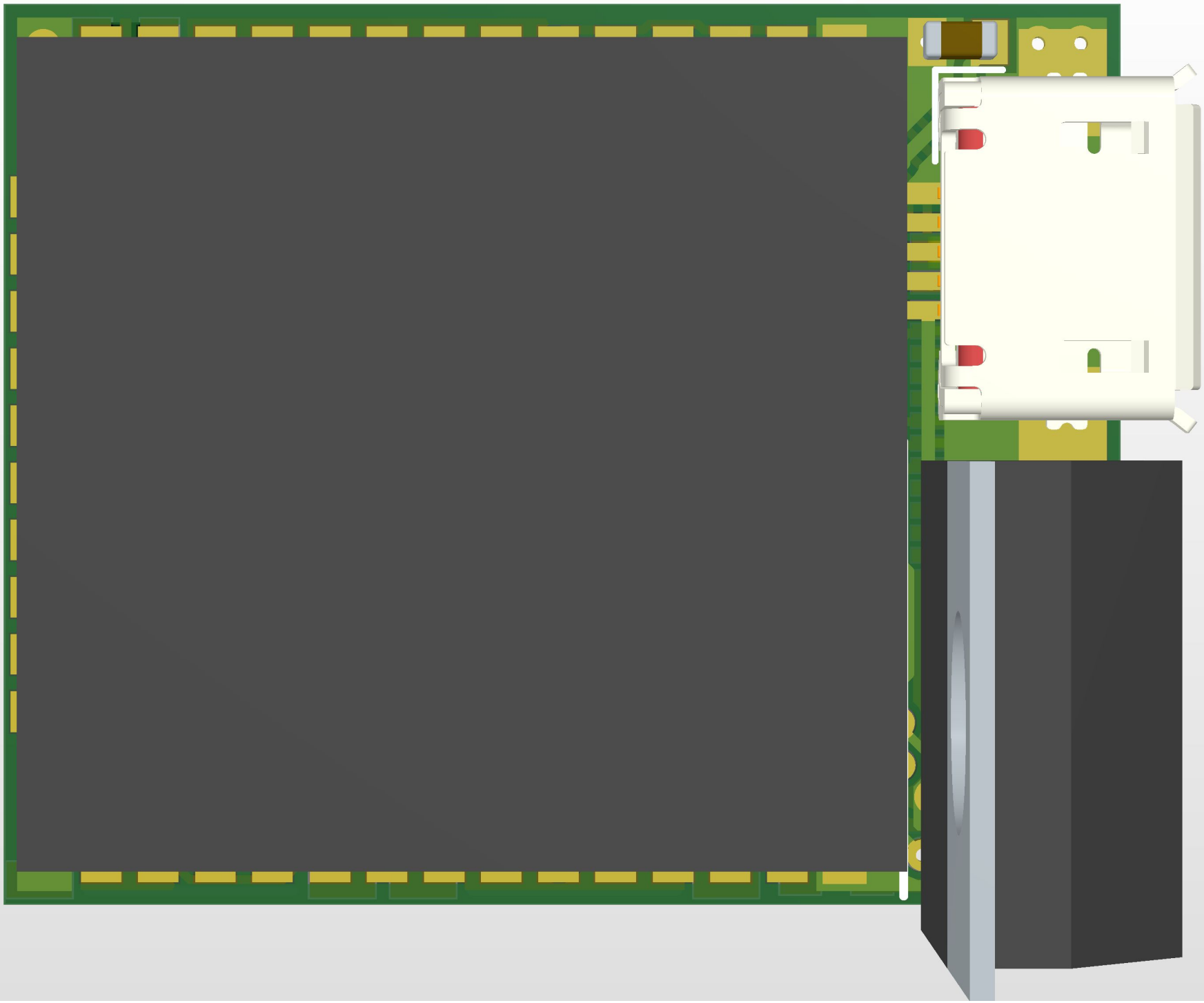
Title: Control Module USB Controller		
Size: A4	Number: 1	Revision: 1
Date: 4.04.2023	Sheet of: EPFL Xplore	
File: \\..\USB.SchDoc	Drawn By: Arion Zimmermann	

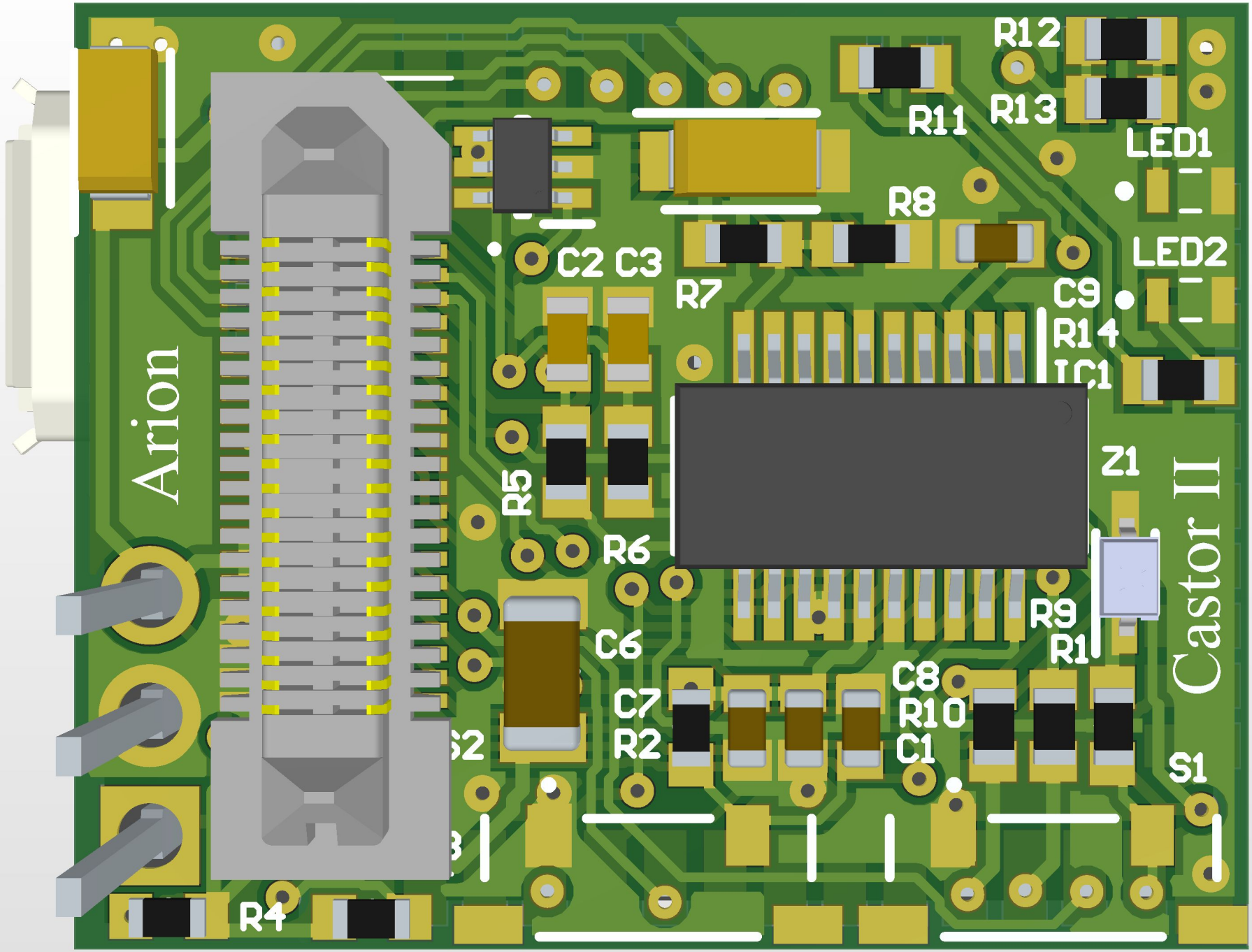


Title: Control Module Interconnect		
Size: A4	Number: 1	Revision: 1
Date: 4.04.2023	Sheet of	EPFL Xplore
File: \\..\Interconnect.SchDoc		Drawn By: Arion Zimmermann



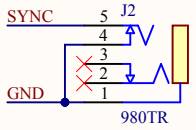

Aria
Castor II
R12
R13
R11
LED1
LED2
R8
R7
C2
C3
C9
R14
IC1
J1
R6
Q3
R9
R1
C8
R10
C1
C6
C7
R2
S2
S1
R3
R4



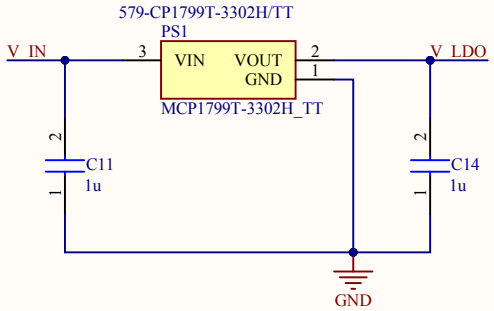

Arion
Castor II
R12
R13
R11
LED1
R8
LED2
C2
C3
R7
C9
R14
IC1
Z1
R5
R6
R9
R1
C6
C8
C7
R10
R2
C1
S1
R4

HV Power Module

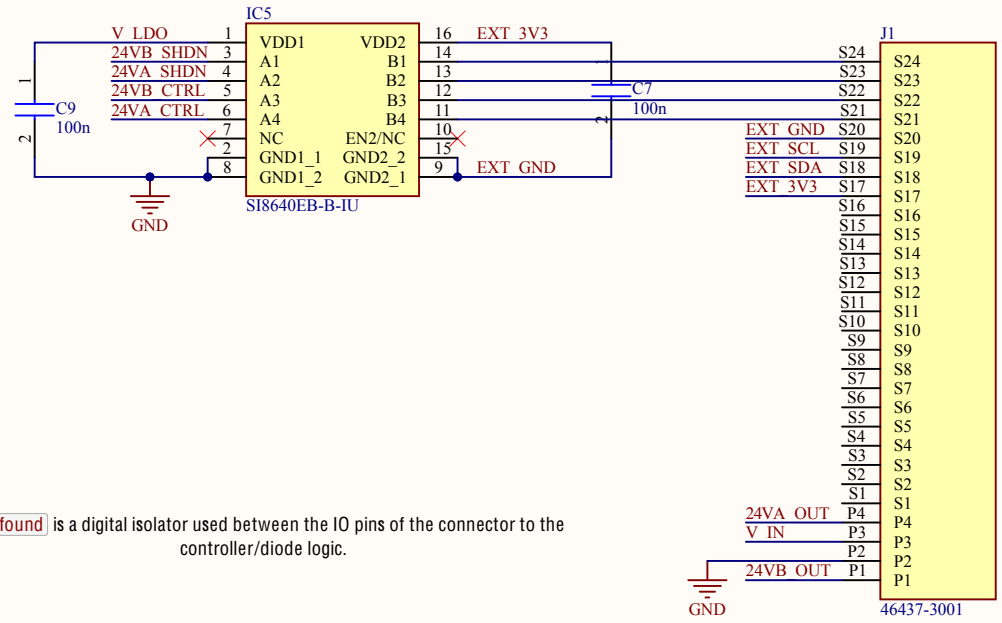
Buck-boost regulators



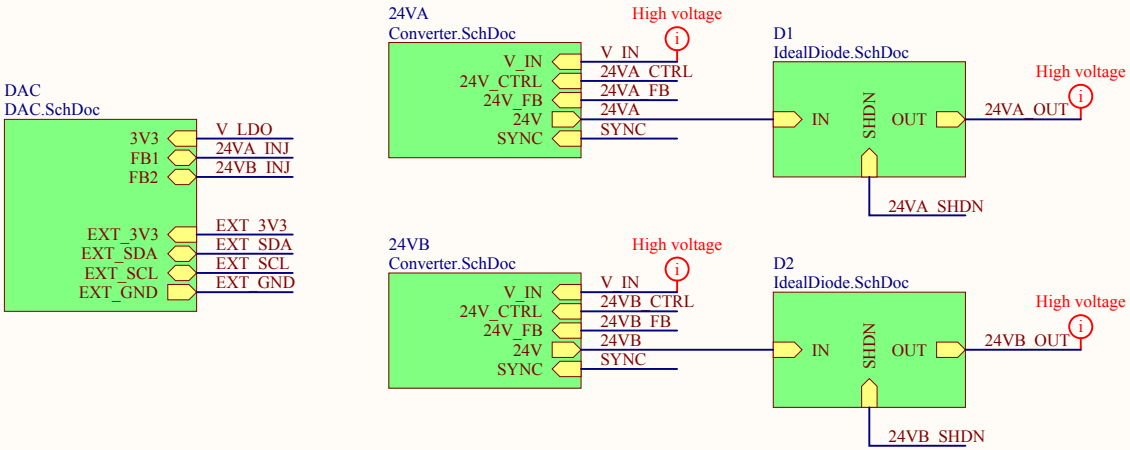
J2 is an audio jack connector to synchronize multiple instances of the buck-boost controllers (for redundancy and parallelizing power supplies).



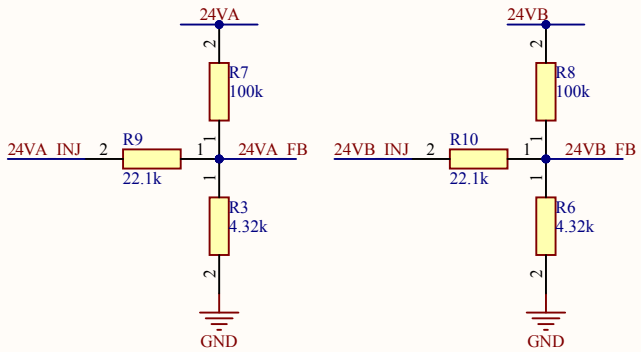
Not found is a 80mA LDO to power the digital isolators and the DAC.



Not found is a digital isolator used between the IO pins of the connector to the controller/diode logic.

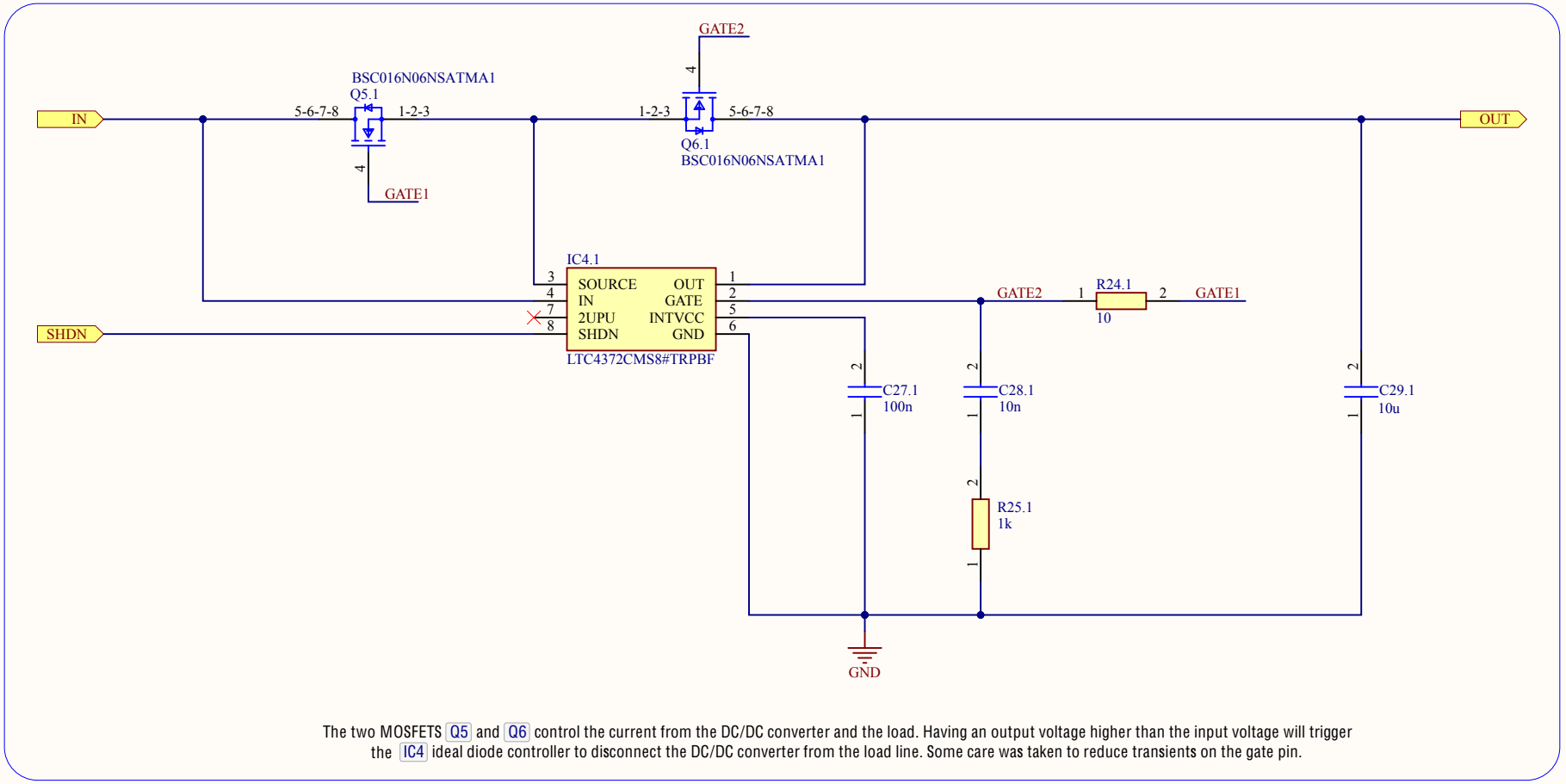


Buck-boost top-level with ideal diodes.



