

Amulet Motion Controller

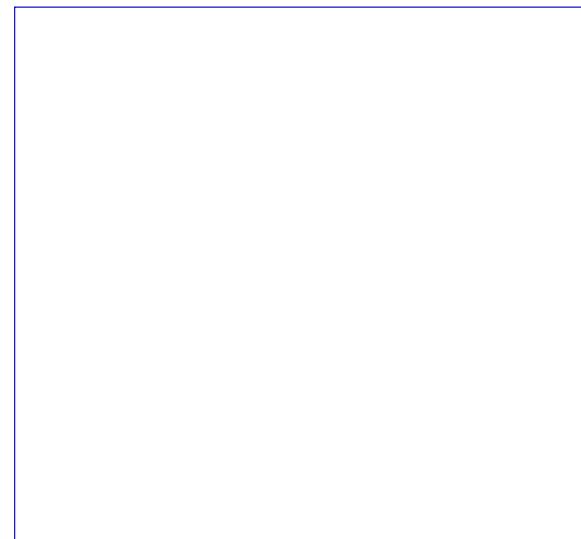
Variant: Preliminary

2023-12-15

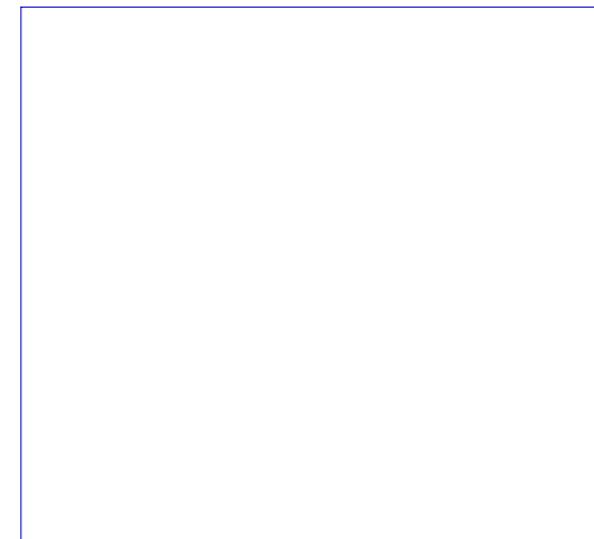
Rev 1.0

Page	Index	Page	Index	Page	Index	Page	Index
1	Cover page	11	User - LED Indicators	21	Revision History	31
2	Block diagram	12	Sensing - Temperature	22	32
3	Project architecture	13	Sensing - Battery	23	33
4	MCU - Power	14	Sensing - Position	24	34
5	MCU - I/Os	15	Interface - RS-422	25	35
6	Power - Generation	16	Interface - FD-CAN	26	36
7	Power - Connectors	17	Interface - Fan Control	27	37
8	Motor Control - Top Level	18	Interface - Interconnects	28	38
9	Motor Control - Inverter	19	Mechanical - Holes	29	39
10	Misc - Board Version Divider	20	Power Sequencing	30	40

TOP VIEW



BOTTOM VIEW



NOTES

Not fitted components are marked as

DRAFT - Very early stage of schematic, ignore details.

PRELIMINARY - Close to final schematic.

CHECKED - There shouldn't be any mistakes. Contact the engineer if you find any.

RELEASED - A board with this schematic has been sent to production.

Preliminary XX.XX.XX

DESIGN CONSIDERATIONS

DESIGN NOTE:
Example text for informational design notes.

DESIGN NOTE:
Example text for debug notes.

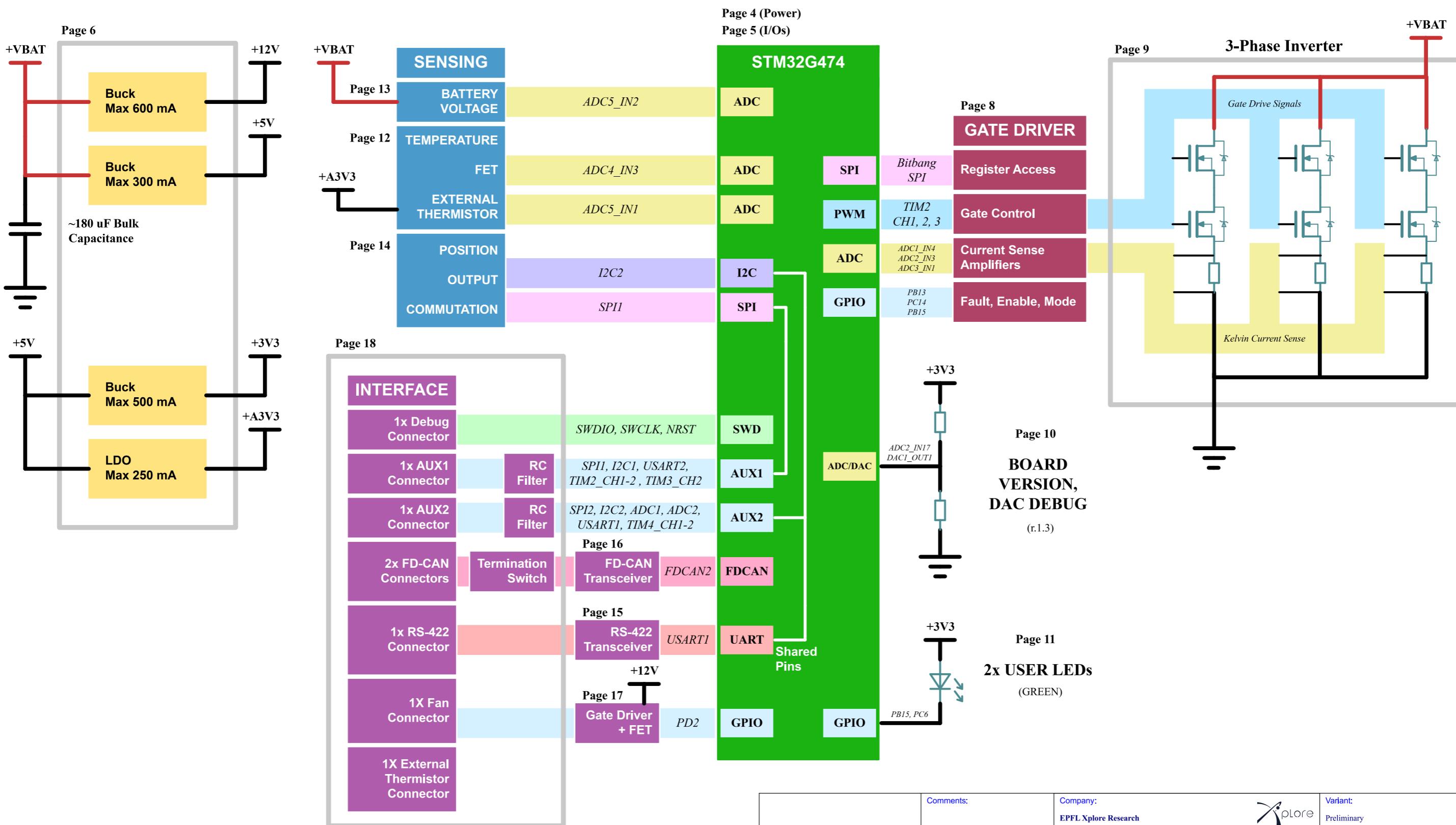
DESIGN NOTE:
Example text for cautionary design notes.

DESIGN NOTE:
Example text for critical design notes.

LAYOUT NOTE:
Example text for critical layout guidelines.

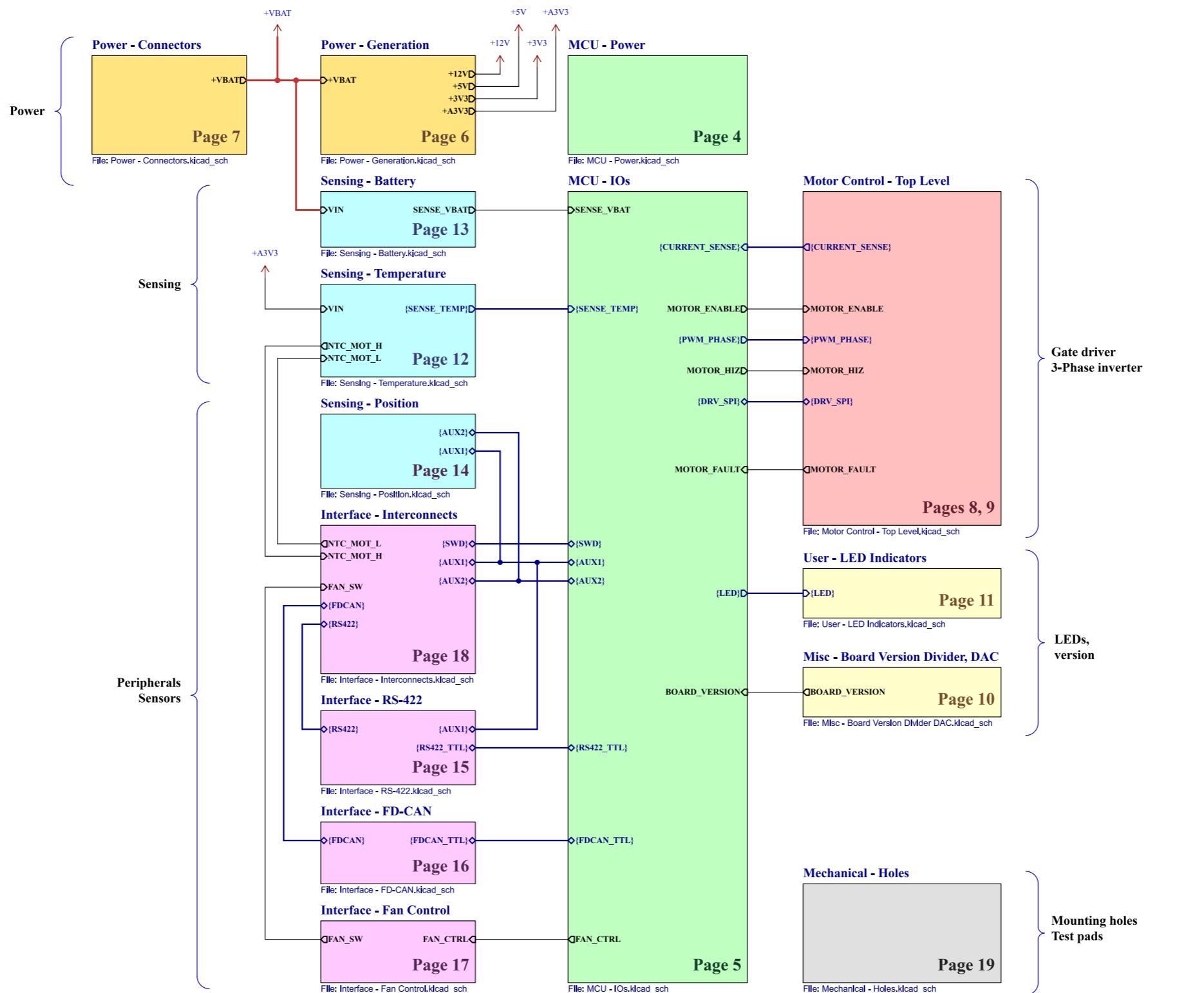
	Comments:	Company: EPFL Xplore Research	Variant: Preliminary
		Board Name: Amulet Motion Controller	Project Name: Chienpanzée
	Sheet Title: Cover Page	File Name: bldc_controller.kicad_sch	Designer: Vincent Nguyen
	Sheet Path: /	Reviewer:	Date: 2023-10-12 Revision: 1.0
		Size: A3	Sheet: 1 of 21