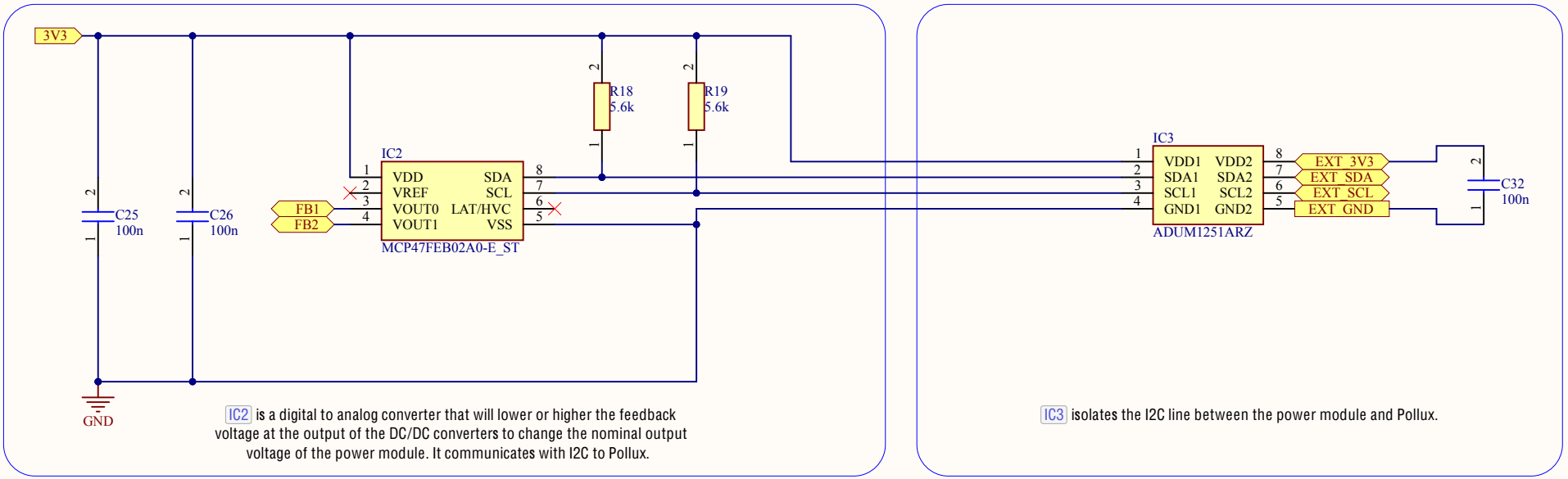
Here, a DAC injects current into the feedback loop of the DC/DC converters.
Feedback reference: 0.8V
The voltage span is (R7+R3)/R20 * 0.8V

Title	High-voltage Power Module (Nominal voltages: 24V/24V)		
Size: A4	Number: 1		Revision: 1
Date: 4.04.2023		Sheet of	EPFL Xplore
File: \\..\Module.SchDoc		Drawn By:	Arion Zimmermann

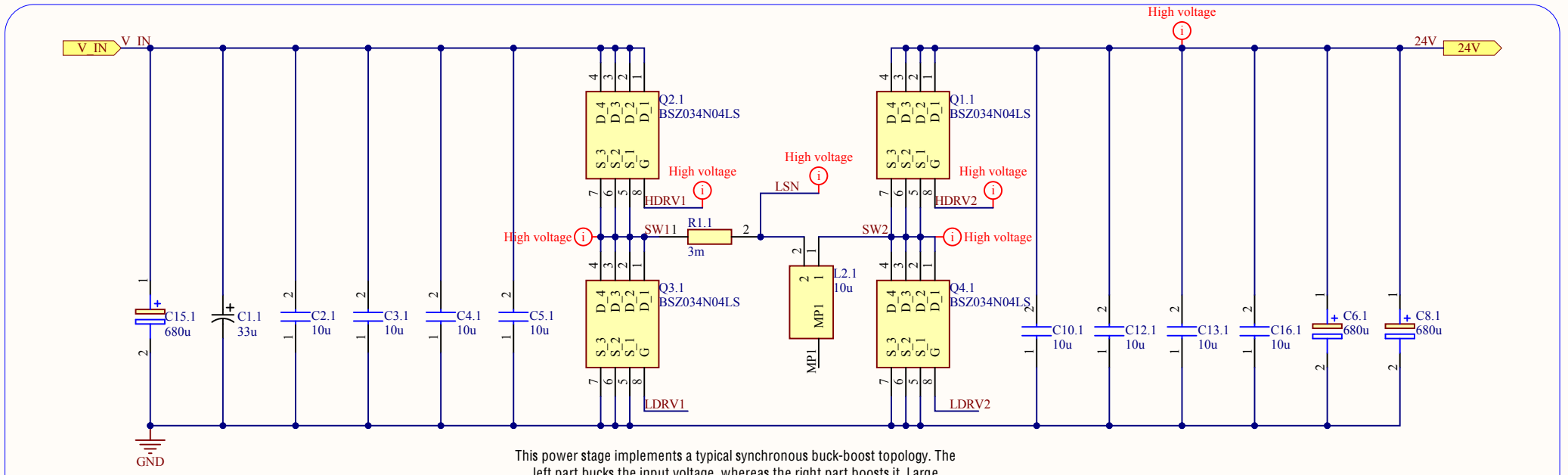


The two MOSFETS Q5 and Q6 control the current from the DC/DC converter and the load. Having an output voltage higher than the input voltage will trigger the IC4 ideal diode controller to disconnect the DC/DC converter from the load line. Some care was taken to reduce transients on the gate pin.

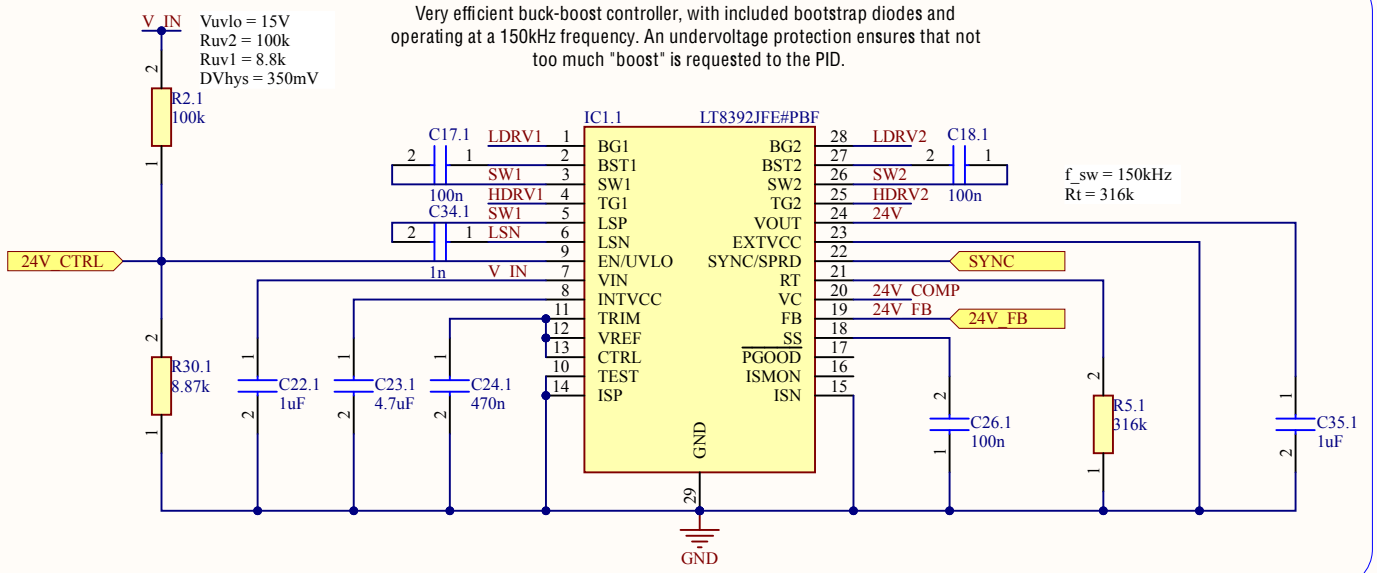
Title: Ideal Diode		
Size: A4	Number: 1	Revision: 1
Date: 4.04.2023	Sheet of	EPFL Xplore
File: \\..\IdealDiode.SchDoc		Drawn By: Arion Zimmermann



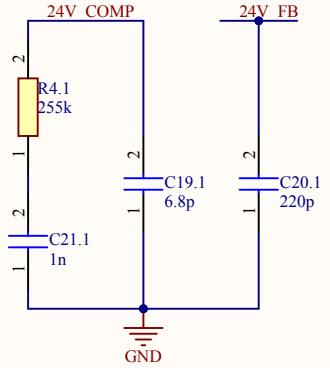
Title: Isolated Digital-to-Analog Converter		
Size: A4	Number: 1	Revision: 1
Date: 4.04.2023	Sheet of	EPFL Xplore
File: \\..\DAC.SchDoc	Drawn By:	Arion Zimmermann



This power stage implements a typical synchronous buck-boost topology. The left part bucks the input voltage, whereas the right part boosts it. Large input/output capacitances ensures that the control system PID remains stable.

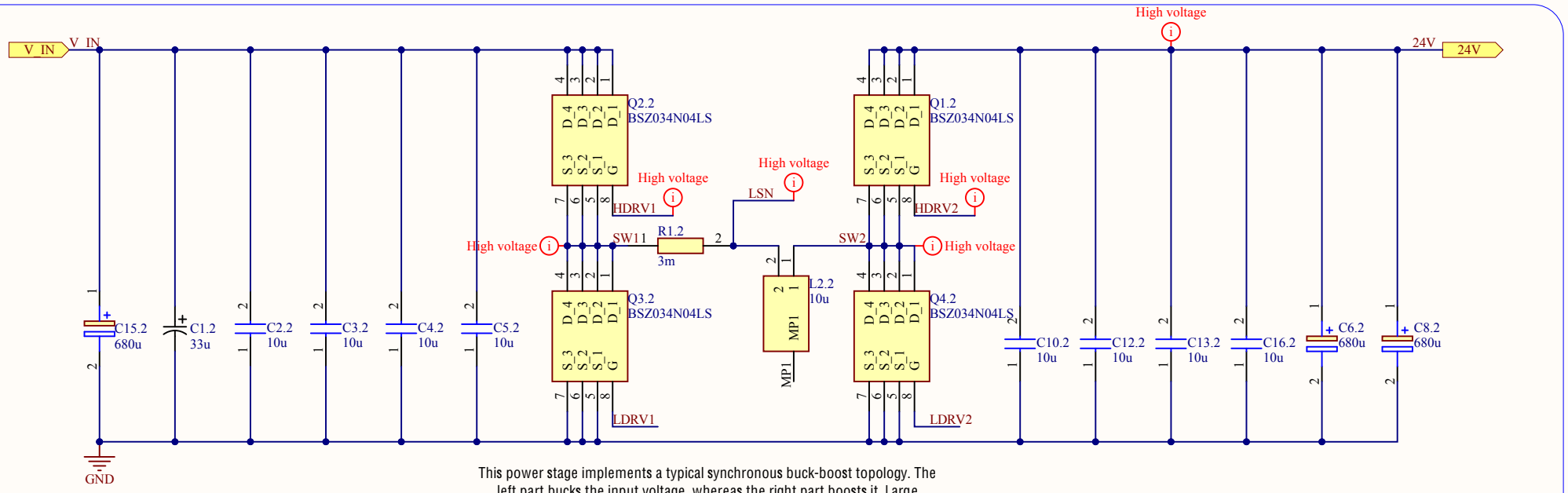


Very efficient buck-boost controller, with included bootstrap diodes and operating at a 150kHz frequency. An undervoltage protection ensures that not too much "boost" is requested to the PID.



PID coefficients tuned through LTPowerCAD.

Title: Power Module Buck-Boost Converter (Nominal 20V:30V -> 24V)		
Size: A4	Number: 1	Revision: 1
Date: 4.04.2023	Sheet of: EPFL Xplore	
File: \\..\Converter.SchDoc	Drawn By: Arion Zimmermann	



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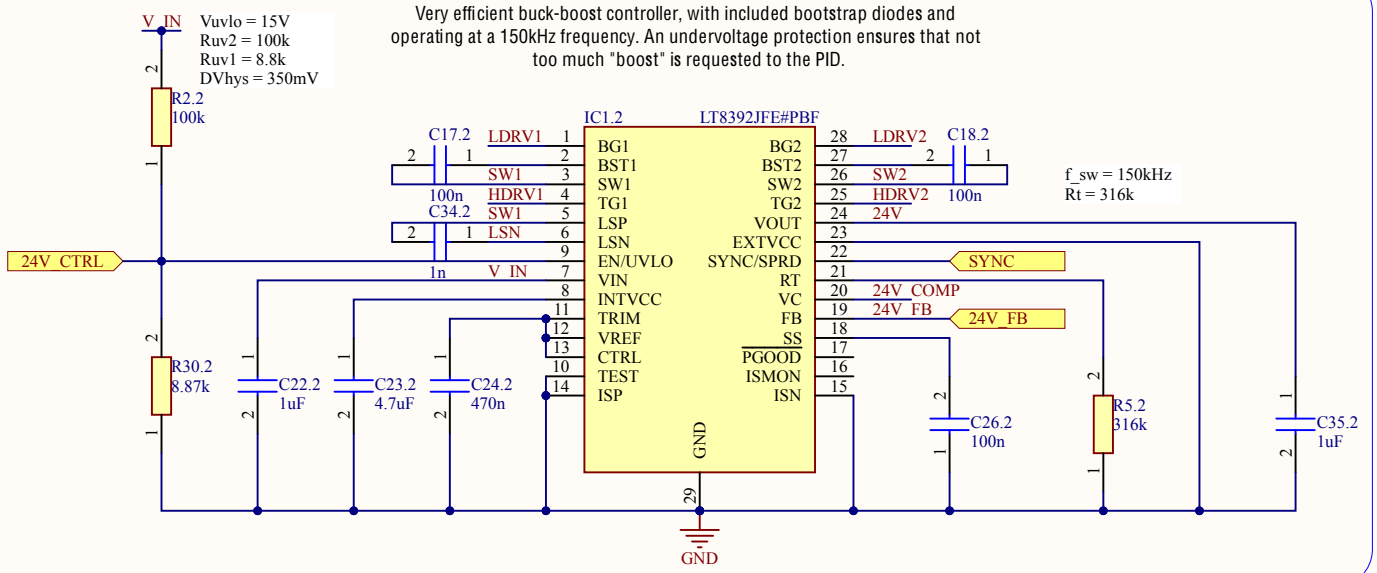
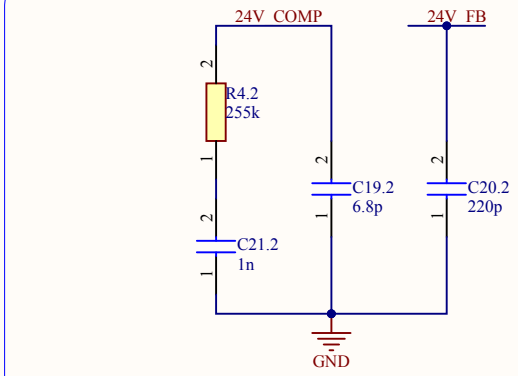
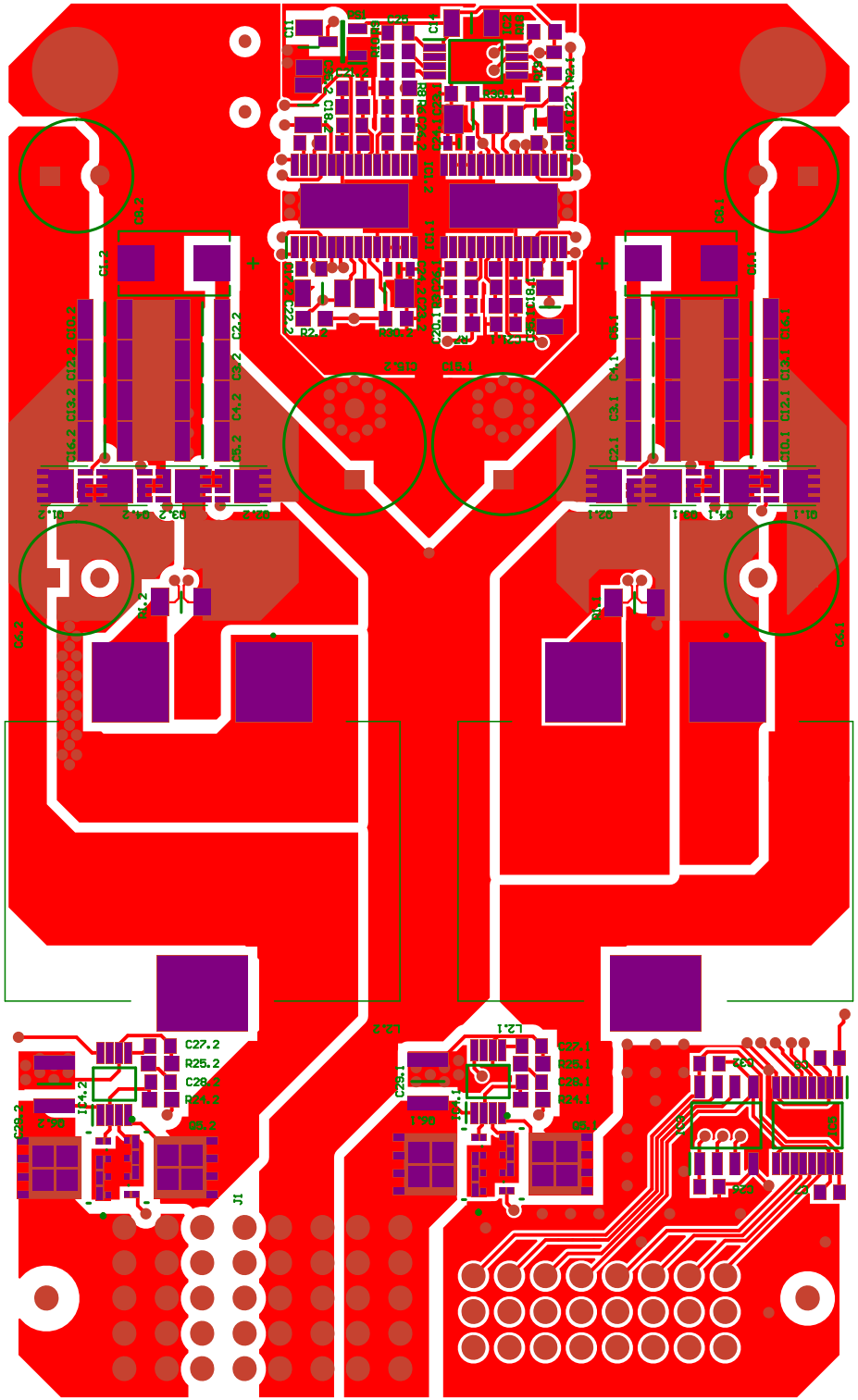