[2] Block Diagram



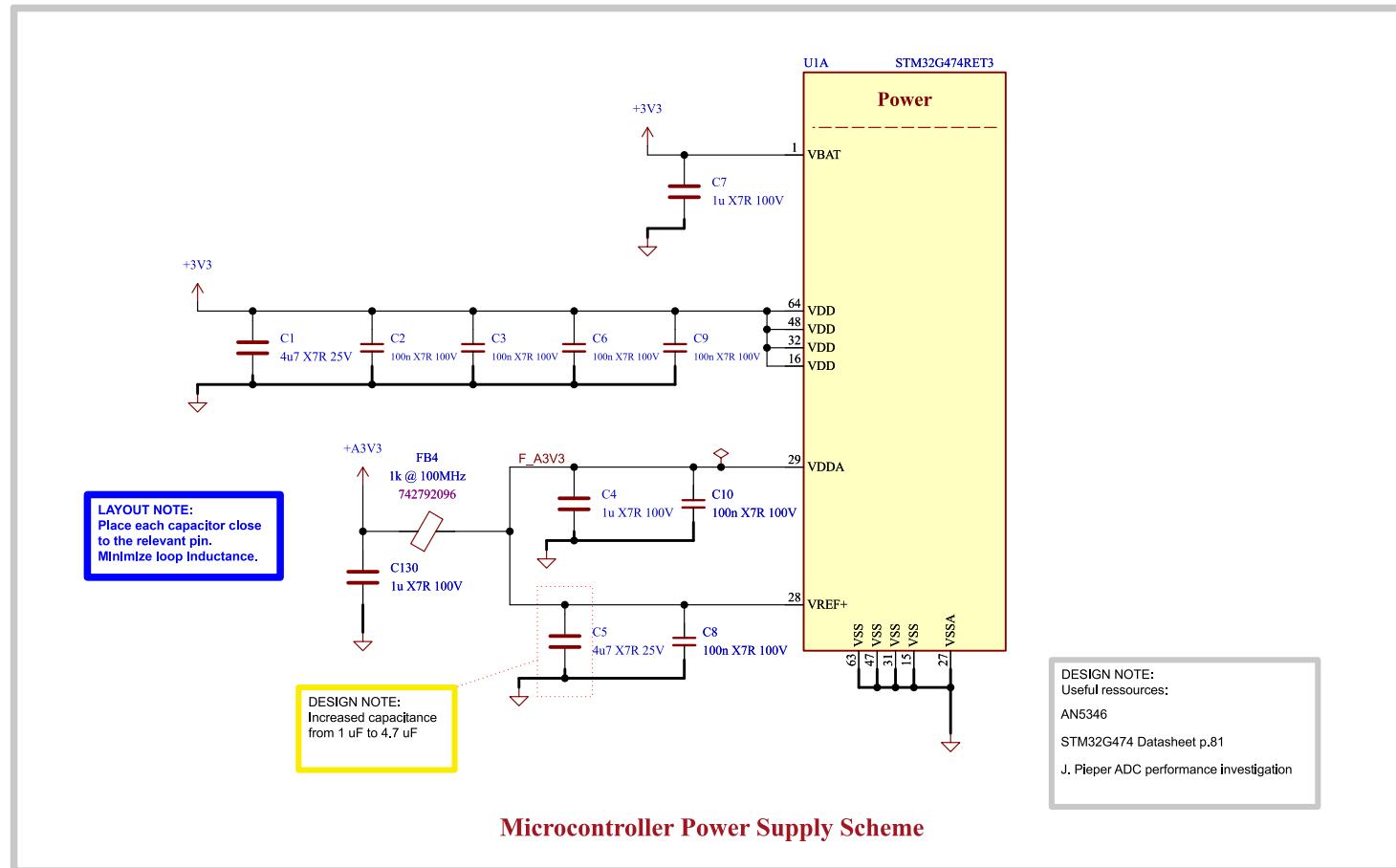
	Comments:	Company:	xplore	Variant:
		EPFL Xplore Research		Preliminary
	Board Name:	Amulet Motion Controller		Project Name: Chienpanzée
	Sheet Title:	File Name:	Designer:	Date: 2023-11-30 Revision: 1.0
	Block Diagram	Block Diagram.kicad_sch	Vincent Nguyen	
	Sheet Path:	/Block Diagram/		Reviewer:
				Size: A3 Sheet: 2 of 21

[3] Project Architecture



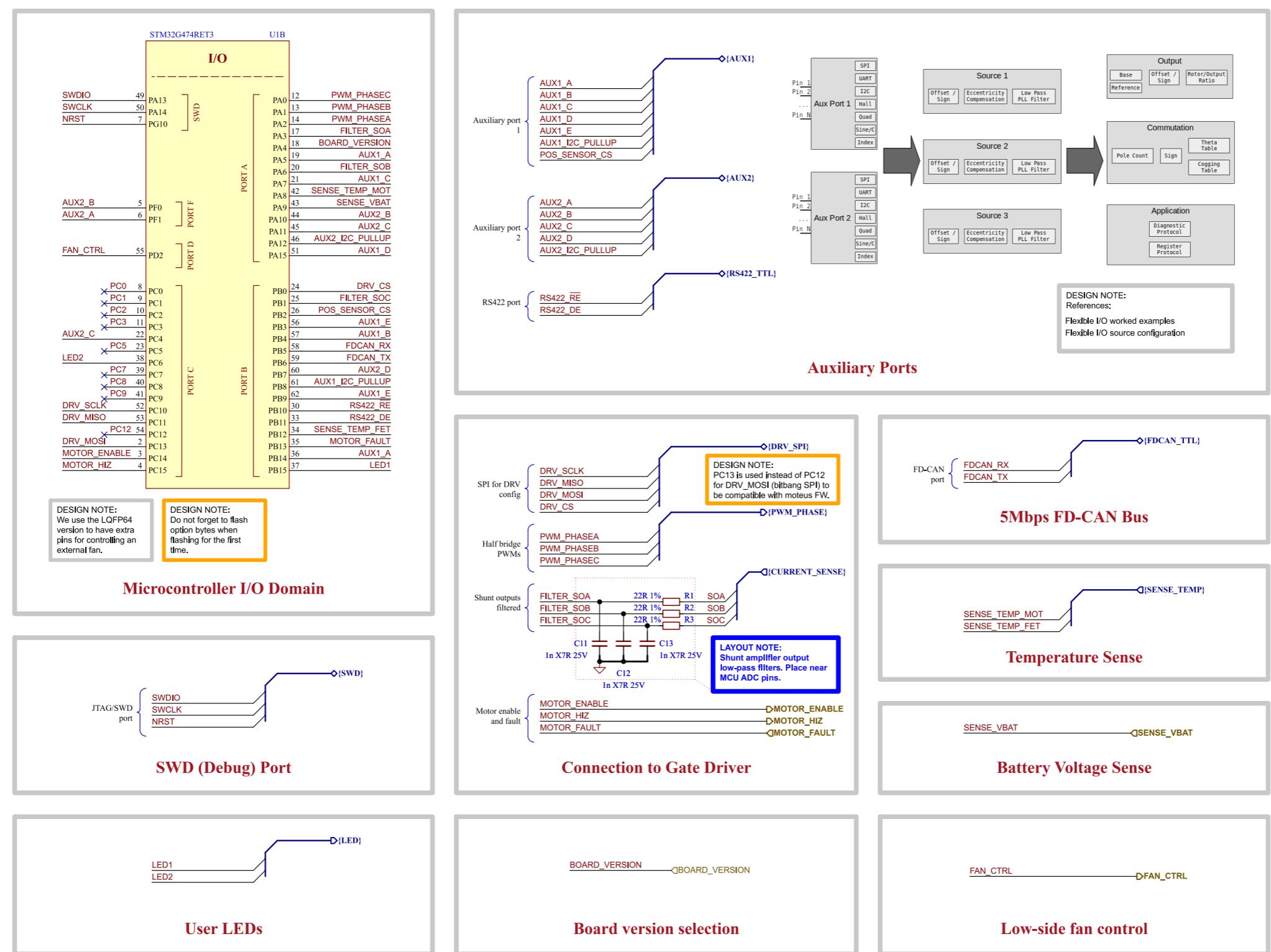
	Comments:	Company: EPFL Xplore Research	Variant: Preliminary
	Board Name: Amulet Motion Controller	Project Name: Chienpanzée	
Sheet Title:	File Name: Project Architecture	Designer: Vincent Nguyen	Date: 2023-11-25
Sheet Path:	/Project Architecture/	Reviewer:	Revision: 1.0
	Size: A3	Sheet: 3 of 21	

[4] MCU - Power

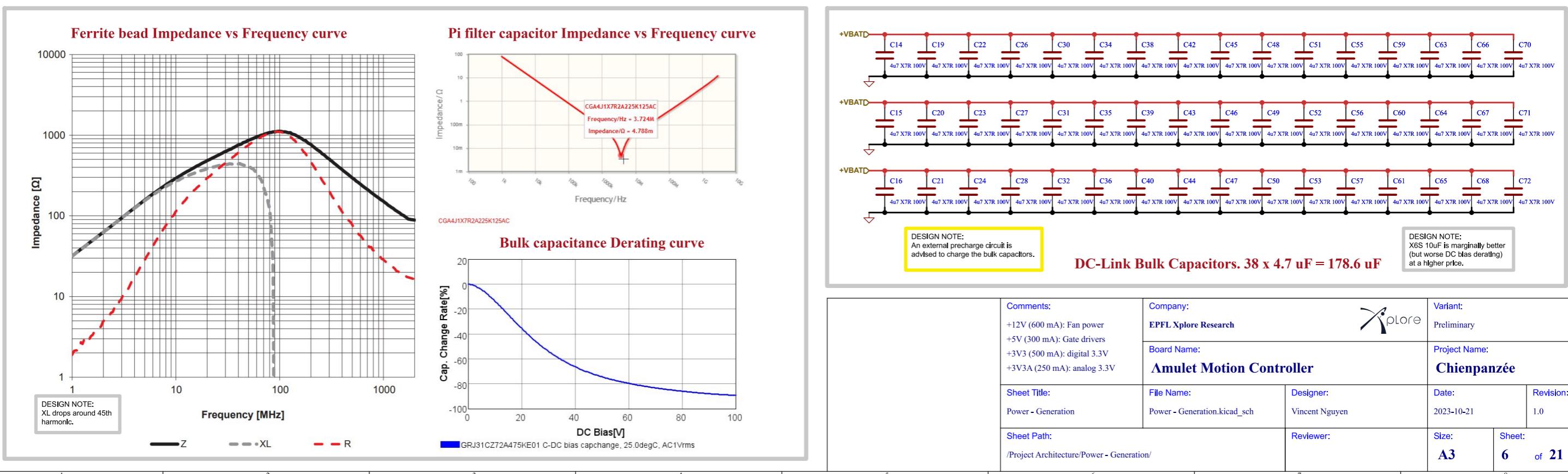
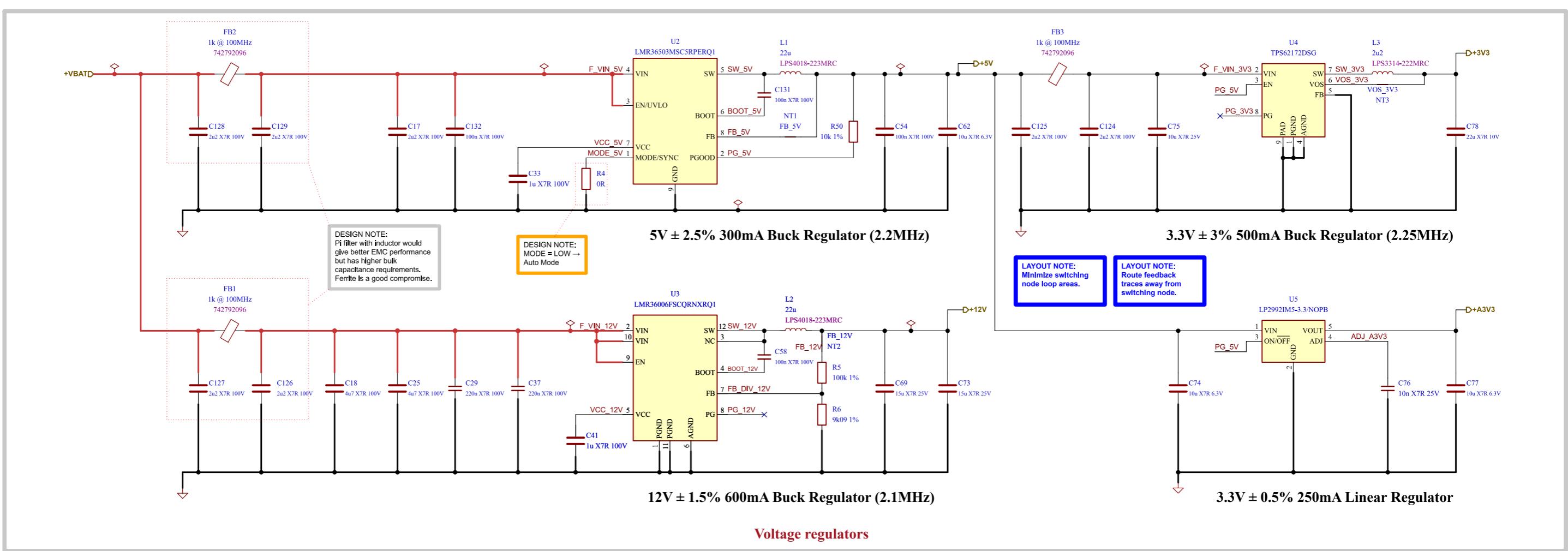


	Comments:	Company: EPFL Xplore Research	Variant: Preliminary
	Board Name: Amulet Motion Controller		
	Sheet Title: MCU - Power	File Name: MCU - Power.kicad_sch	Designer: Vincent Nguyen
	Sheet Path: /Project Architecture/MCU - Power/	Reviewer:	Date: 2023-10-14 Revision: 1.0