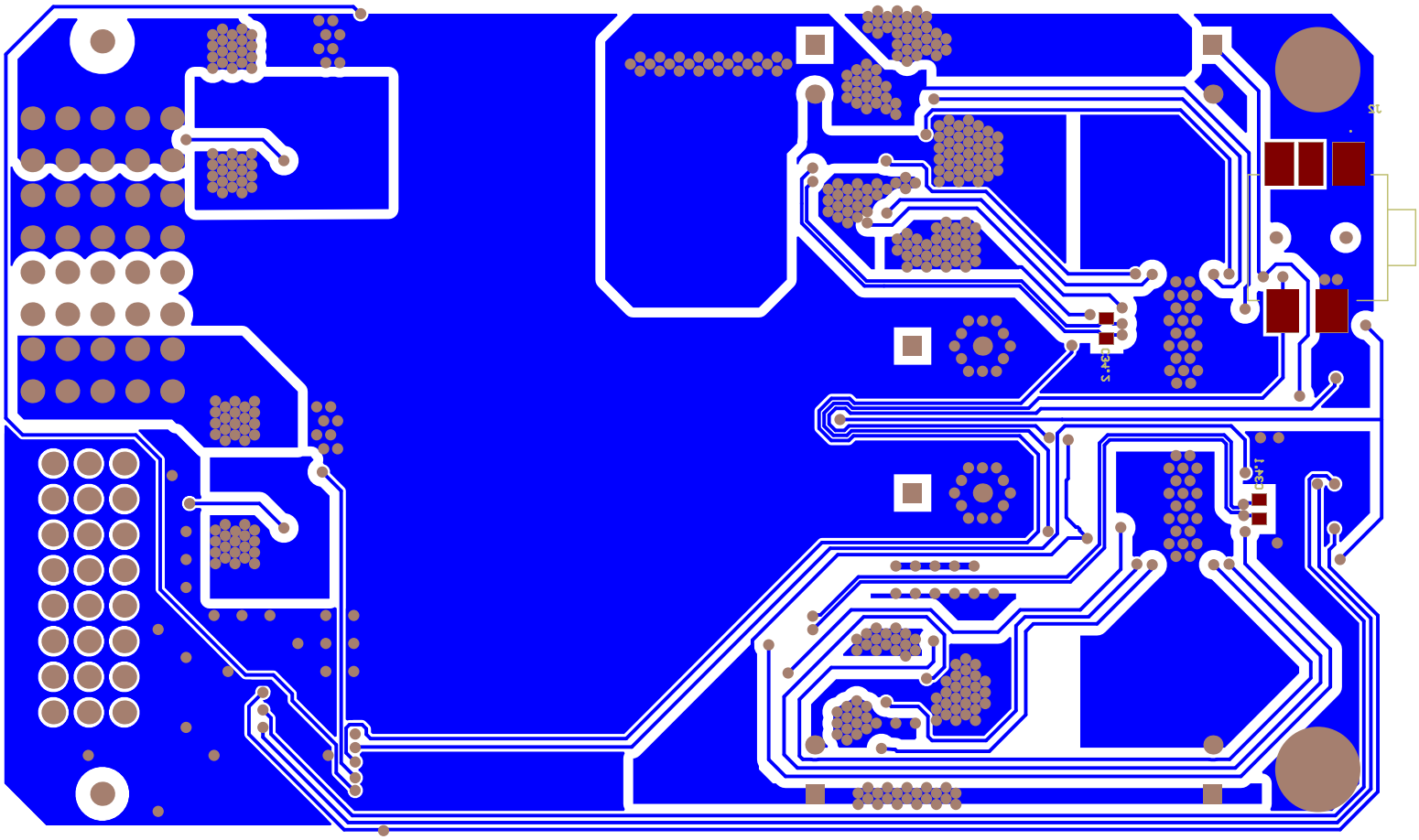
Very efficient buck-boost controller, with included bootstrap diodes and operating at a 150kHz frequency. An undervoltage protection ensures that not too much "boost" is requested to the PID.



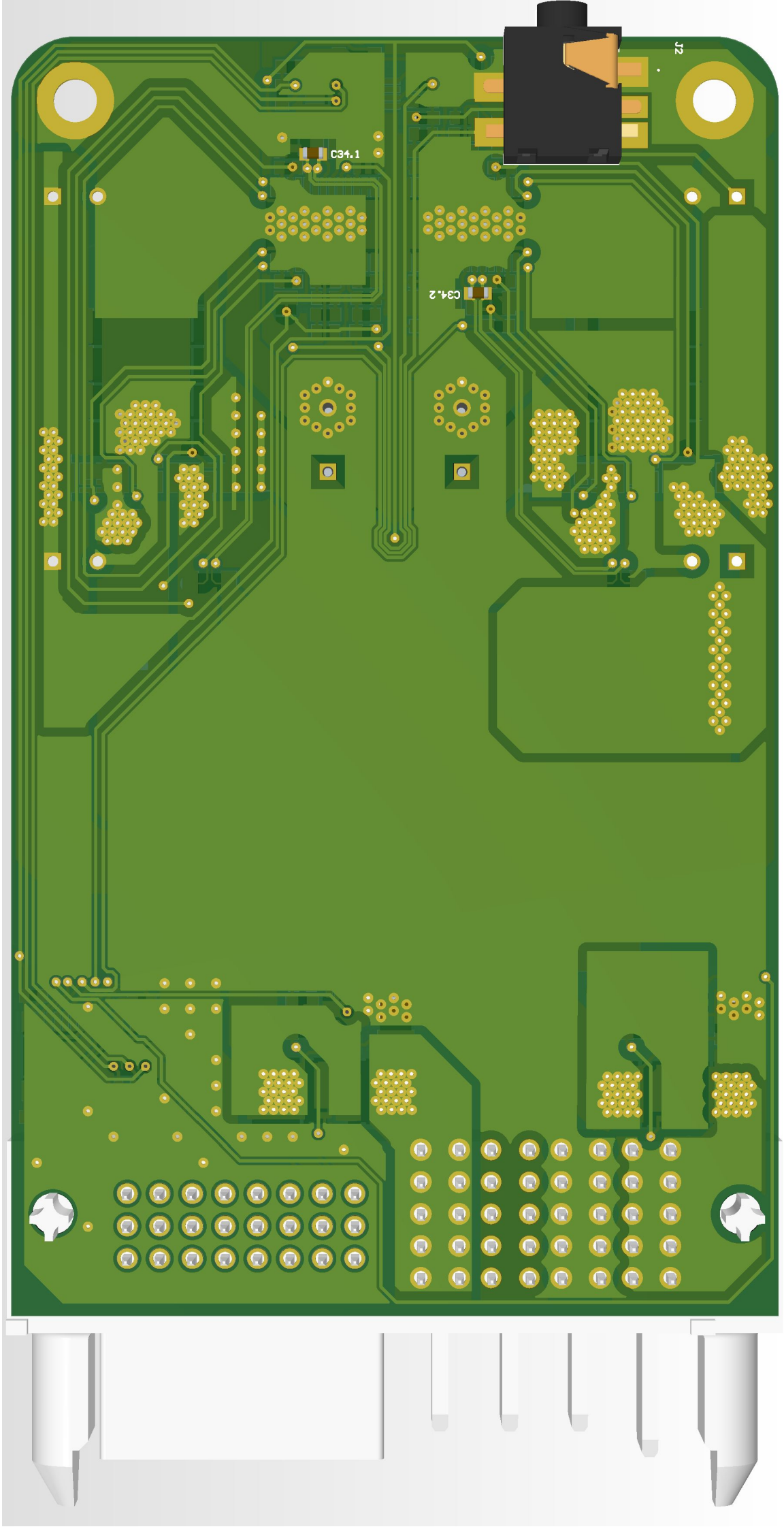
PID coefficients tuned through LTPowerCAD.

Title: Power Module Buck-Boost Converter (Nominal 20V:30V -> 24V)		
Size: A4	Number: 1	Revision: 1
Date: 4.04.2023	Sheet of: EPFL Xplore	
File: \\..\Converter.SchDoc	Drawn By: Arion Zimmermann	



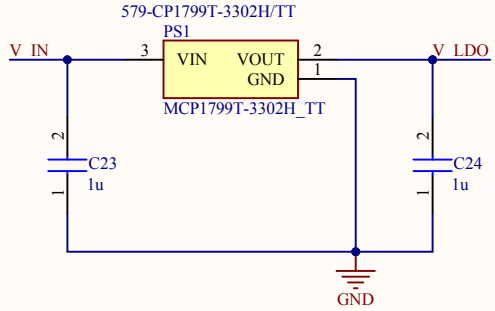


C29.2
C6.2
C16.2 C13.2 C12.2 C10.2
C1.2
C8.2
IC4.2
R1.2
J1
C29.1
IC4.1
IC1.1
IC1.2
C11
C14
IC2
R18
R19
C25
C20.1 R3 C26.1
C24.1 C23.1
C17.1 C22.1 R2.1
R30.1
C2.1 C3.1 C4.1 C5.1
C1.1
C8.1
IC3
C10.1 C12.1 C13.1 C16.1
C6.1

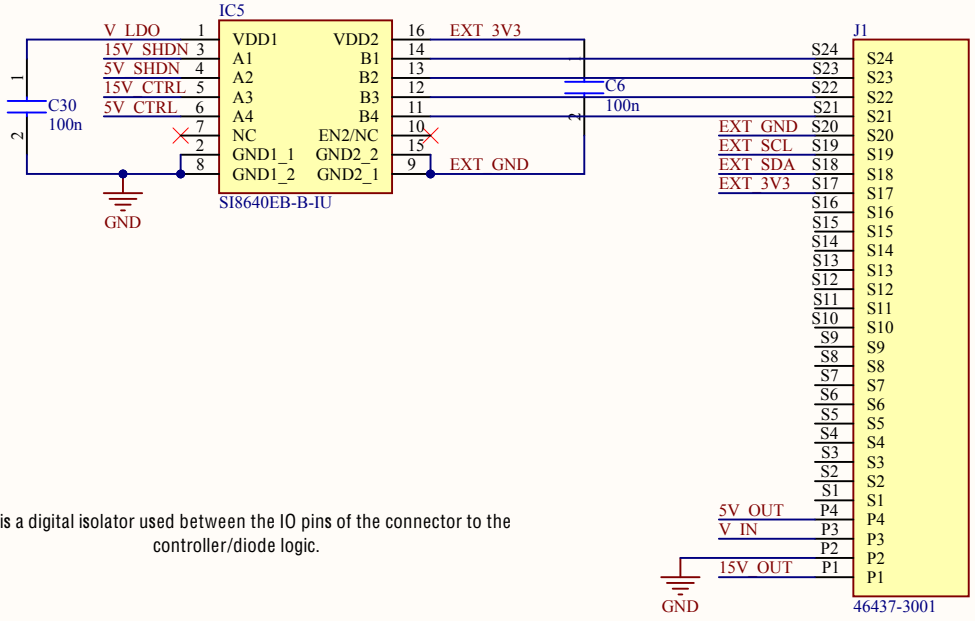

J2
C34.1
C34.2

LV Power Module

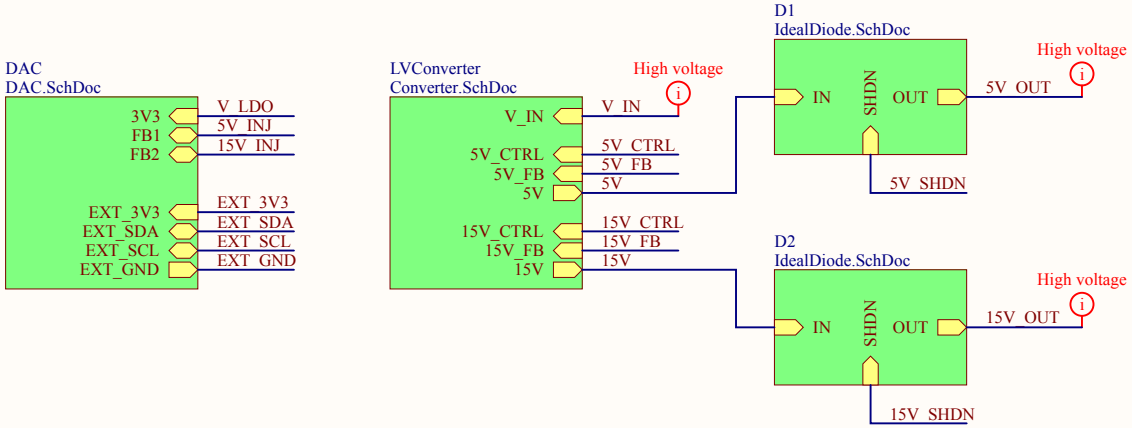
Buck regulators



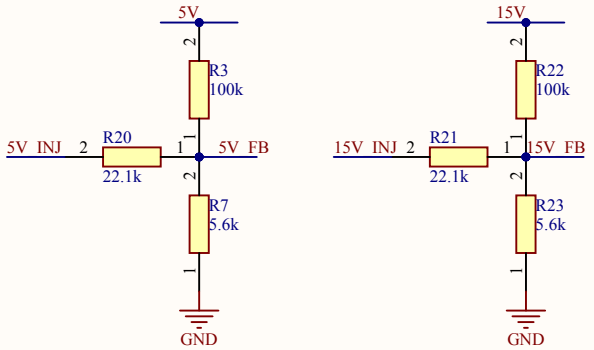
PS1 is a 80mA LDO to power the digital isolators and the DAC.



IC5 is a digital isolator used between the IO pins of the connector to the controller/diode logic.

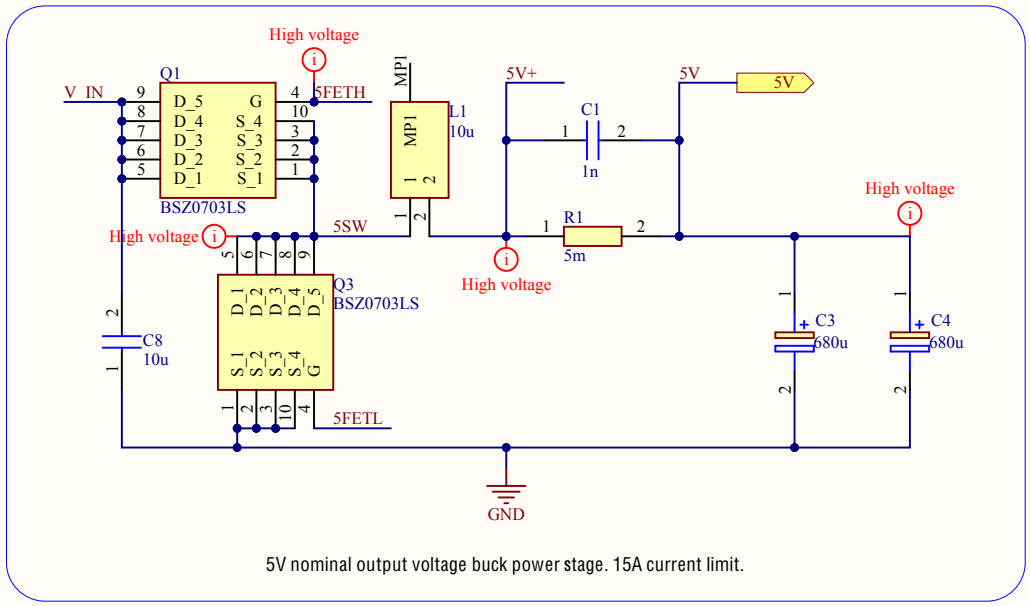


Dual buck top-level with ideal diodes.