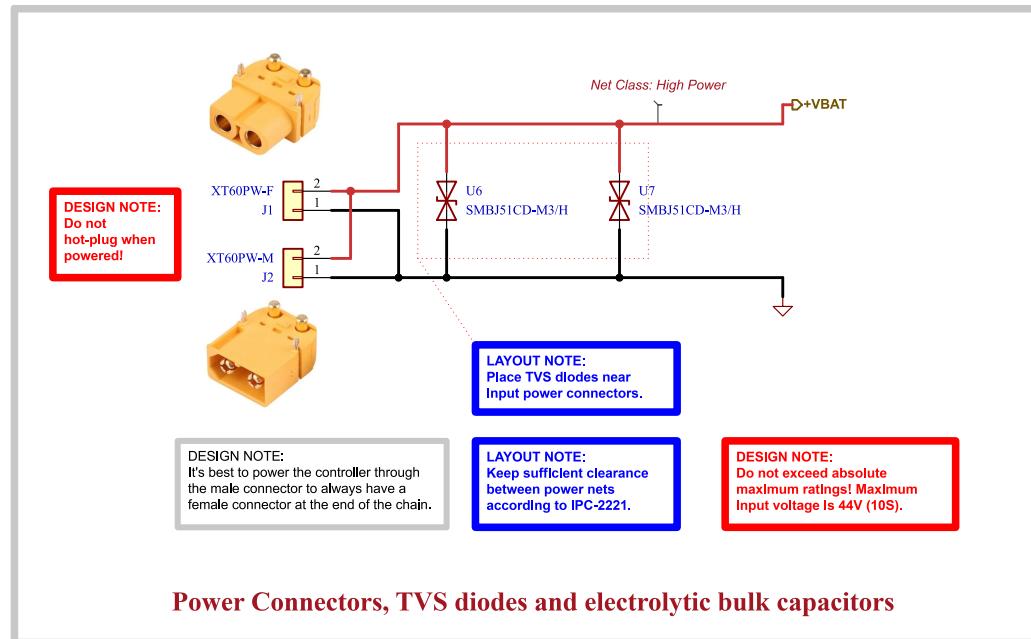
[5] MCU - I/Os



[6] Power - Generation

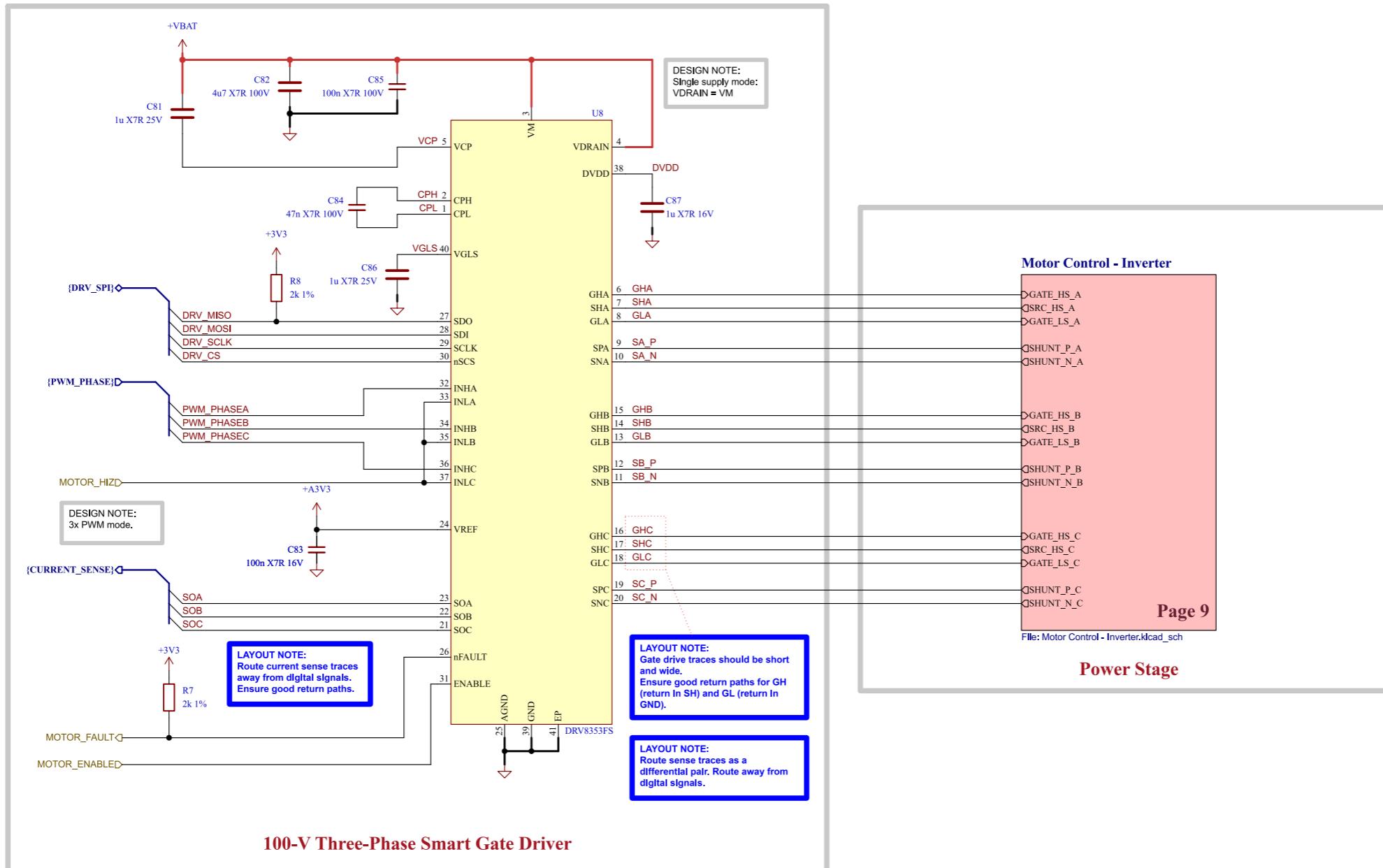


[7] Power - Connectors



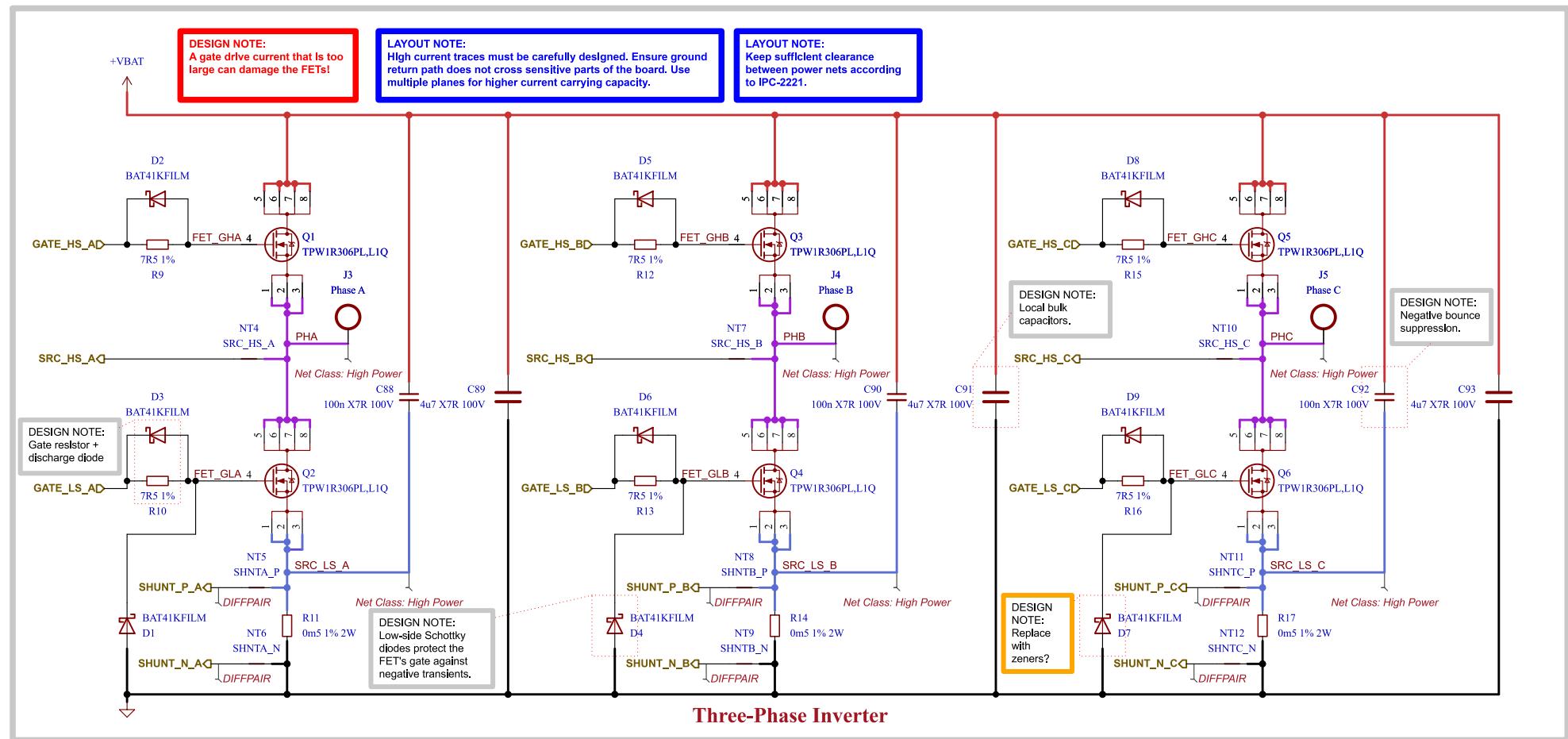
	Comments: 	Company: EPFL Xplore Research 	Variant: Preliminary
	Board Name: Amulet Motion Controller		Project Name: Chienpanzée
	Sheet Title: Power - Connectors	File Name: Power - Connectors.kicad_sch	Designer: Vincent Nguyen
	Sheet Path: /Project Architecture/Power - Connectors/	Reviewer: 	Date: 2023-10-14
		Size: A4	Revision: 1.0
		Sheet: 7	of 21

[8] Motor Control - Top Level



	Comments:	Company:		
		EPFL Xplore Research	Variant:	
	Board Name:	Amulet Motion Controller		Project Name:
		Chienpanzée		
	Sheet Title:	File Name:	Designer:	Date: Revision:
	Motor Control - Top Level	Motor Control - Top Level.kicad_sch	Vincent Nguyen	2023-10-16 1.0
	Sheet Path:	/Project Architecture/Motor Control - Top Level/		Reviewer:
				Size: Sheet:
		A3		8 of 21

[9] Motor Control - Inverter



DESIGN NOTE:
References:
System Design Considerations for High-Power Motor Driver Applications
Best Practices for Board Layout of Motor Drivers

Comments:

Company:
EPFL Xplore Research



Variant:
Preliminary

Board Name:
Amulet Motion Controller

Project Name:
Chienpanzée

Sheet Title:
Motor Control - Inverter

File Name:
Motor Control - Inverter.kicad_sch

Designer:
Vincent Nguyen

Date:
2023-10-18

Revision:
1.0

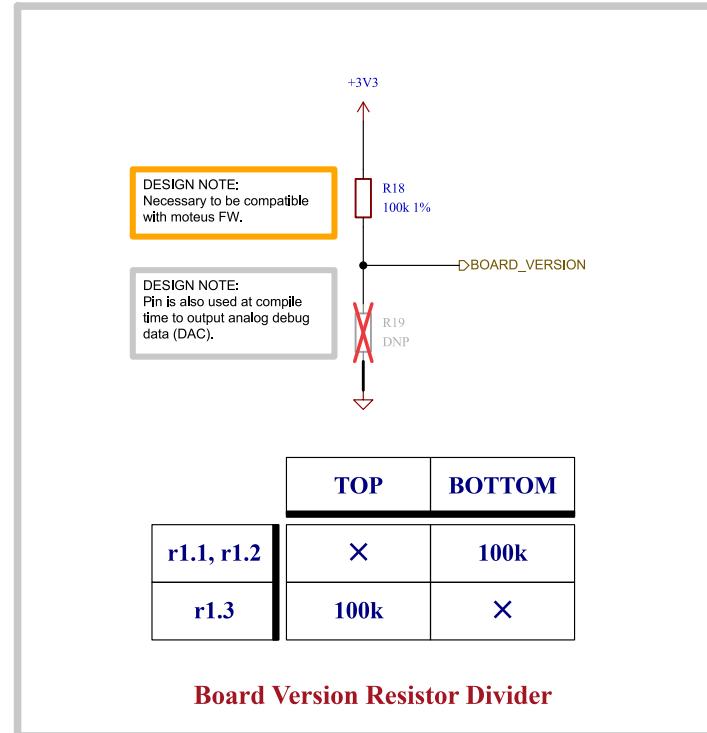
Sheet Path:
/Project Architecture/Motor Control - Top Level/Motor Control - Inverter/

Reviewer:

Size:
A4

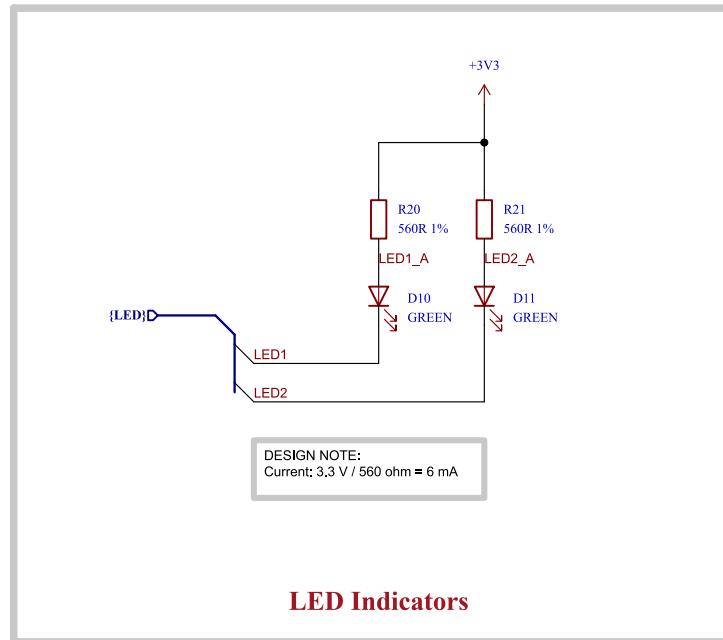
Sheet:
9 of **21**

[10] Misc - Board Version Divider, DAC



	Comments:	Company: EPFL Xplore Research	Variant: Preliminary
	Board Name: Amulet Motion Controller		
	Sheet Title: Misc - Board Version Divider, DAC	File Name: Misc - Board Version Divider DAC.kicad_file	Designer: Adrian Nguyen
	Sheet Path: /Project Architecture/Misc - Board Version Divider, DAC/	Reviewer:	Date: 2023-10-14 Revision: 1.0

[11] User - LED Indicators



	Comments:	Company: EPFL Xplore Research		Variant: polore Preliminary	
		Board Name: Amulet Motion Controller		Project Name: Chienpanzée	
	Sheet Title: User - LED Indicators	File Name: User - LED Indicators.kicad_sch	Designer: Vincent Nguyen	Date: 2023-10-15	Revision: 1.0
	Sheet Path: /Project Architecture/User - LED Indicators/		Reviewer:	Size: A4	Sheet: 11 of 21

[12] Sensing - Temperature

A

B

C

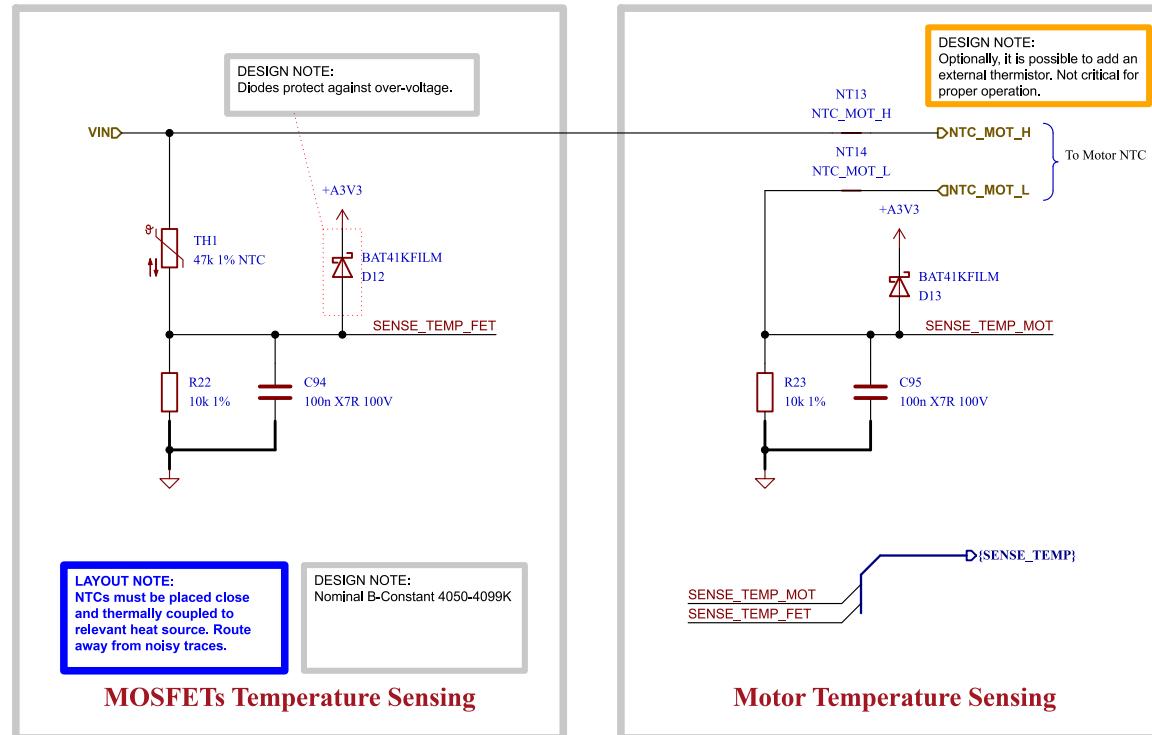
D

A

B

C

D



[13] Sensing - Battery

A

B

C

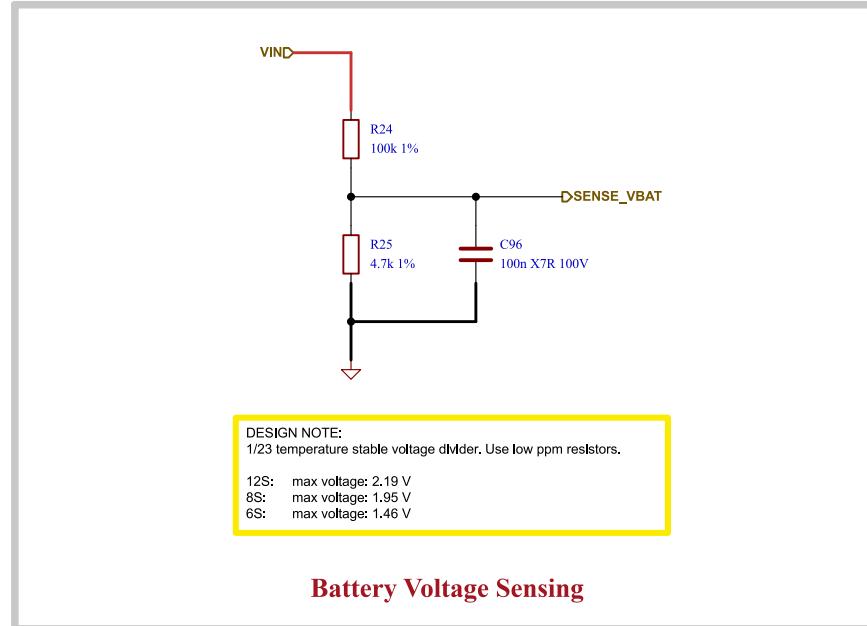
D

A

B

C

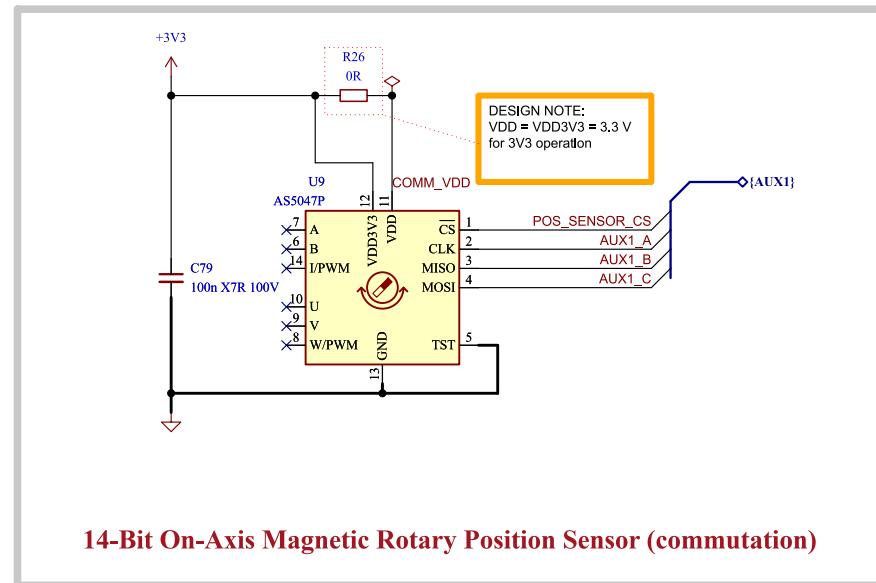
D



	Comments:	Company: EPFL Xplore Research	Variant: Preliminary
	Board Name: Amulet Motion Controller		
	Sheet Title: Sensing - Battery	File Name: Sensing - Battery.kicad_sch	Designer: Vincent Nguyen
	Sheet Path: /Project Architecture/Sensing - Battery/	Reviewer:	Date: 2023-10-14 Revision: 1.0
		Size: A4	Sheet: 13 of 21

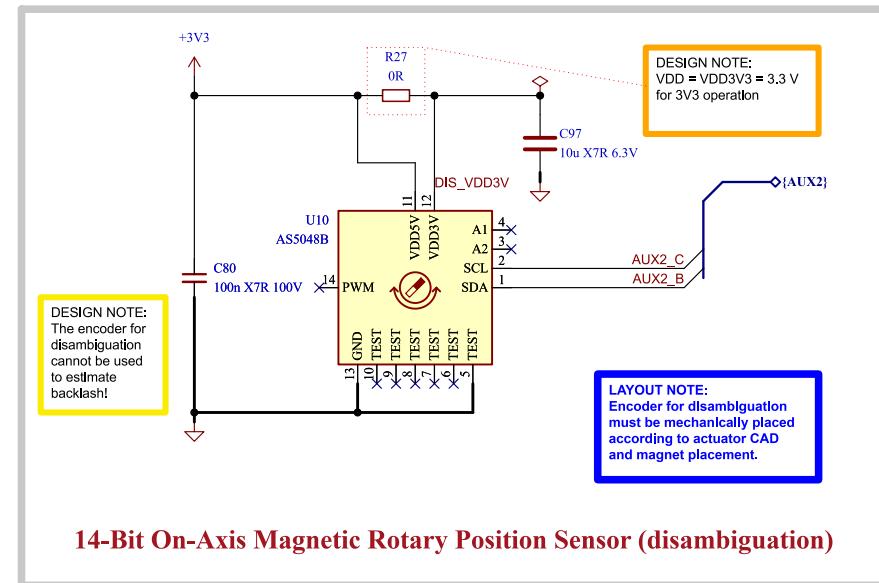
[14] Sensing - Position

A



14-Bit On-Axis Magnetic Rotary Position Sensor (commutation)