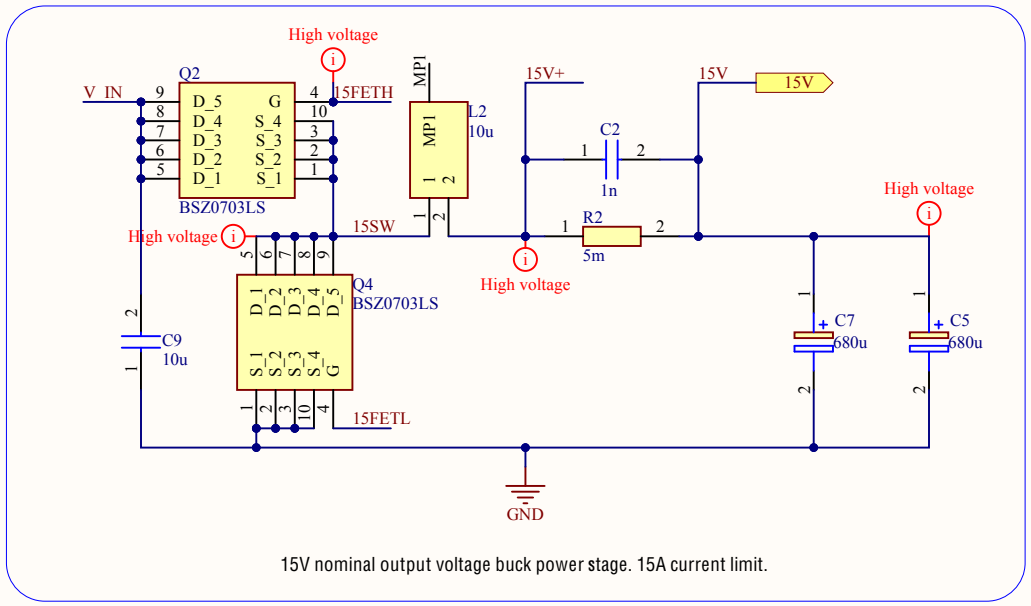


Here, a DAC injects current into the feedback loop of the DC/DC converters.
Feedback reference: 1.2V
The voltage span is (R7+R3)/R20 * 0.8V

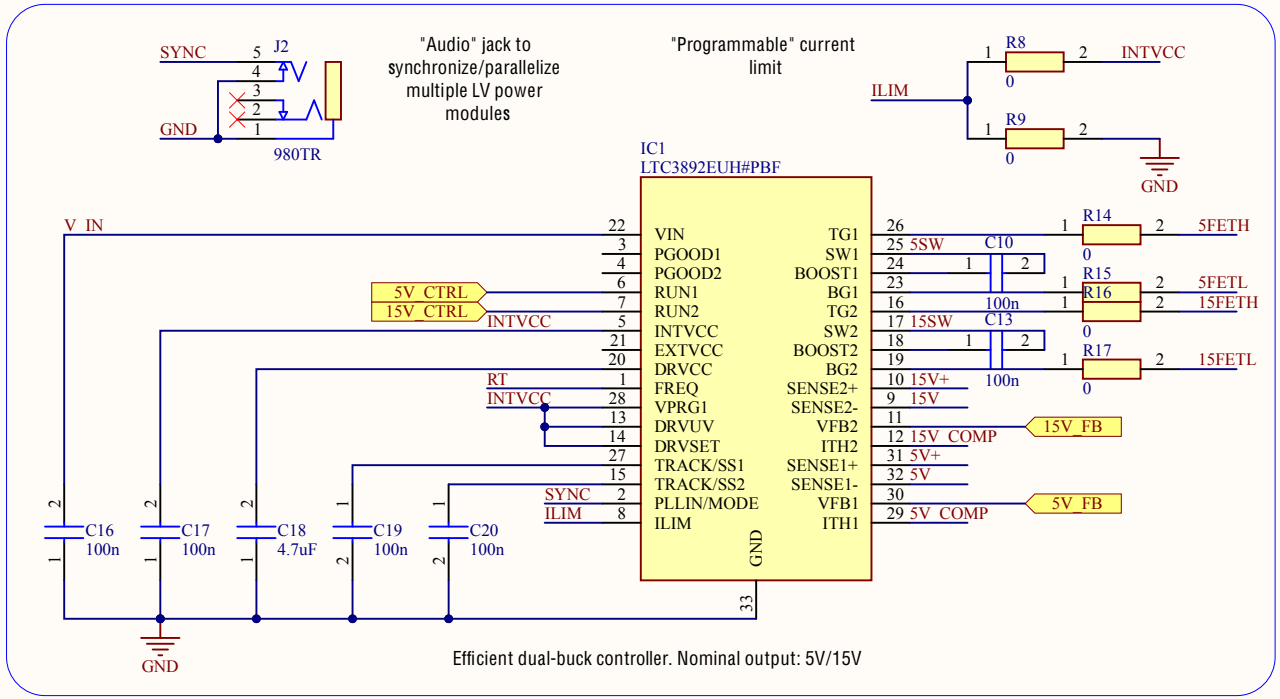
Title: Low-voltage Power Module (Nominal voltages: 5V/15V)		
Size: A4	Number: 1	Revision: 1
Date: 4.04.2023	Sheet of: EPFL Xplore	
File: \\..\Module.SchDoc	Drawn By: Arion Zimmermann	



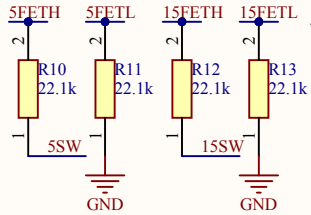
5V nominal output voltage buck power stage. 15A current limit.



15V nominal output voltage buck power stage. 15A current limit.



Efficient dual-buck controller. Nominal output: 5V/15V

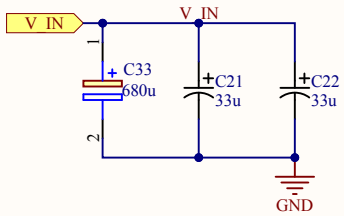


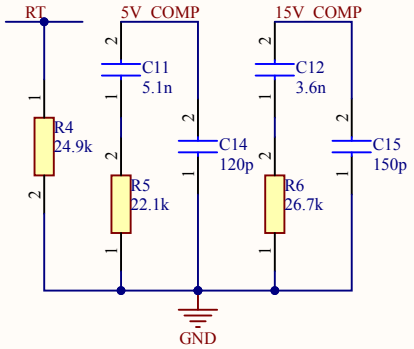
Clipping resistors because large gate transients were observed during testing

Frequency: 85kHz

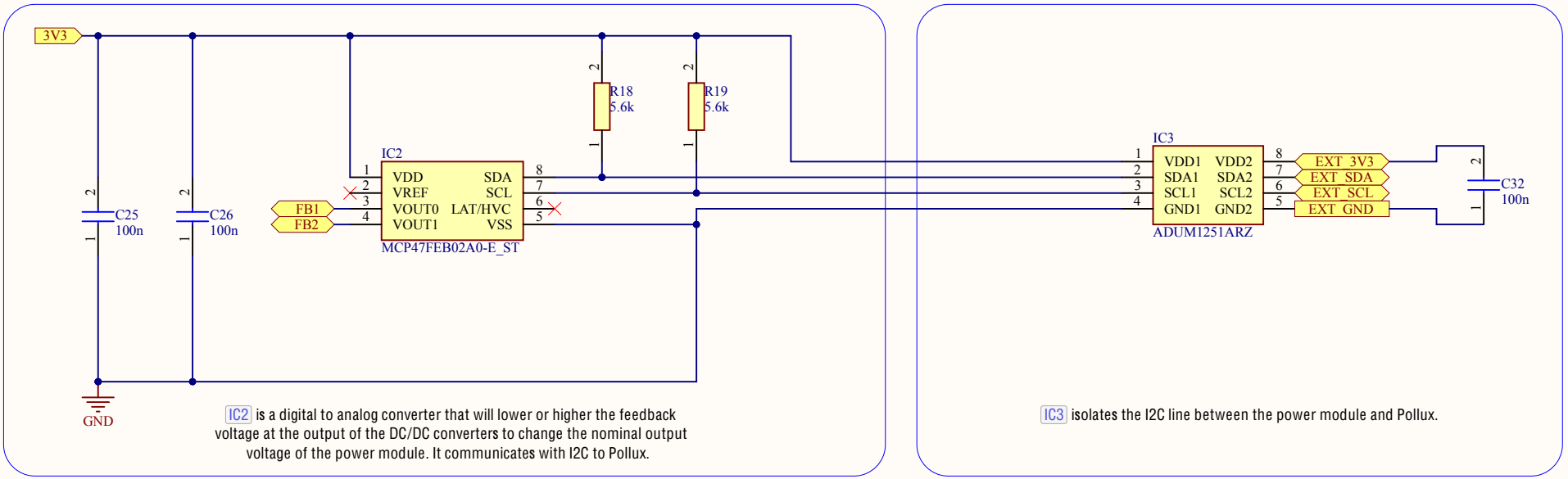
PID controller tuned with LTPowerCAD

Large input caps to reduce current transients from battery

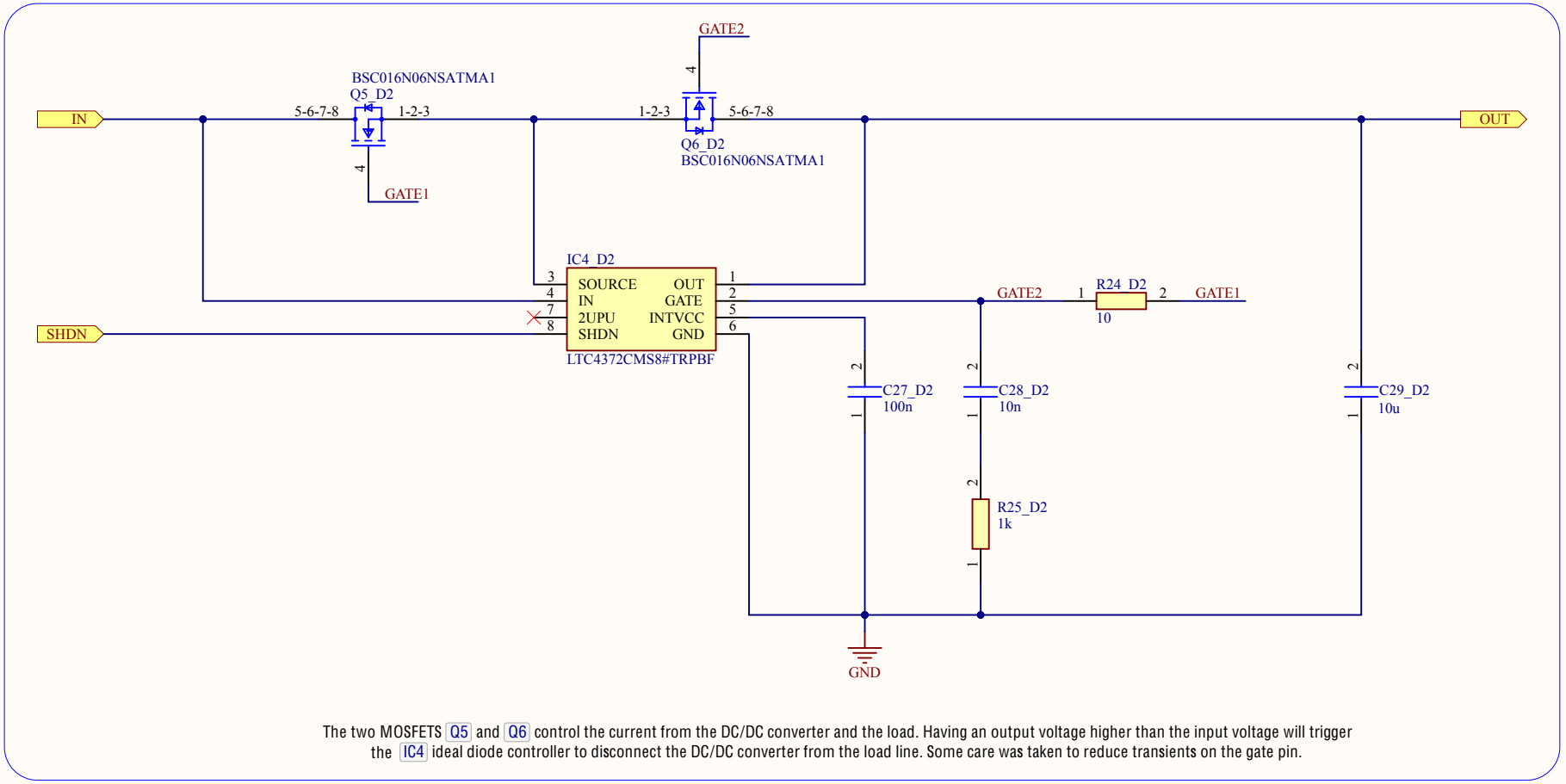




Title: Power Module LTC3892 Dual Buck Converters (24V --> 5V / 15V)		
Size: A4	Number: 1	Revision: 1
Date: 4.04.2023	Sheet of: EPFL Xplore	
File: \\..\Converter.SchDoc	Drawn By: Arion Zimmermann	

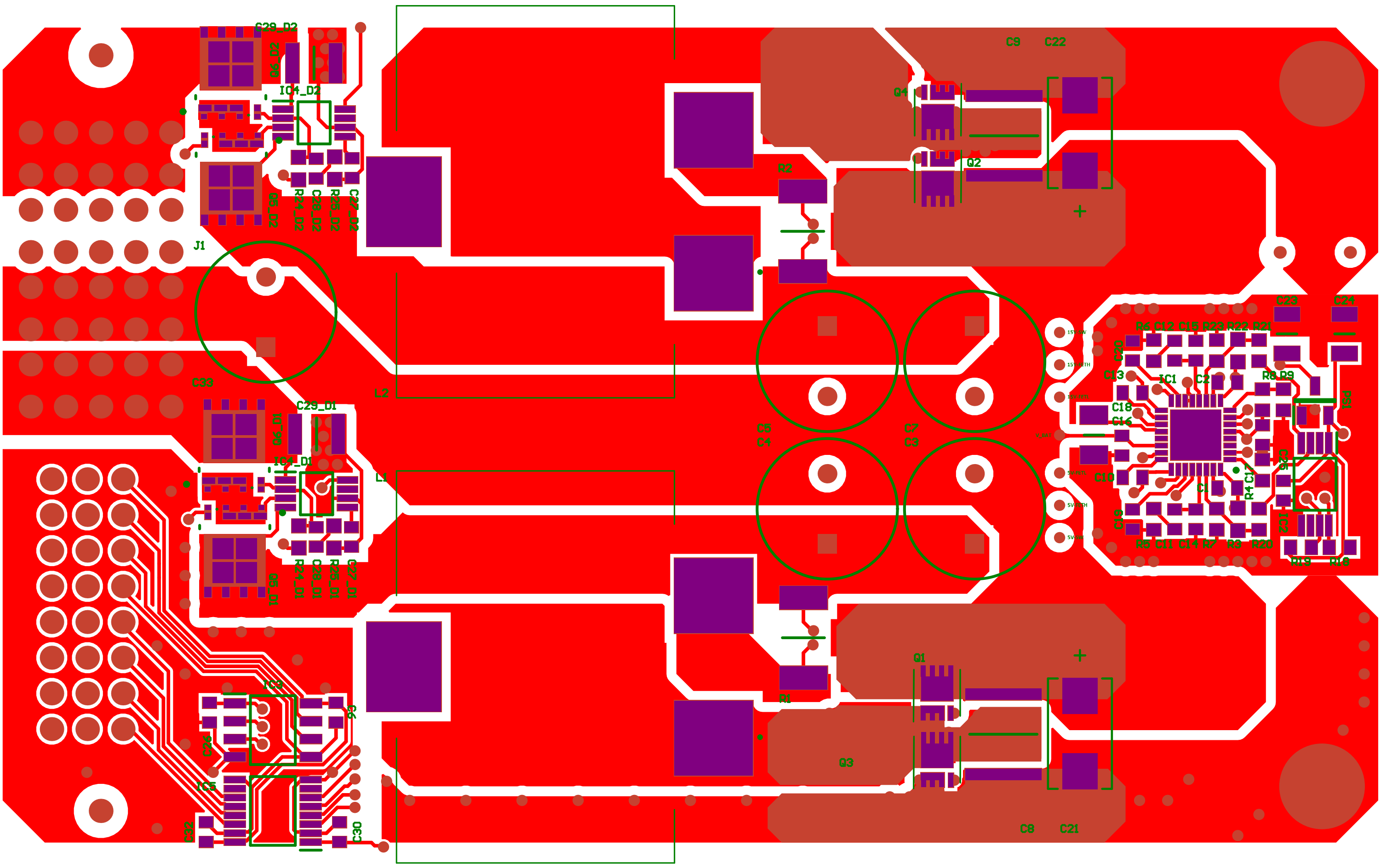


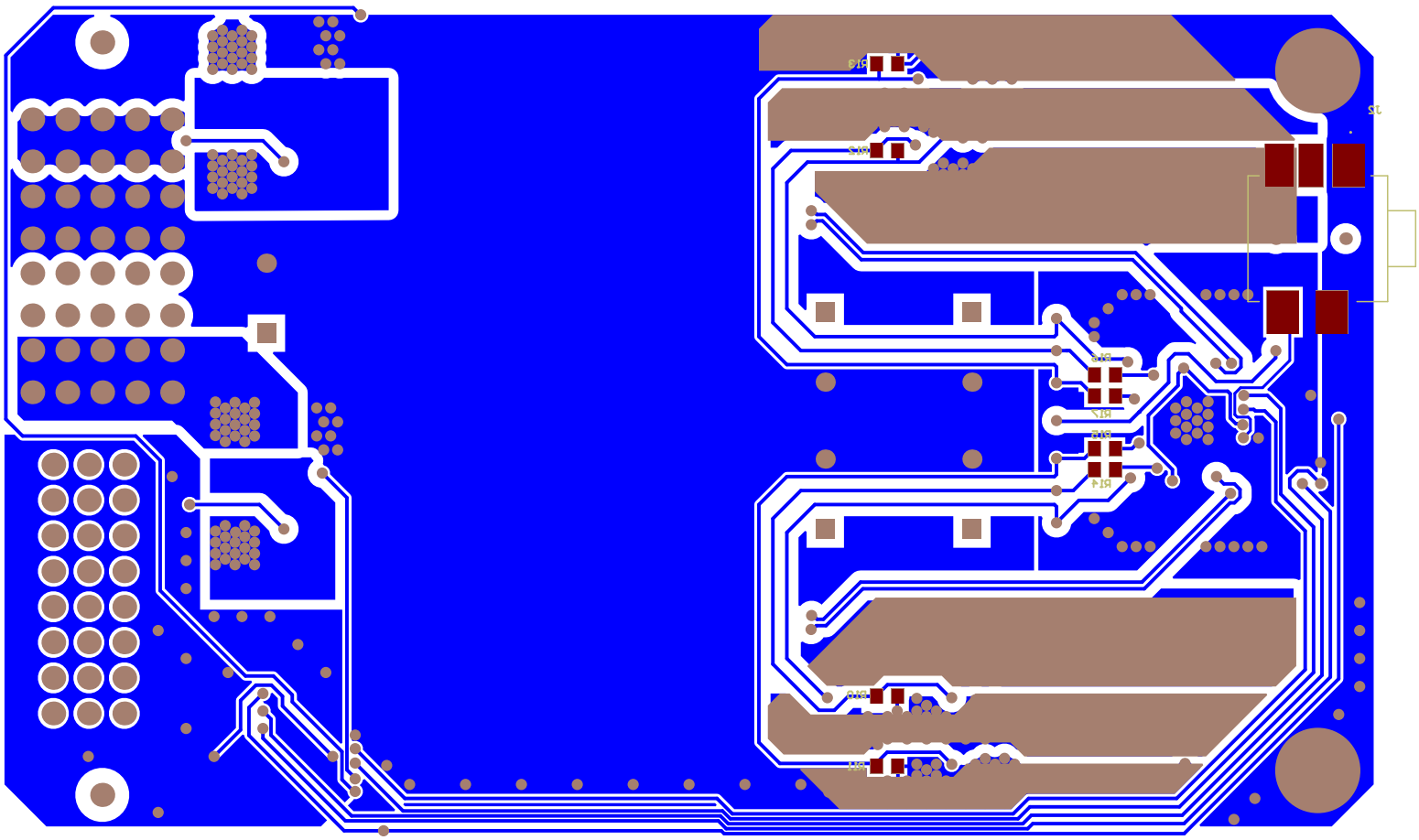
Title: Isolated Digital-to-Analog Converter		
Size: A4	Number: 1	Revision: 1
Date: 4.04.2023	Sheet of	EPFL Xplore
File: \\..\DAC.SchDoc	Drawn By:	Arion Zimmermann



The two MOSFETS Q5 and Q6 control the current from the DC/DC converter and the load. Having an output voltage higher than the input voltage will trigger the IC4 ideal diode controller to disconnect the DC/DC converter from the load line. Some care was taken to reduce transients on the gate pin.