B



14-Bit On-Axis Magnetic Rotary Position Sensor (disambiguation)

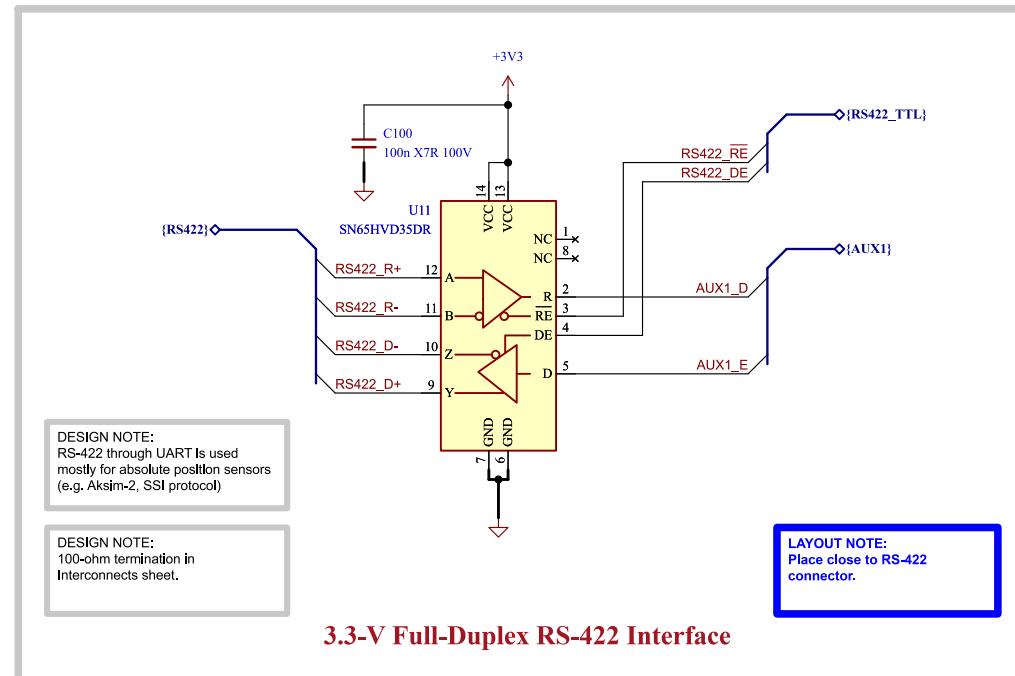
C

DESIGN NOTE:
AS5047P senses magnet mounted on planetary sun gear, for commutation.
AS5048B senses magnet mounted on shaft with same reduction factor as planetary gearbox for disambiguation.

D

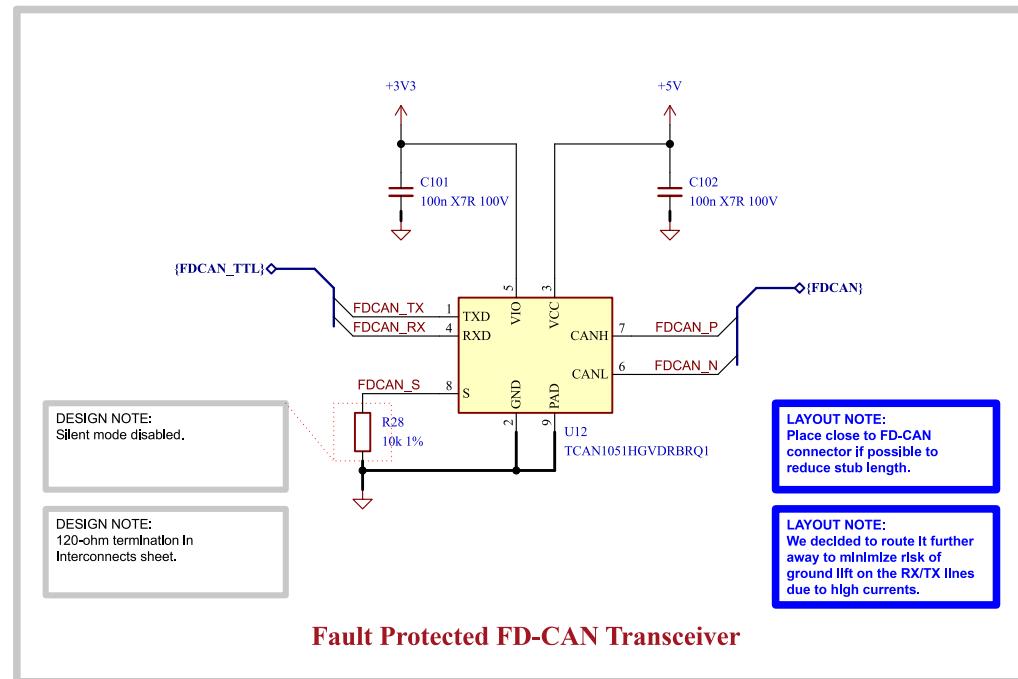
	Comments:	Company: EPFL Xplore Research	Variant: Preliminary
	Board Name: Amulet Motion Controller		
	Sheet Title: Sensing - Position	File Name: Sensing - Position.kicad_sch	Designer: Vincent Nguyen
	Sheet Path: /Project Architecture/Sensing - Position/	Reviewer:	Date: 2023-10-14 Revision: 1.0

[15] Interface - RS-422



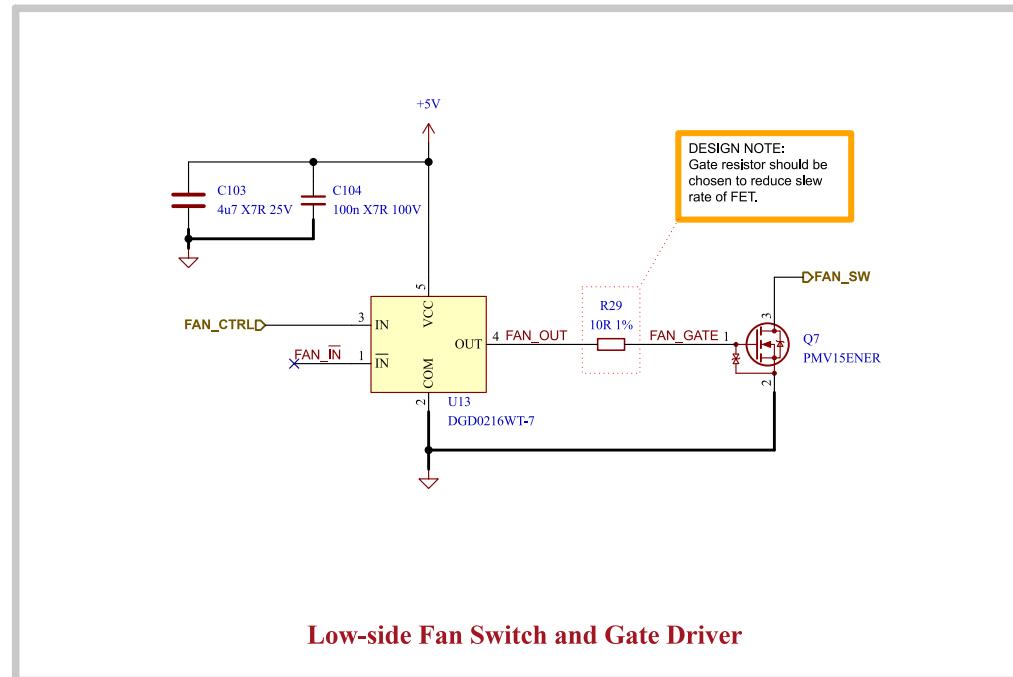
	Comments:	Company: EPFL Xplore Research	Variant: Preliminary
	Board Name: Amulet Motion Controller		
	Sheet Title: Interface - RS-422	File Name: Interface - RS-422.kicad_sch	Designer: Vincent Nguyen
	Sheet Path: /Project Architecture/Interface - RS-422/	Reviewer:	Date: 2023-10-15 Revision: 1.0

[16] Interface - FD-CAN



	Comments:	Company: EPFL Xplore Research	Variant: Preliminary
	Board Name: Amulet Motion Controller		
	Sheet Title: Interface - FD-CAN	File Name: Interface - FD-CAN.kicad_sch	Designer: Vincent Nguyen
	Sheet Path: /Project Architecture/Interface - FD-CAN/	Reviewer:	Date: 2023-10-15 Revision: 1.0

[17] Interface - Fan Control



A

B

C

D

A

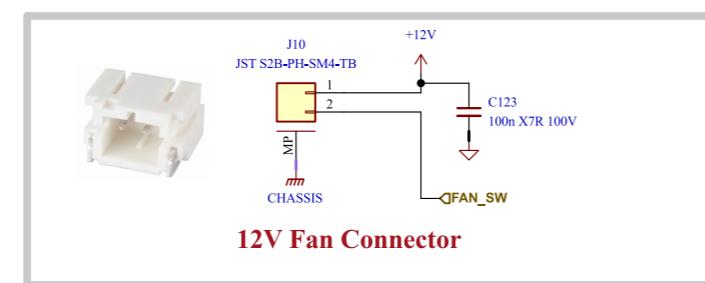
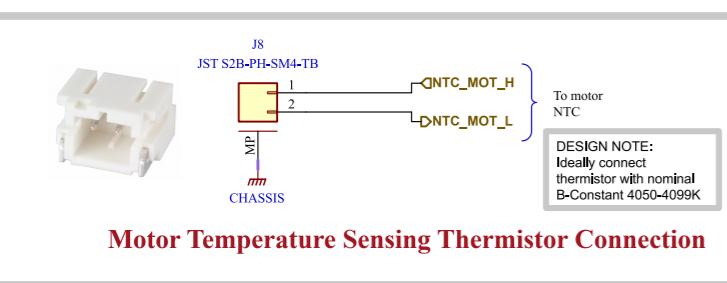
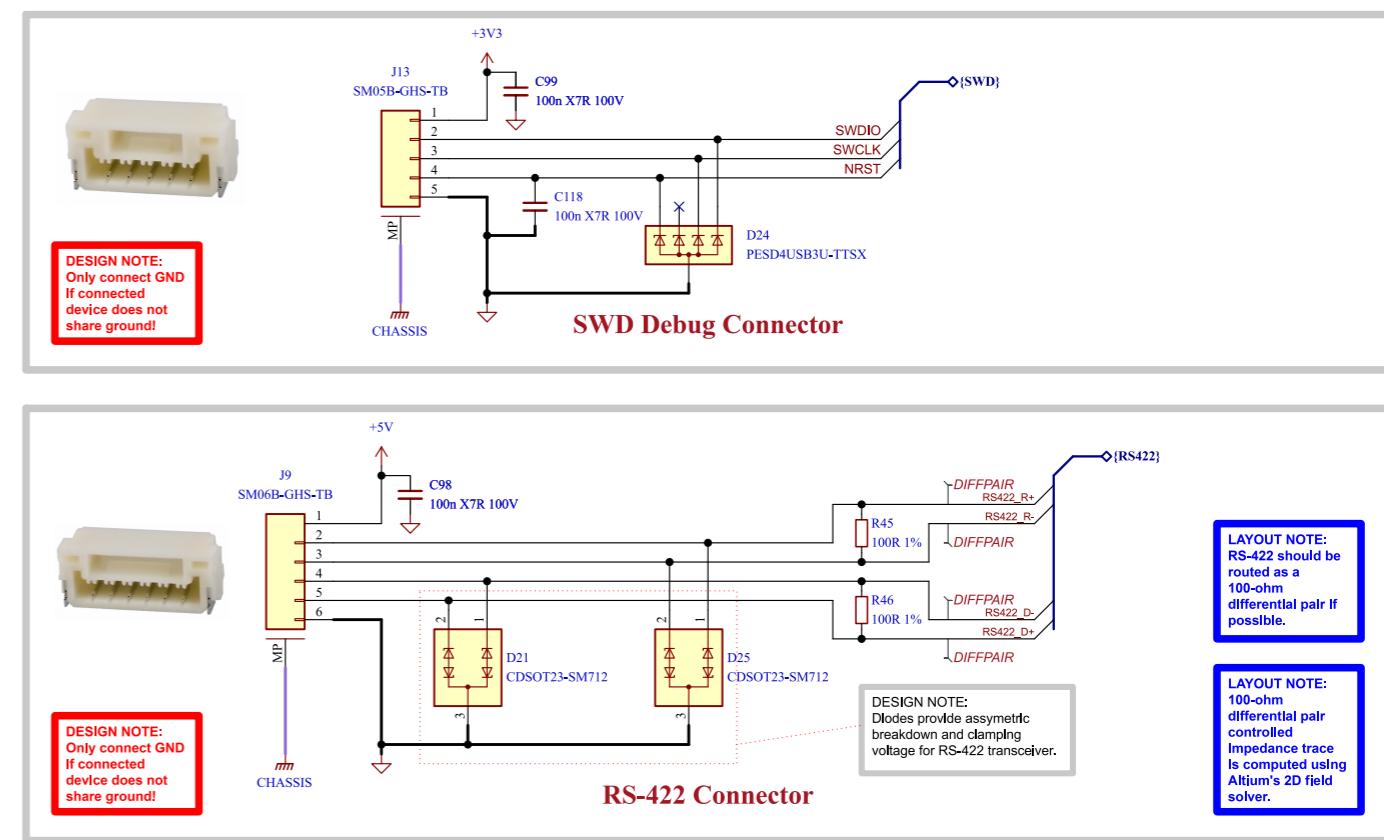
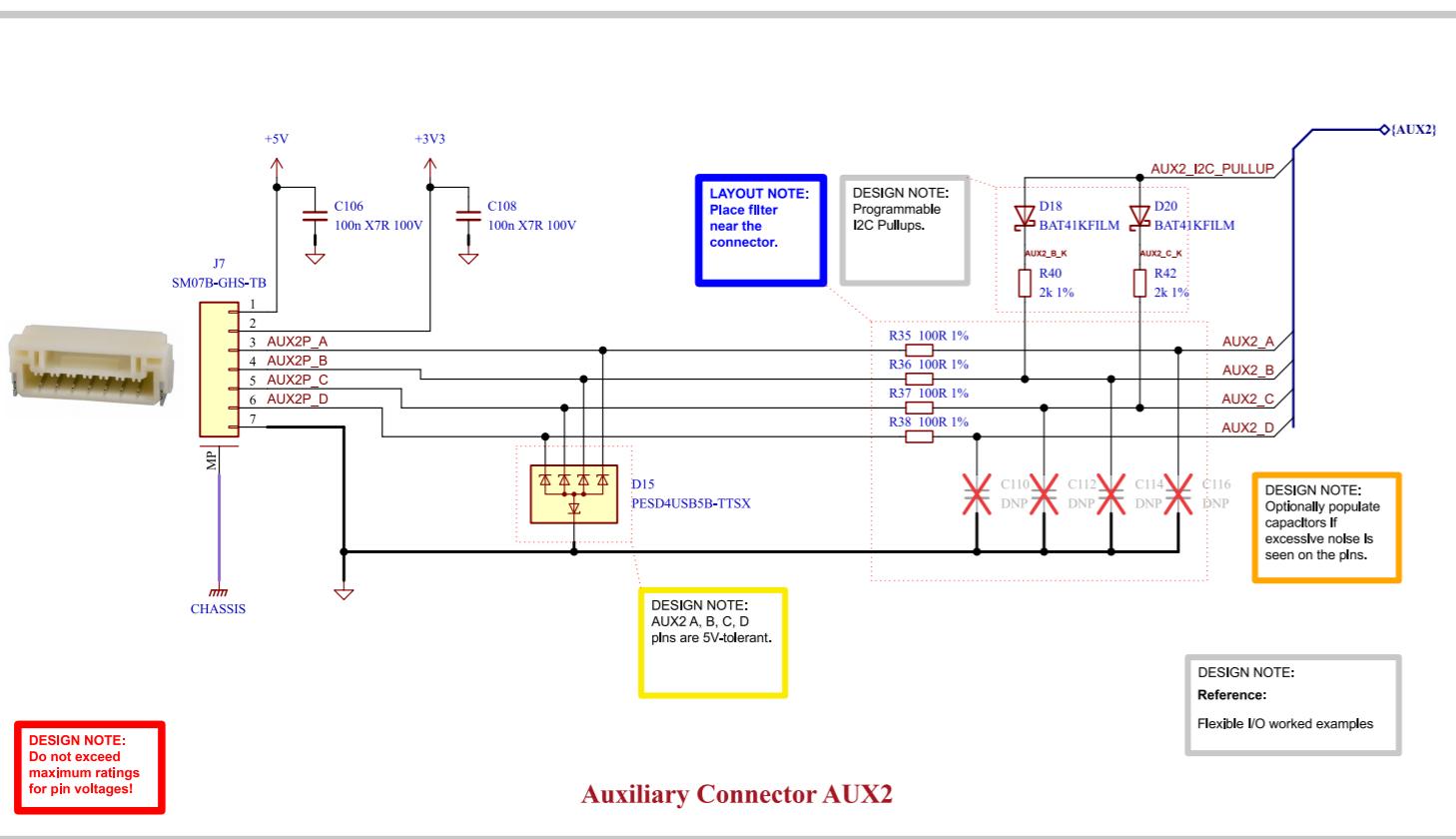
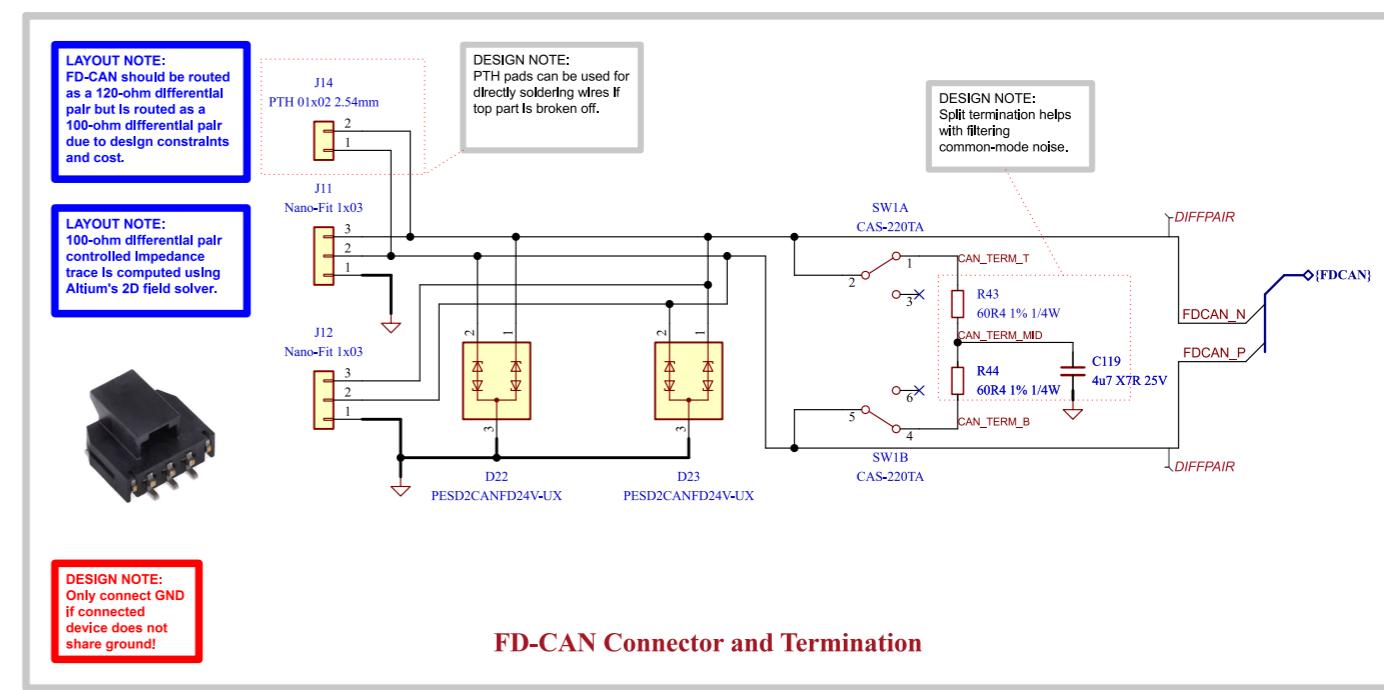
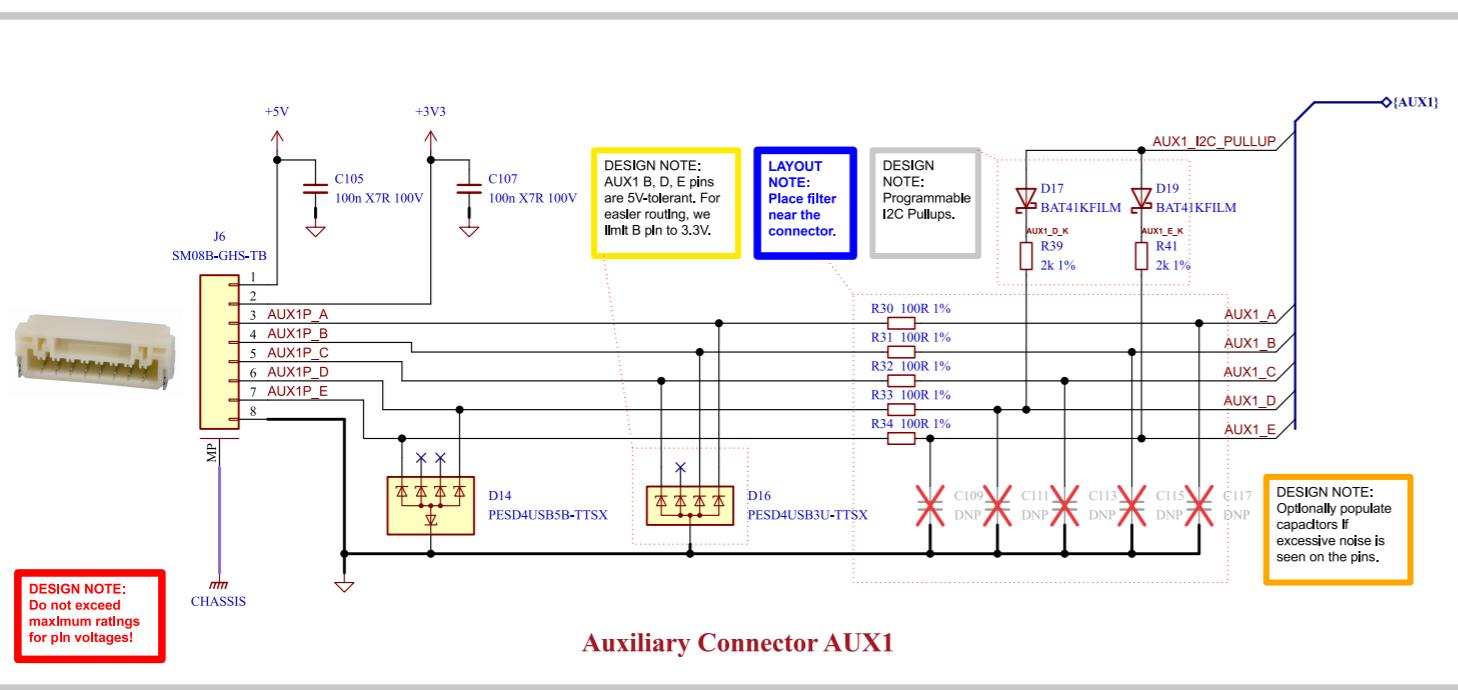
B