Title: Ideal Diode		
Size: A4	Number: 1	Revision: 1
Date: 4.04.2023	Sheet of	EPFL Xplore
File: \\..\IdealDiode.SchDoc		Drawn By: Arion Zimmermann


C29_D2
IC4_D2
J1
C33
C29_D1
IC4_D1
L2
L1
C9
C22
Q4
Q2
R2
C5
C4
C7
C3
Q1
Q3
C8
C21
IC1
C2
IC2
IC5
C30



C29_D2
IC4_D2
C33
C29_D1
IC4_D1
IC3
IC5
C9
C22
Q4
R2
C5
C4
C7
C3
L2
L1
R1
Q1
Q3
C8
C21
C23
C24
R6 C12 C15 R23 R22 R21
C20
C13
IC1
C2
R8 R9
C18
C16
C10
C1
R4 C17
C19
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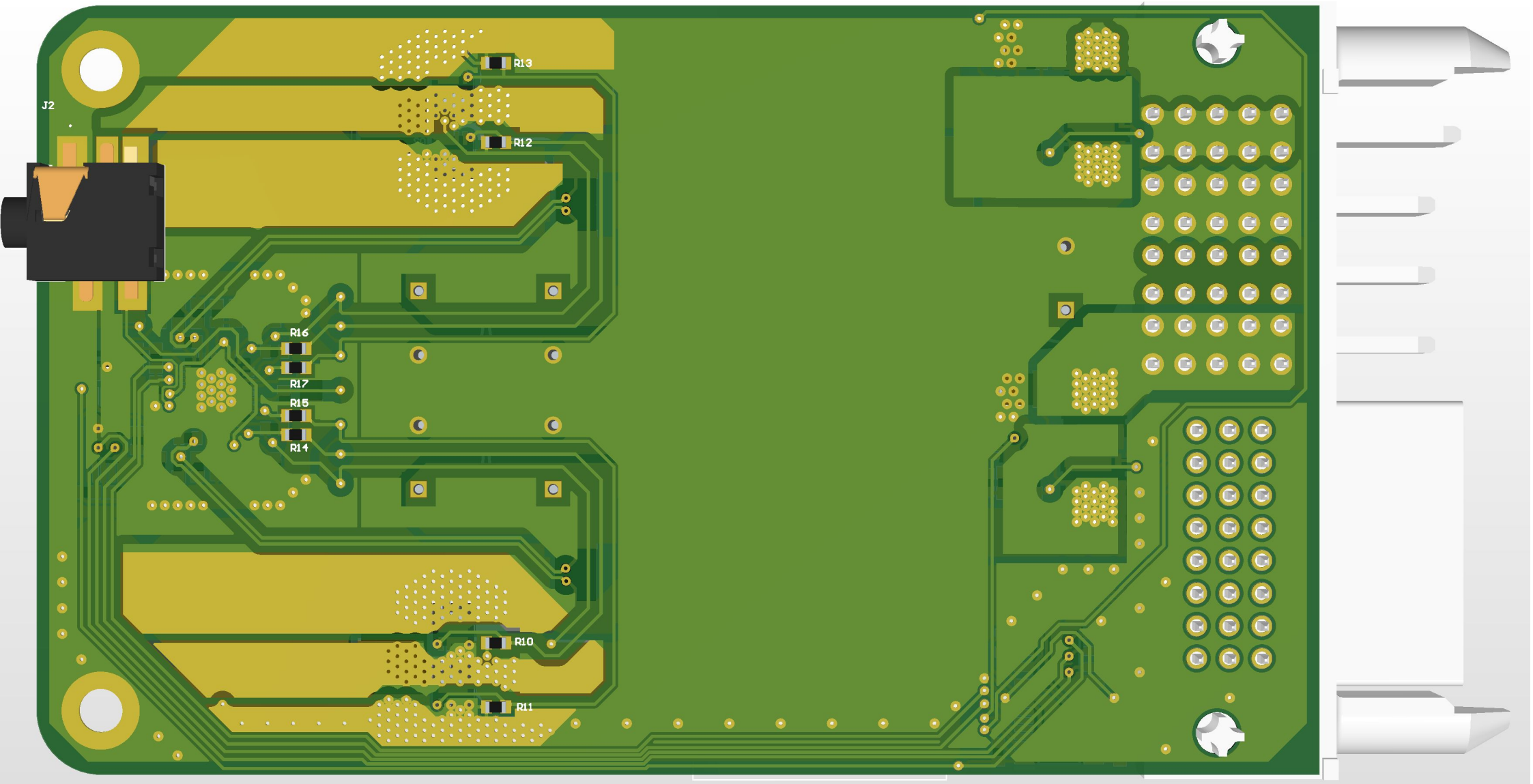
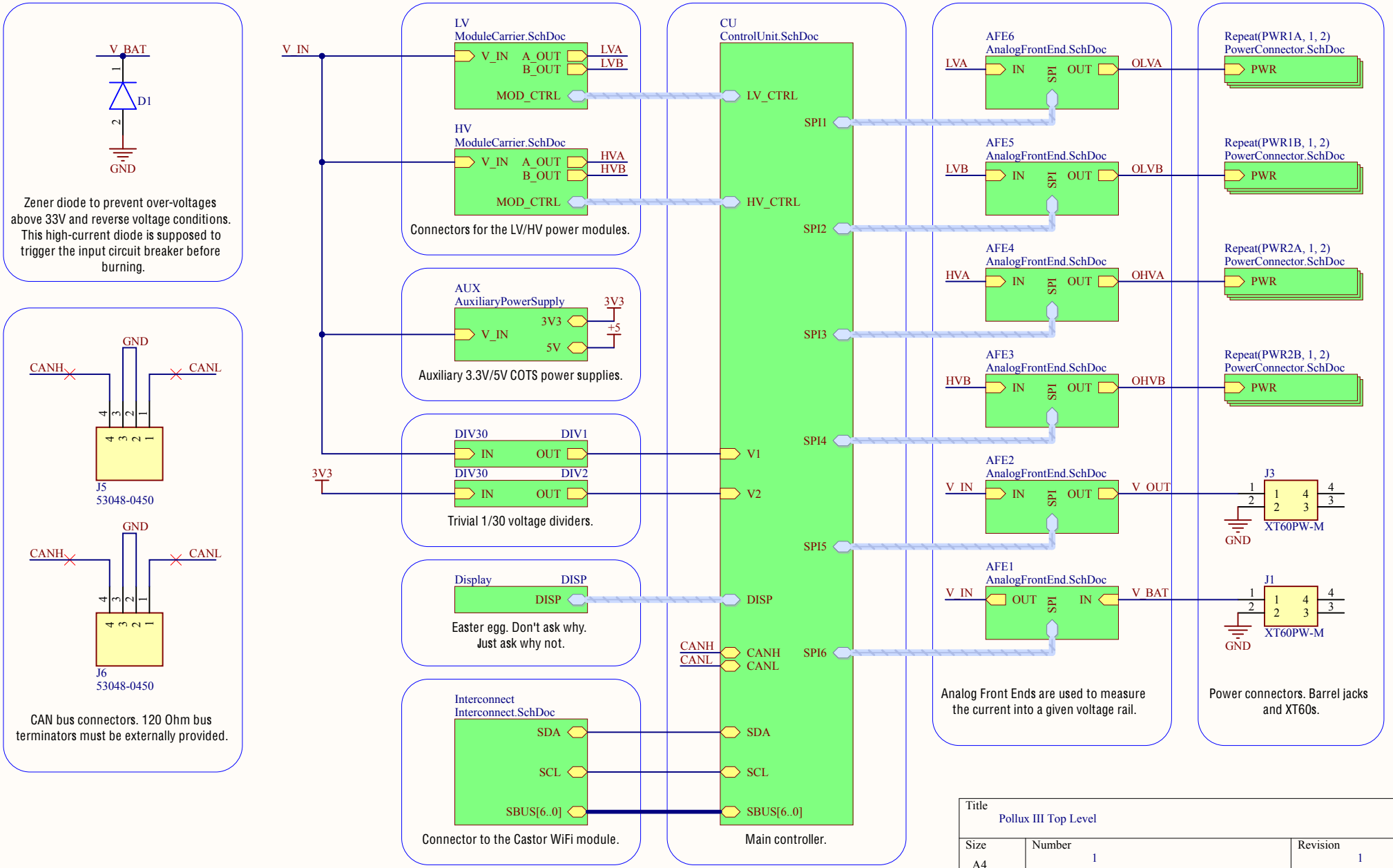
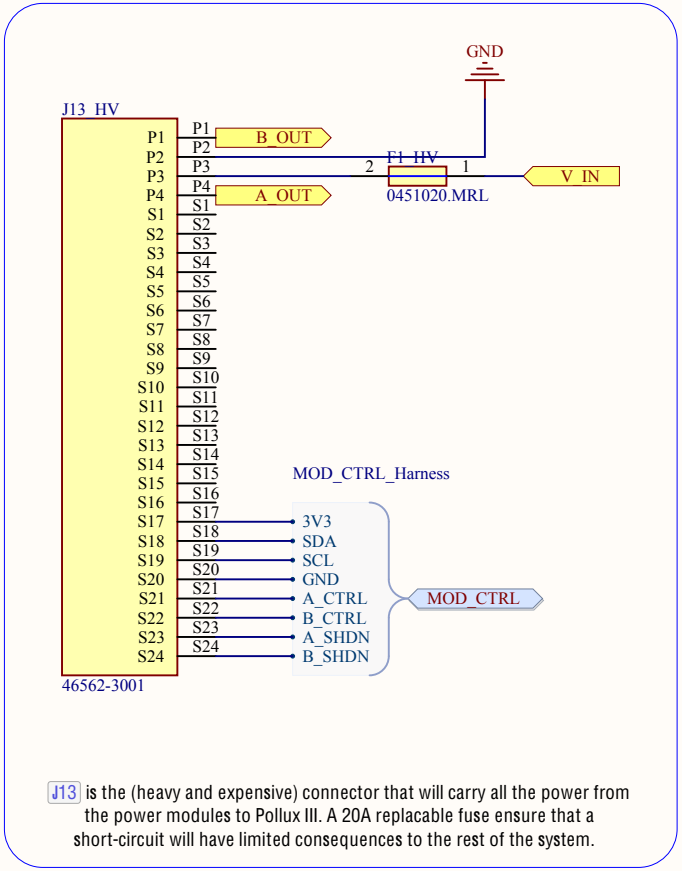
R19
R18
PSI
C25
C31


J2
R13
R12
R16
R17
R15
R14
R10
R11

Pollux III

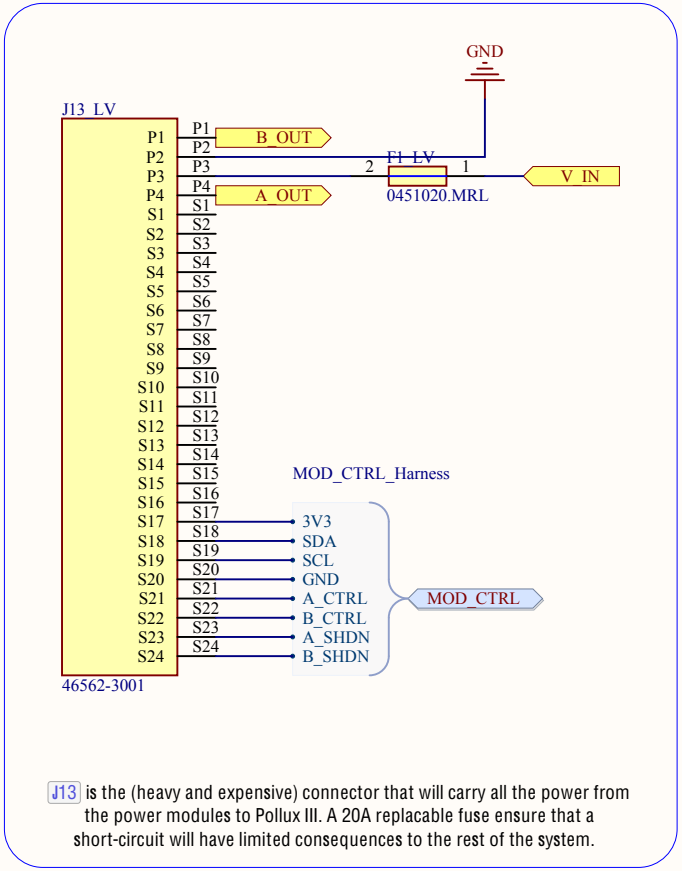
Motherboard


V_BAT
D1
GND
Zener diode to prevent over-voltages above 33V and reverse voltage conditions. This high-current diode is supposed to trigger the input circuit breaker before burning.
GND
CANH
CANL
J5
53048-0450
J6
53048-0450
CAN bus connectors. 120 Ohm bus terminators must be externally provided.
V_IN
LV
ModuleCarrier.SchDoc
V_IN
A_OUT
B_OUT
MOD_CTRL
LVA
LVB
HV
ModuleCarrier.SchDoc
HVA
HVB
Connectors for the LV/HV power modules.
AUX
AuxiliaryPowerSupply
3V3
5V
+5
Auxiliary 3.3V/5V COTS power supplies.
DIV30
DIV1
DIV2
IN
OUT
3V3
Trivial 1/30 voltage dividers.
Display
DISP
Easter egg. Don't ask why. Just ask why not.
Interconnect
Interconnect.SchDoc
SDA
SCL
SBUS[6..0]
Connector to the Castor WiFi module.
CU
ControlUnit.SchDoc
LV_CTRL
HV_CTRL
V1
V2
DISP
CANH
CANL
SPI1
SPI2
SPI3
SPI4
SPI5
SPI6
Main controller.
AFE6
AFE5
AFE4
AFE3
AFE2
AFE1
AnalogFrontEnd.SchDoc
SPI
OLVA
OLVB
OHVA
OHVB
V_OUT
V_BAT
Analog Front Ends are used to measure the current into a given voltage rail.
Repeat(PWR1A, 1, 2)
Repeat(PWR1B, 1, 2)
Repeat(PWR2A, 1, 2)
Repeat(PWR2B, 1, 2)
PowerConnector.SchDoc
PWR
J3
J1
XT60PW-M
Power connectors. Barrel jacks and XT60s.
Title
Pollux III Top Level
Size
A4
Number
1
Revision
1
Date:
4.04.2023
Sheet of
EPFL Xplore
File:
\\..\TopLevel.SchDoc
Drawn By:
Arion Zimmermann



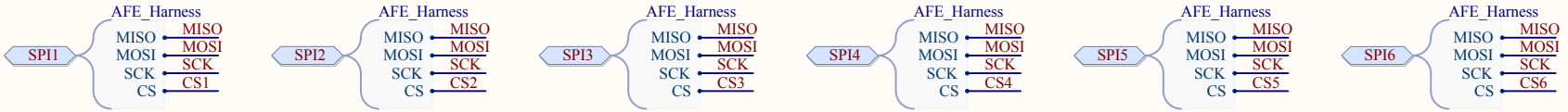
J13 is the (heavy and expensive) connector that will carry all the power from the power modules to Pollux III. A 20A replacable fuse ensure that a short-circuit will have limited consequences to the rest of the system.

Title	Interface to the Power Modules		
Size: A4	Number: 1		Revision: 1
Date: 4.04.2023		Sheet of	EPFL Xplore
File: \\..\ModuleCarrier.SchDoc		Drawn By:	Arion Zimmermann

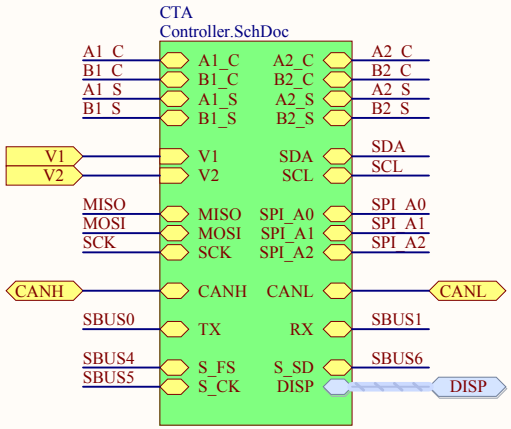


J13 is the (heavy and expensive) connector that will carry all the power from the power modules to Pollux III. A 20A replacable fuse ensure that a short-circuit will have limited consequences to the rest of the system.