C

D

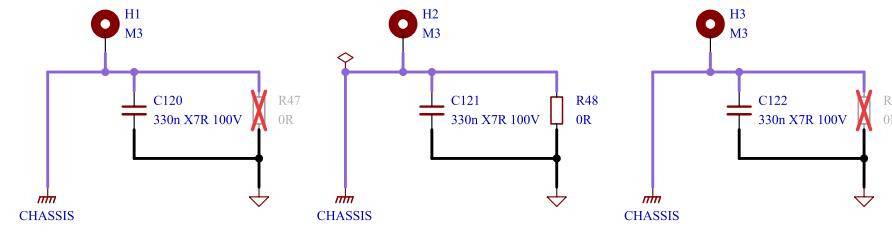
	Comments:	Company: EPFL Xplore Research	Variant: Preliminary
	Board Name: Amulet Motion Controller	Project Name: Chienpanzée	
	Sheet Title: Interface - Fan Control	File Name: Interface - Fan Control.kicad_sch	Designer: Vincent Nguyen
	Sheet Path: /Project Architecture/Interface - Fan Control/	Reviewer:	Date: 2023-11-19 Revision: 1.0

[18] Interface - Interconnects



Comments:	Company:	Variant:
	EPFL Xplore Research	Preliminary
Sheet Title:	File Name:	Designer:
Interface - Interconnects	Interface - Interconnects.kicad_sch	Vincent Nguyen
Sheet Path:	Reviewer:	Date:
/Project Architecture/Interface - Interconnects/		2023-10-14
Size:	Sheet:	Revision:
A3	18	of 21

[19] Mechanical - Holes



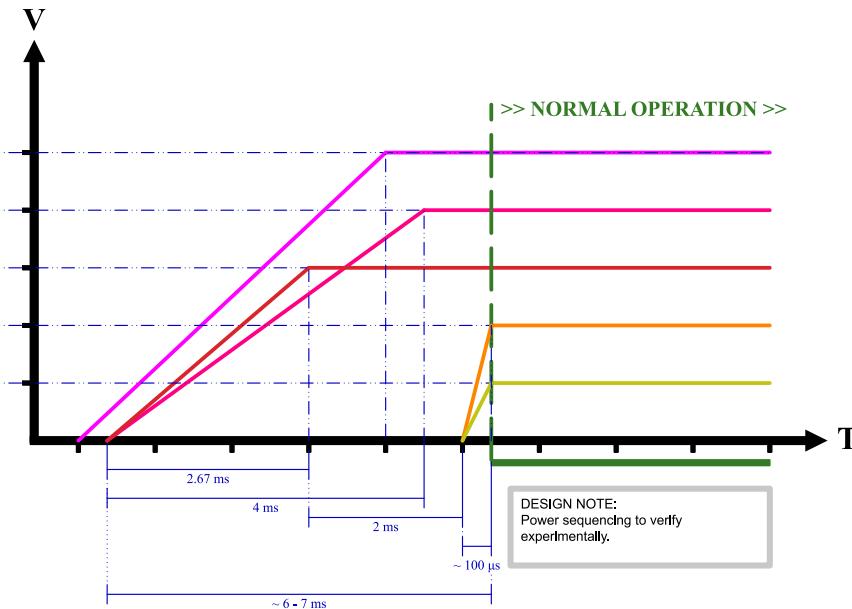
DESIGN NOTE:
Optional RC filter for chassis
grounding. Capacitors offer multi-point
low-impedance connections at
high-frequencies.

Mounting Holes and Chassis Connection

	Comments:	Company: EPFL Xplore Research	Variant: Preliminary
	Board Name: Amulet Motion Controller	Project Name: Chienpanzée	
	Sheet Title: Mechanical - Holes	File Name: Mechanical - Holes.kicad_sch	Designer: Vincent Nguyen
	Sheet Path: /Project Architecture/Mechanical - Holes/	Reviewer:	Date: 2023-10-22 Revision: 1.0

[20] Power - Sequencing

NAME	SOURCE	LEVEL
+VBAT	BATTERY	12 - 44V
+12V	LMR36006	12V \pm 1.5%
+5V	LMR36503	5V \pm 1.5%
+3V3	TPS62172	3.3V \pm 3%
+A3V3	LP2992	3.3V \pm 0.5%



	Comments:	Company: EPFL Xplore Research		Variant: Preliminary	
		Board Name: Amulet Motion Controller		Project Name: Chienpanzée	
	Sheet Title: Power - Sequencing	File Name: Power - Sequencing.kicad_sch	Designer: Vincent Nguyen	Date:	Revision: 1.0
	Sheet Path: /Power - Sequencing/		Reviewer:	Size: A4	Sheet: 20 of 21

[21] Revision History

A Rev 1.0

- Changed CPH-CPL capacitor to 47nF (gate driver)
- Changed FD-CAN transceiver IC
- Added TVS protection and termination switch to FD-CAN
- Added low-side switched 12V 600mA source for external fan
- Added LDO for analog supply
- Changed input power TVS diode to bidirectional and added one diode per connector

B - Moved SOx low-pass filter to MCU section.
Should be placed near MCU to avoid noise coupling into ADC lines.

- Added second onboard I2C magnetic encoder for disambiguation.
- Switched PWM_PHASEA with PWM_PHASEC on STM32G474 pinout for easier routing.
- Changed RS422 pinout on connector
- Added ESD protection to all interfaces
- Added overvoltage protection on thermistor ADC inputs
- Changed buck regulators and added Pi filters
- Doubled bulk capacitance using 10uF X6S ceramics

C

D

1

	Comments:	Company: EPFL Xplore Research 	Variant: Preliminary
	Board Name: Amulet Motion Controller		
	Sheet Title: Revision History	File Name: Revision History.kicad_sch	Designer: Vincent Nguyen Date: 2023-10-15 Revision: 1.0
	Sheet Path: /Revision History/	Reviewer:	Size: A4 Sheet: 21 of 21

2

3

4

5

6