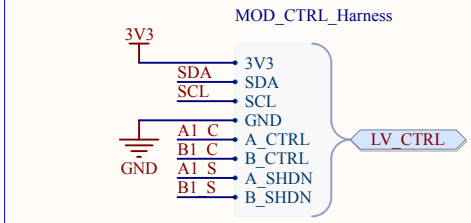
Title	Interface to the Power Modules		
Size: A4	Number: 1		Revision: 1
Date: 4.04.2023		Sheet of	EPFL Xplore
File: \\..\ModuleCarrier.SchDoc		Drawn By:	Arion Zimmermann



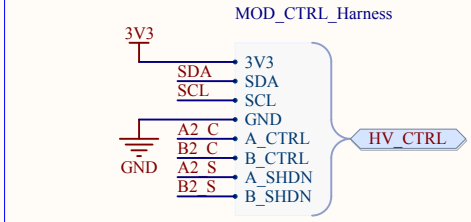
For each power monitor, a harness is defined with the correct chip-select and a shared MISO/MOSI/SCK SPI bus



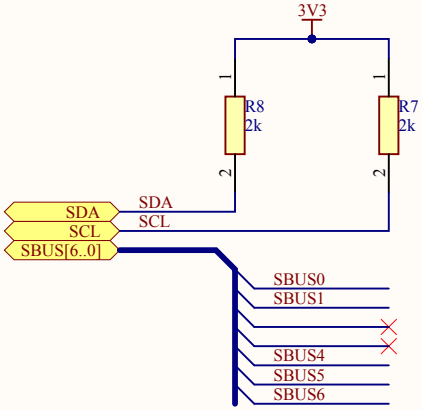
This block is the abstraction respresenting a microcontroller and all the I/O ports required by the high-level architecture



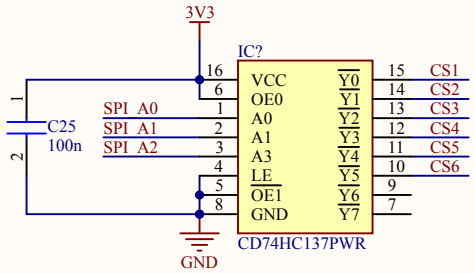
This harness provides a control interface to the low-voltage power modules



This harness provides a control interface to the high-voltage power modules

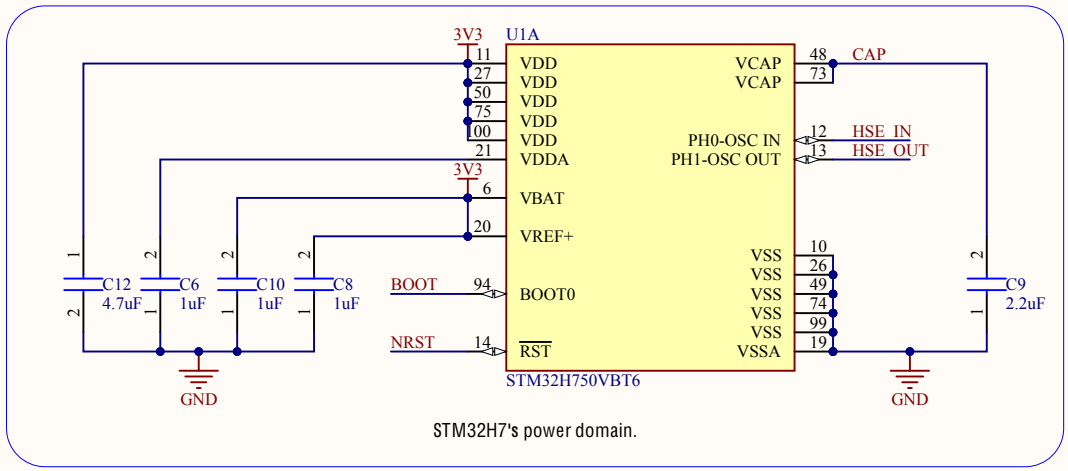


This block describes the interface between the WiFi module (Interconnect.SchDoc) and the microcontroller

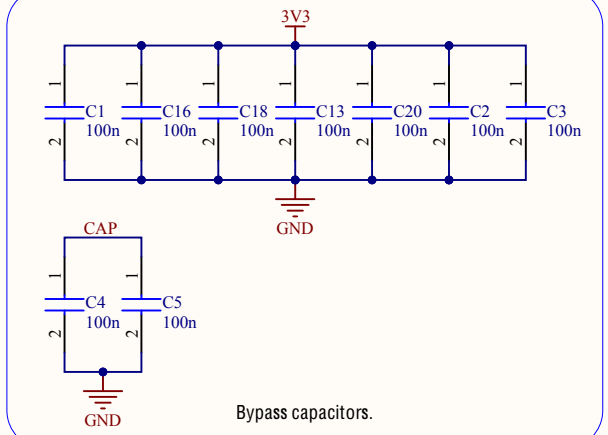


Not found is a multiplexer that converts the 3 bits address SPI_A0, SPI_A1, SPI_A2 to a chip-select signal for the

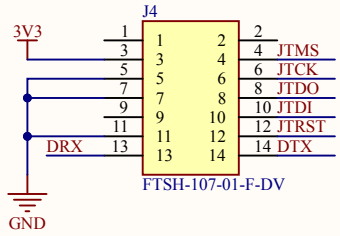
Title: Control Unit Top Level		
Size: A4	Number: 1	Revision: 1
Date: 4.04.2023		Sheet of EPFL Xplore
File: \\..\ControlUnit.SchDoc		Drawn By: Arion Zimmermann



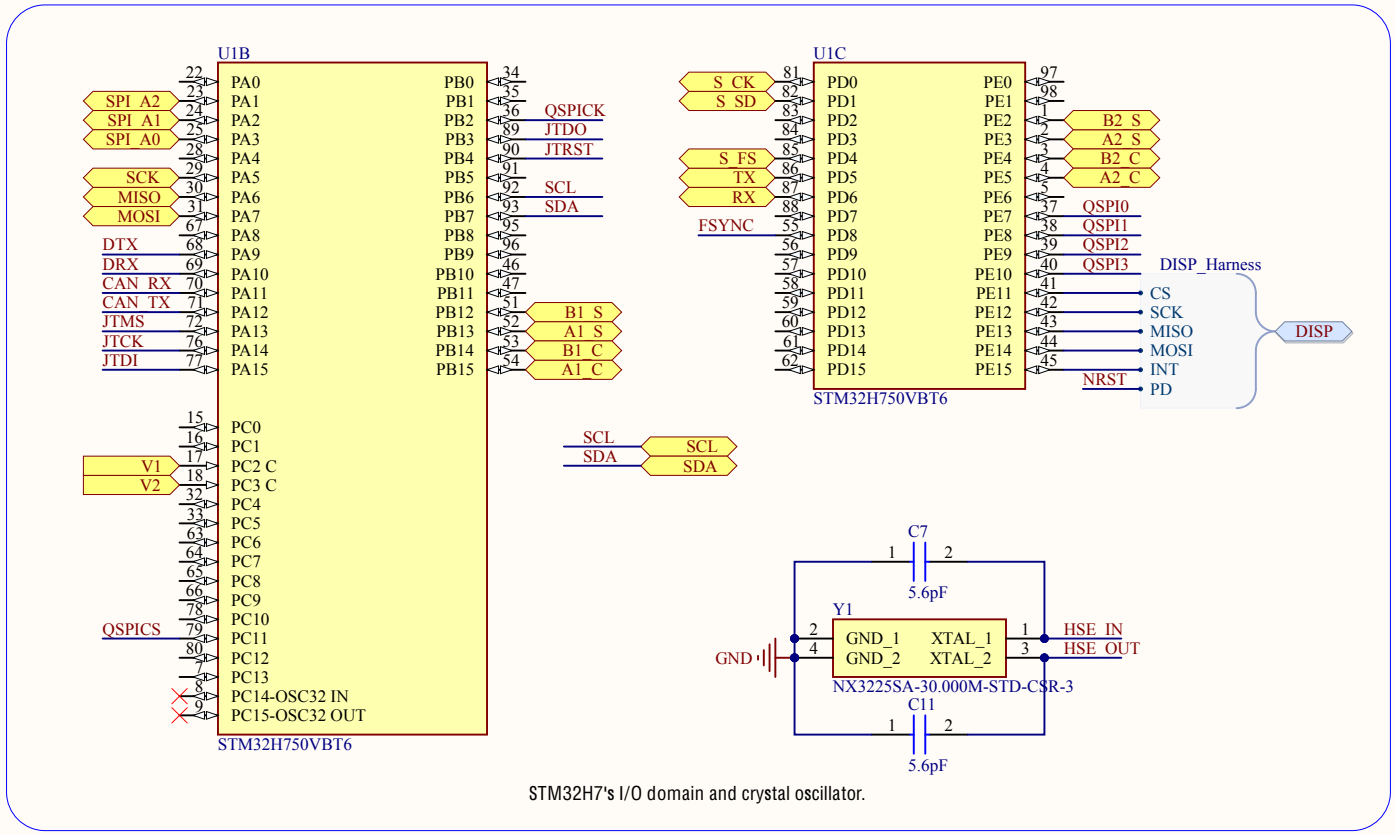
STM32H7's power domain.



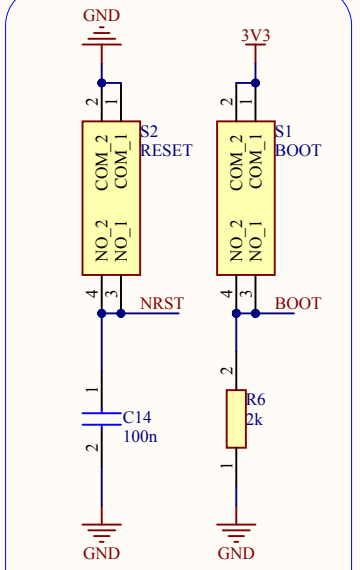
Bypass capacitors.



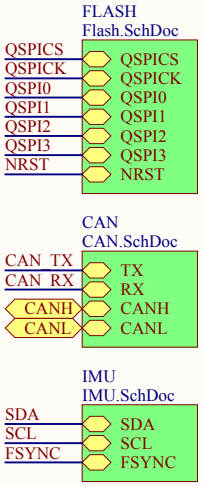
JTAG connector.



STM32H7's I/O domain and crystal oscillator.

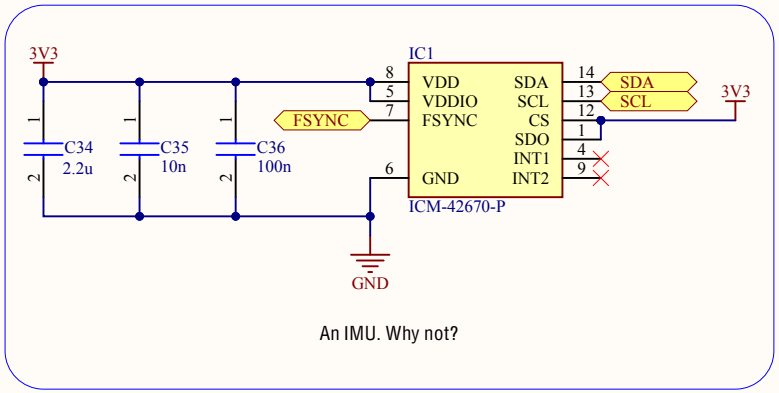


STM32H7's BOOT and RESET buttons.

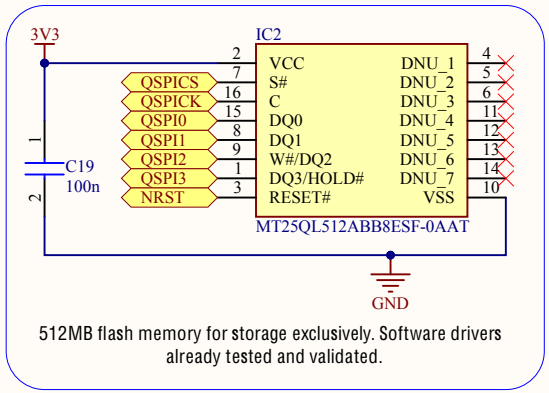


Additional peripherals.

Title: Digital Signal Processor (STM32H750VBT6)		
Size: A4	Number: 1	Revision: 1
Date: 4.04.2023	Sheet of: EPFL Xplore	
File: \\..\Controller.SchDoc	Drawn By: Arion Zimmermann	

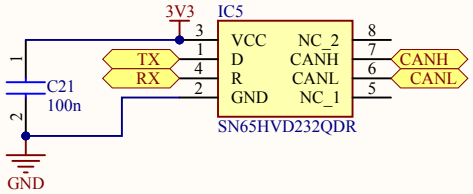


Title	IMU		
Size	Number		Revision
A4	1		1
Date:	4.04.2023	Sheet of	EPFL Xplore
File:	\\..\IMU.SchDoc	Drawn By:	Arion Zimmermann



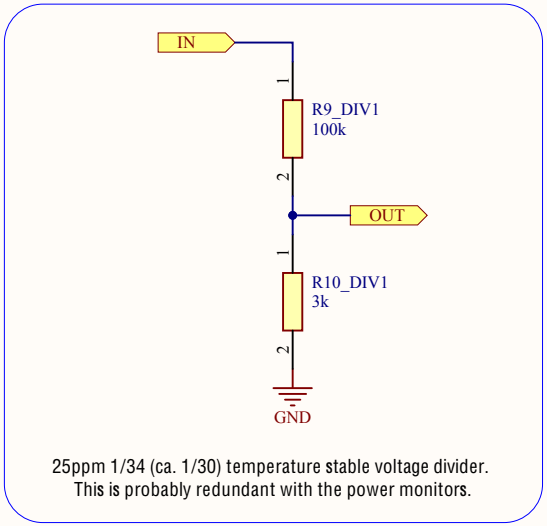
512MB flash memory for storage exclusively. Software drivers already tested and validated.

Title	Flash Memory		
Size	Number		Revision
A4	1		1
Date:	4.04.2023	Sheet of	EPFL Xplore
File:	\\..\Flash.SchDoc	Drawn By:	Arion Zimmermann



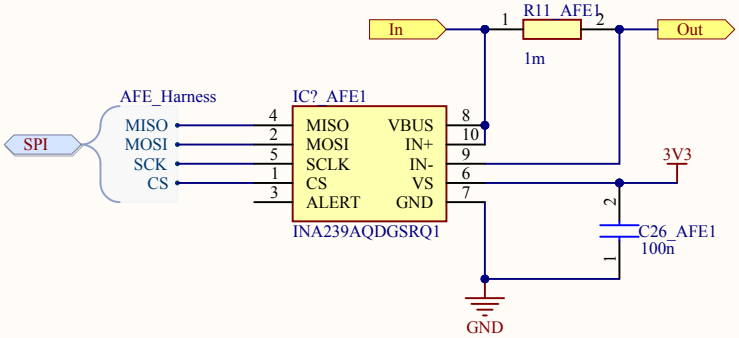
CAN controller to communicate with the Maxon motors and potentially the Jetson.

Title	CAN Bus Controller		
Size: A4	Number: 1		Revision: 1
Date: 4.04.2023		Sheet of	EPFL Xplore
File: \\..\CAN.SchDoc		Drawn By:	Arion Zimmermann



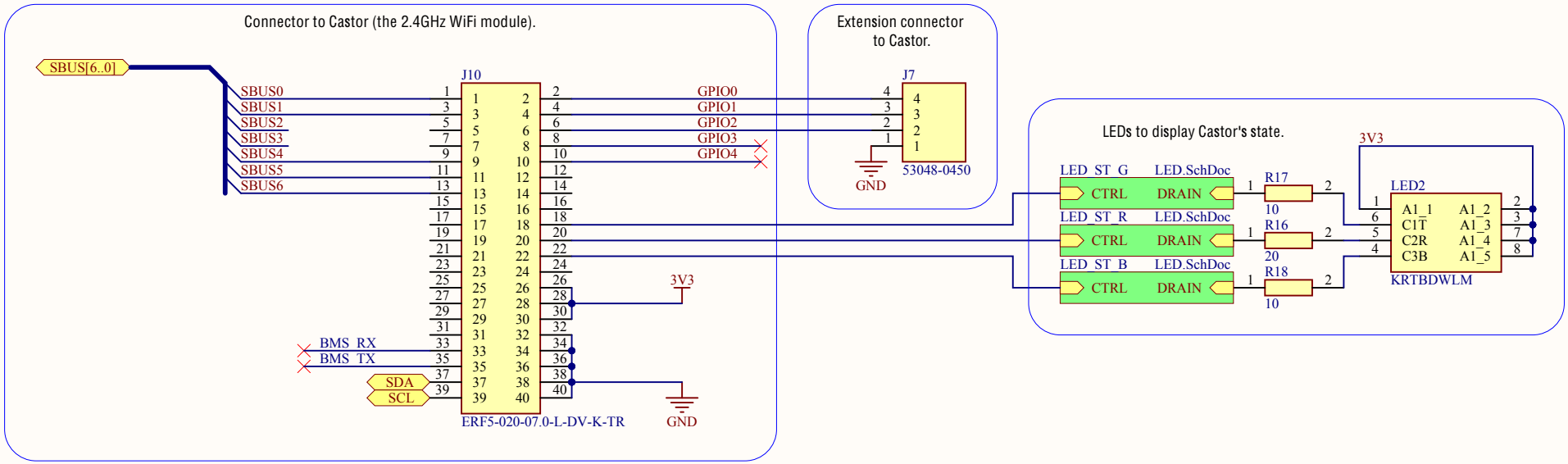
25ppm 1/34 (ca. 1/30) temperature stable voltage divider.
This is probably redundant with the power monitors.

Title	1/30 Stable Voltage Divider		
Size	Number		Revision
A4	1		1
Date:	4.04.2023	Sheet of	EPFL Xplore
File:	\\..\DIV30.SchDoc	Drawn By:	Arion Zimmermann

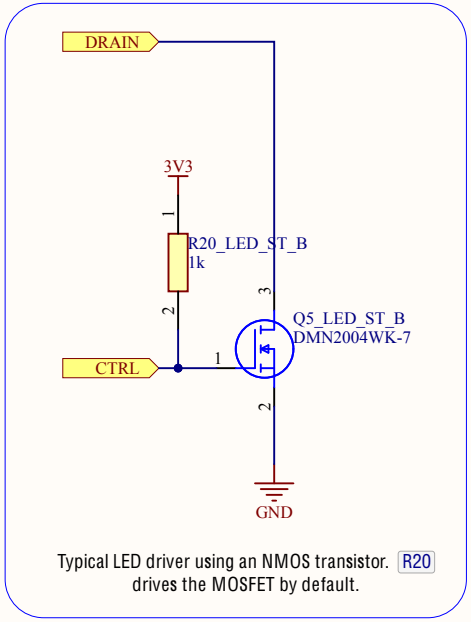


SPI delta-sigma power monitor with embedded temperature sensor. 16-bits. 160mV full-scale. Maximum sensed current: 40A (shunt thermal limit)

Title: Power Monitor			
Size: A4	Number: 1		Revision: 1
Date: 4.04.2023		Sheet of	EPFL Xplore
File: \\..\AnalogFrontEnd.SchDoc		Drawn By:	Arion Zimmermann

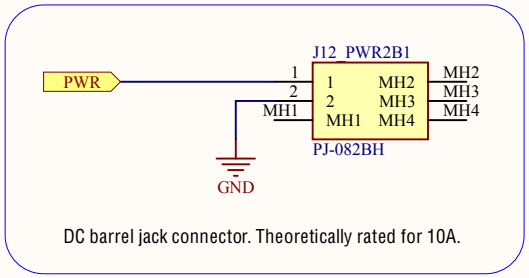


Title: Interface to Castor		
Size: A4	Number: 1	Revision: 1
Date: 4.04.2023	Sheet of: EPFL Xplore	
File: \\..\Interconnect.SchDoc	Drawn By: Arion Zimmermann	



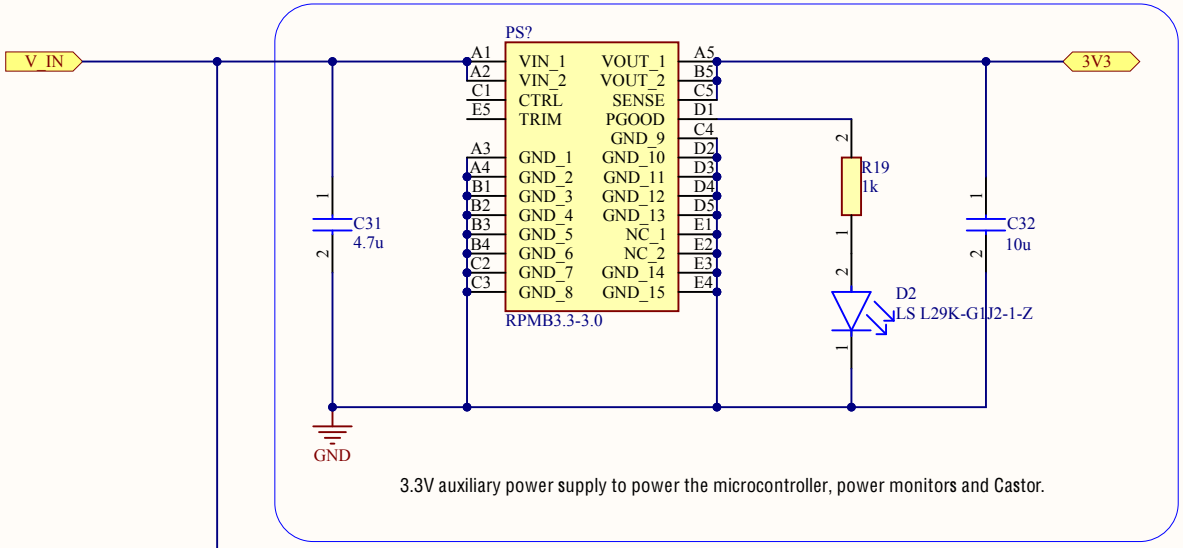
Typical LED driver using an NMOS transistor. R20 drives the MOSFET by default.

Title	LED Driver		
Size	Number		Revision
A4	1		1
Date:	4.04.2023	Sheet of	EPFL Xplore
File:	\\..\LED.SchDoc	Drawn By:	Arion Zimmermann

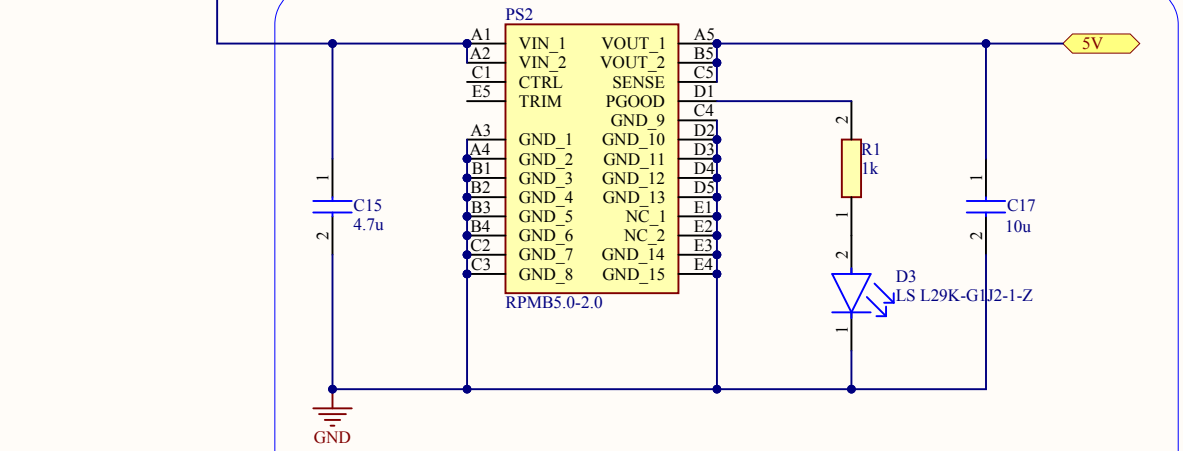


DC barrel jack connector. Theoretically rated for 10A.

Title	Power Connector		
Size	Number		Revision
A4	1		1
Date:	4.04.2023	Sheet of	EPFL Xplore
File:	\\..\PowerConnector.SchDoc	Drawn By:	Arion Zimmermann

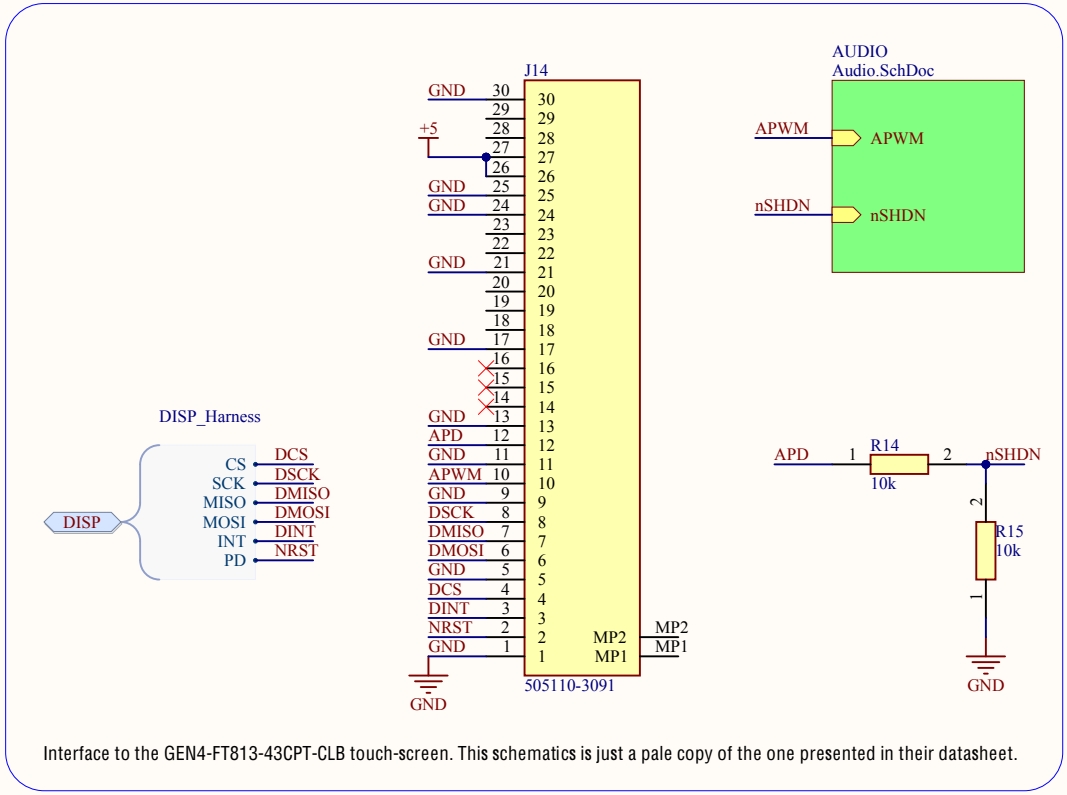


3.3V auxiliary power supply to power the microcontroller, power monitors and Castor.



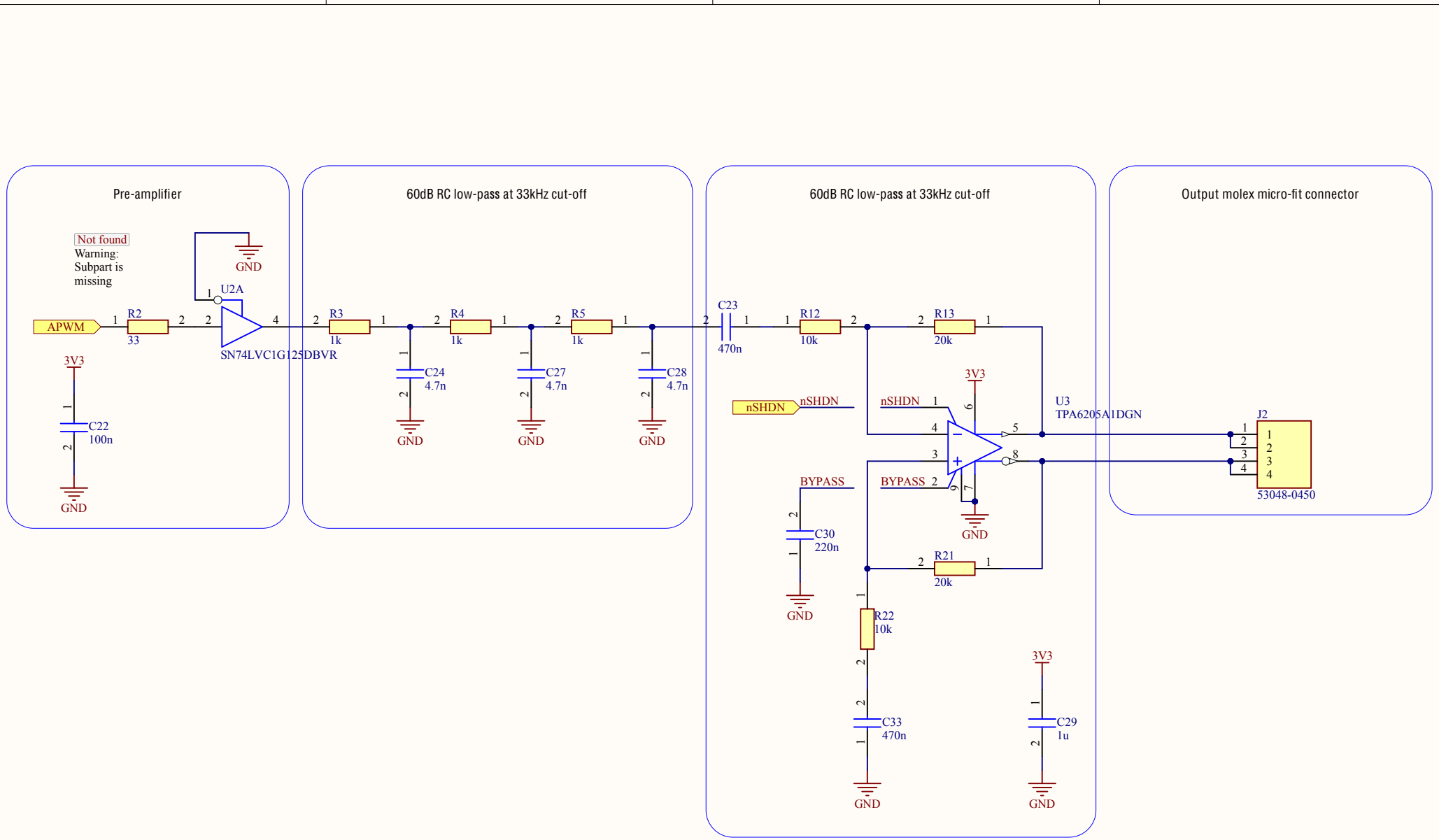
5V auxiliary power supply to power the touch-screen's sound system.

Title	Auxiliary Power Supplies		
Size	Number		Revision
A4	1		1
Date:	4.04.2023	Sheet of	DC/DC converters
File:	\\..\AuxiliaryPowerSupply.SchDoc	Drawn By:	Arion Zimmermann

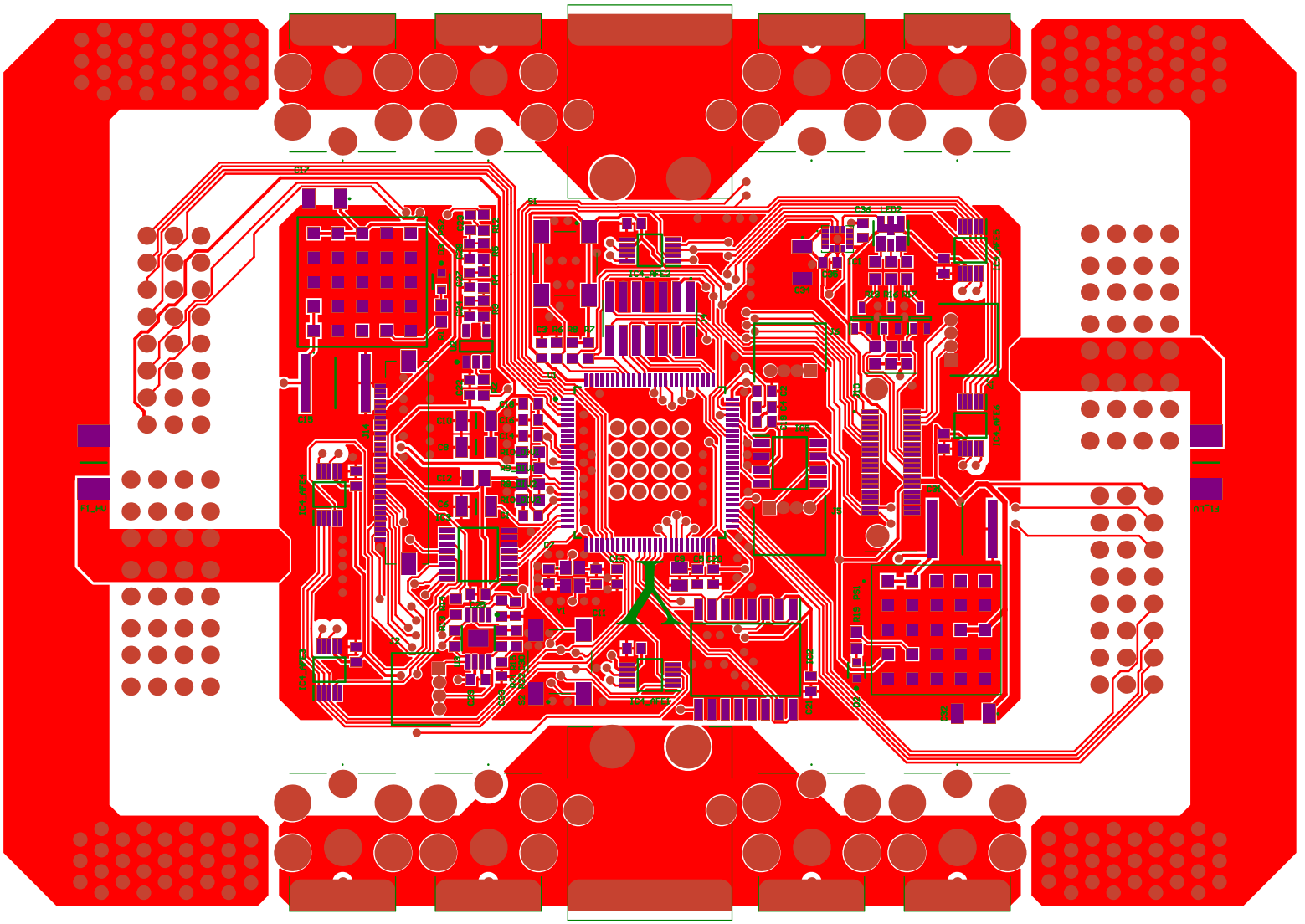


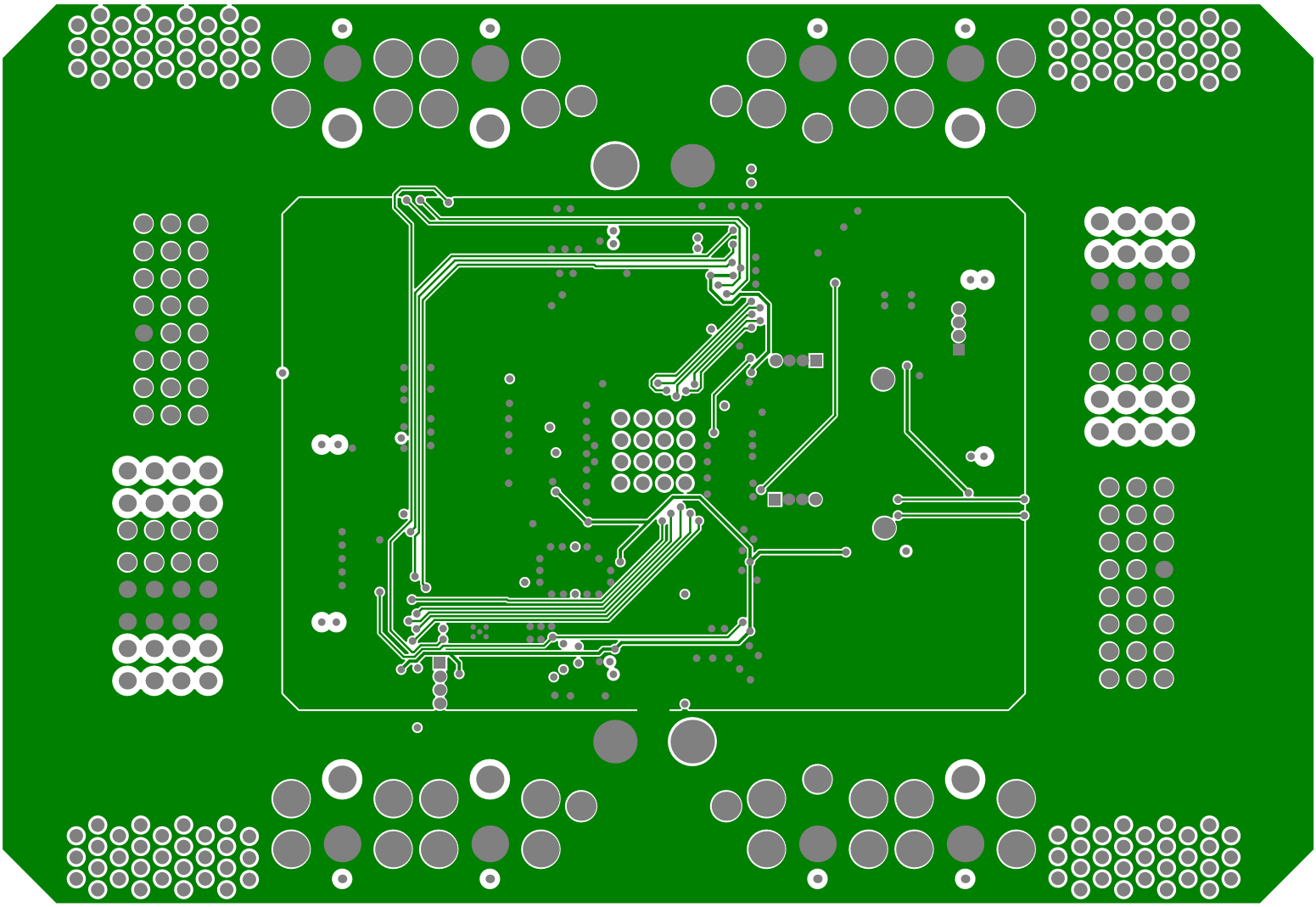
Interface to the GEN4-FT813-43CPT-CLB touch-screen. This schematics is just a pale copy of the one presented in their datasheet.

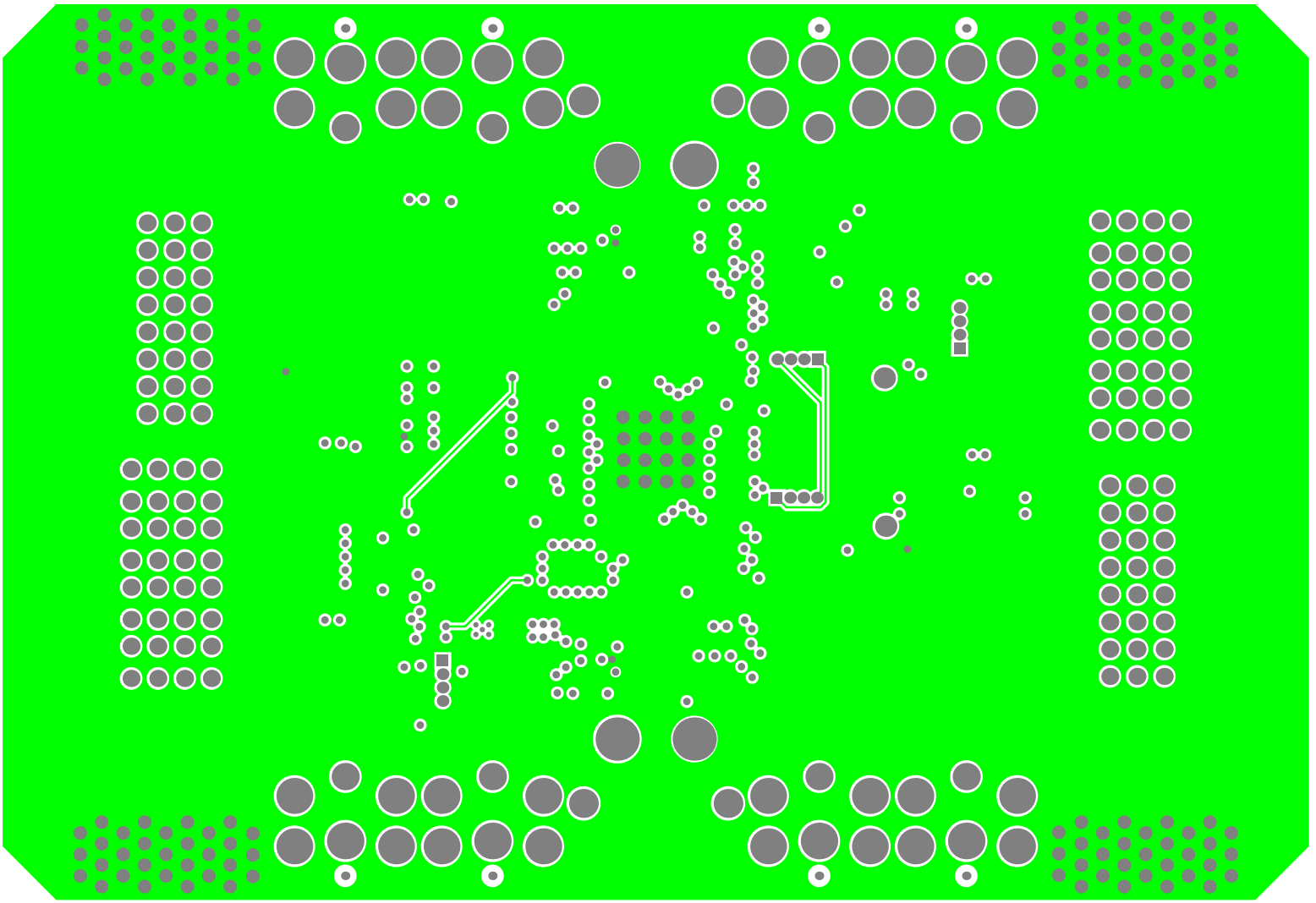
Title: Interface to the Touch-Screen		
Size: A4	Number: 1	Revision: 1
Date: 4.04.2023	Sheet of	EPFL Xplore
File: \\..\Display.SchDoc		Drawn By: Arion Zimmermann

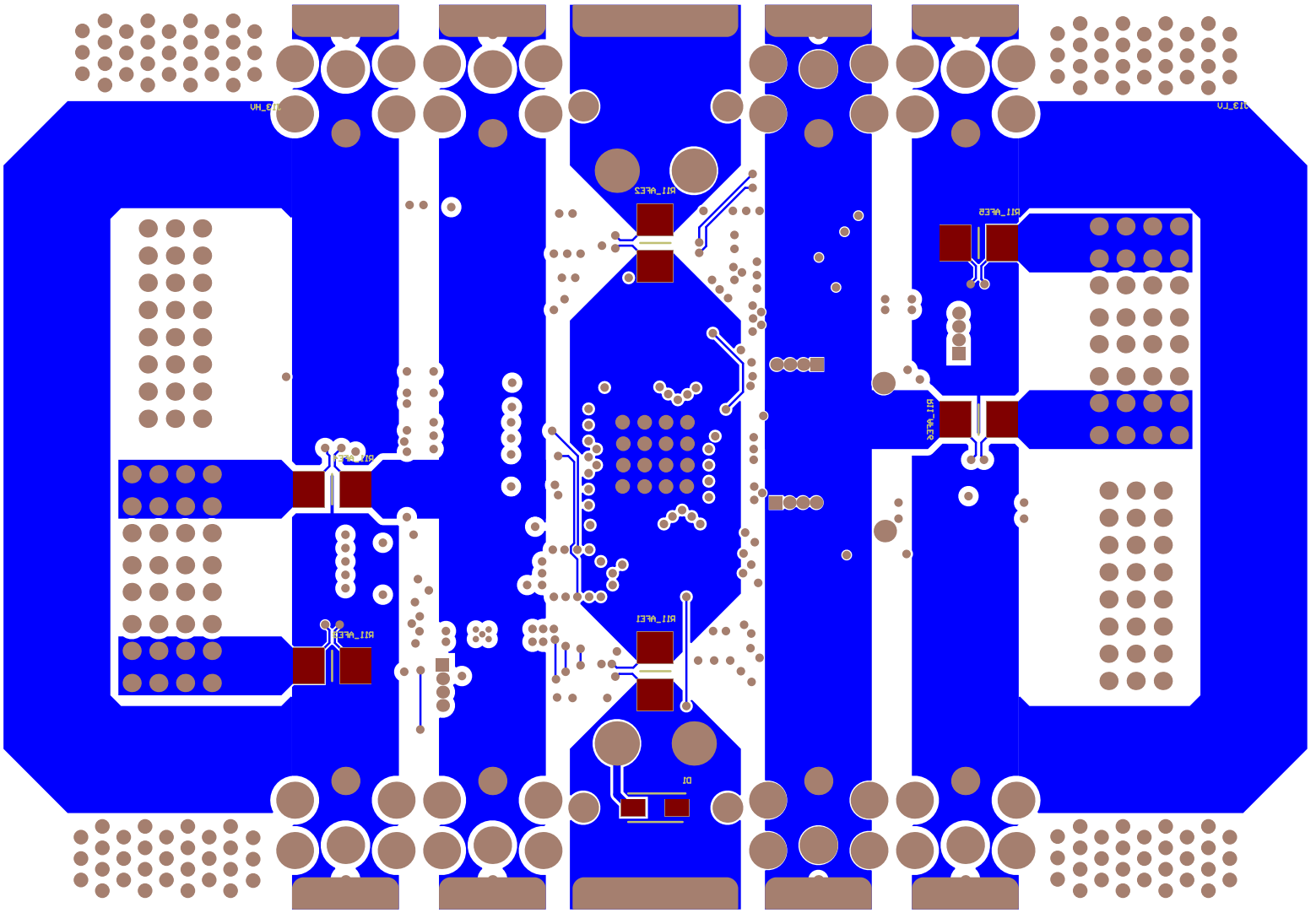


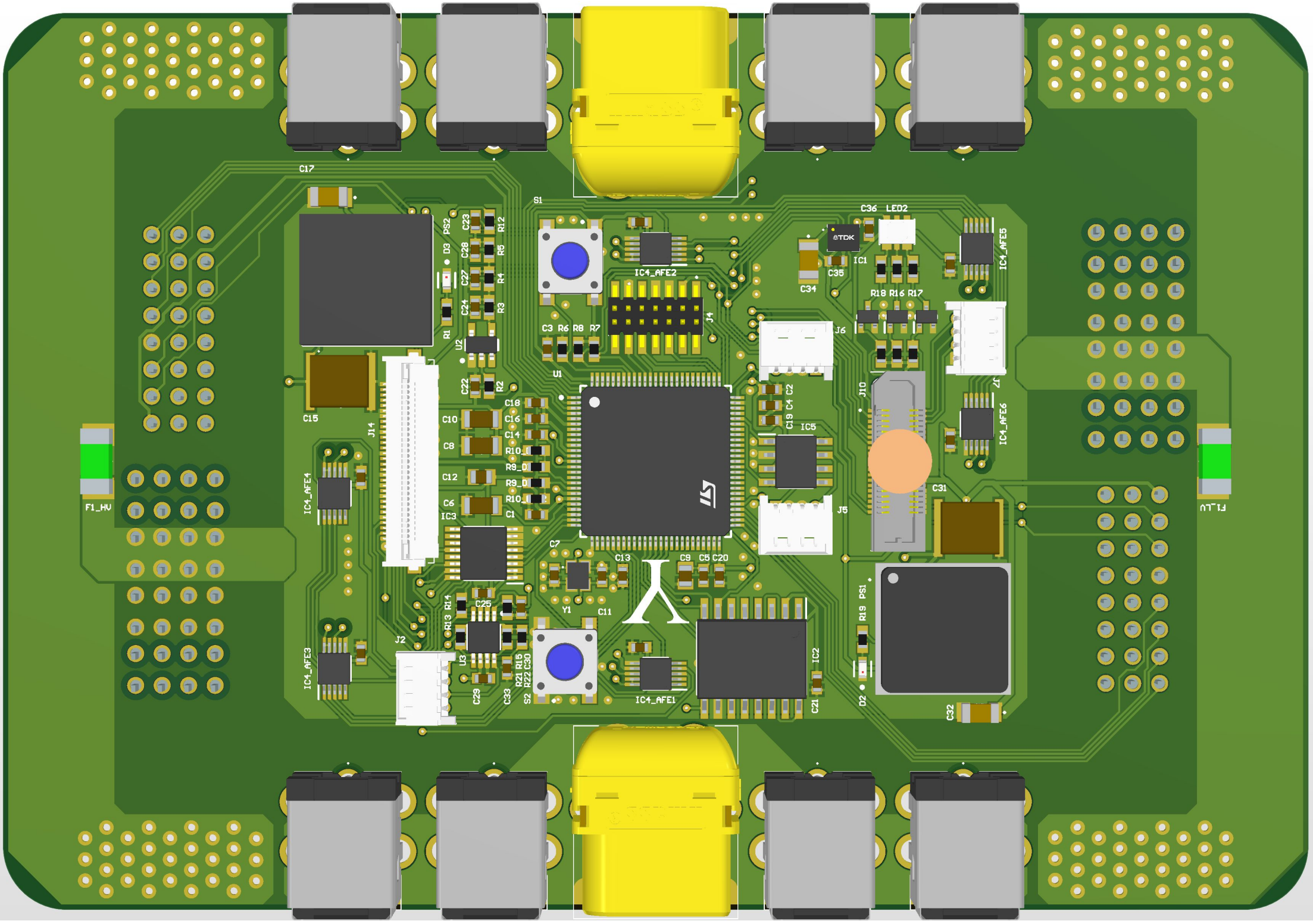
Title: Audio Amplifier		
Size: A4	Number: 1	Revision: 1
Date: 4.04.2023	Sheet of EPFL Xplore	
File: \\..\Audio.SchDoc	Drawn By: Arion Zimmermann	

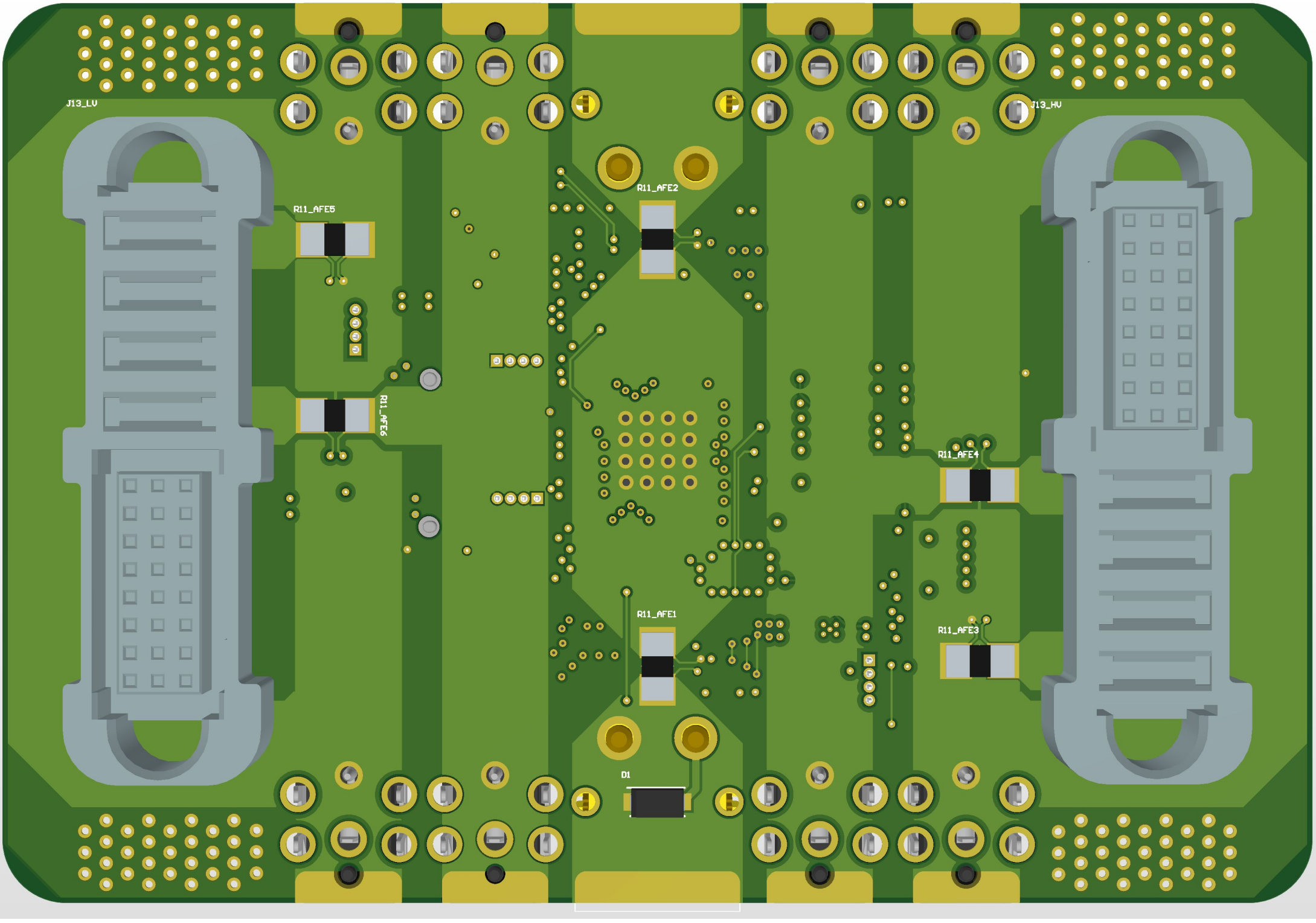









C17
S1
C36
LED2
IC4_AFE2
IC1
C34
C35
IC4_AFE5
R18 R16 R17
C3 R6 R8 R7
J4
J6
U1
C2
C4
C19
IC5
J10
J7
IC4_AFE6
C15
J14
C10
C8
C12
C6
IC3
C18
C16
C14
C1
IC4_AFE4
C31
J5
C7
C13
C9
C5
C20
Y1
C11
J2
C25
R14
R13
U3
R21
R15
R22
C30
C29
C33
S2
IC4_AFE1
IC2
C21
R19
PS1
D2
C32
F1_HV
F1_LV


J13_LV
J13_HV
R11_AFE2
R11_AFE5
R11_AFE6
R11_AFE4
R11_AFE1
R11_AFE3
D1