

# Amulet Motion Controller

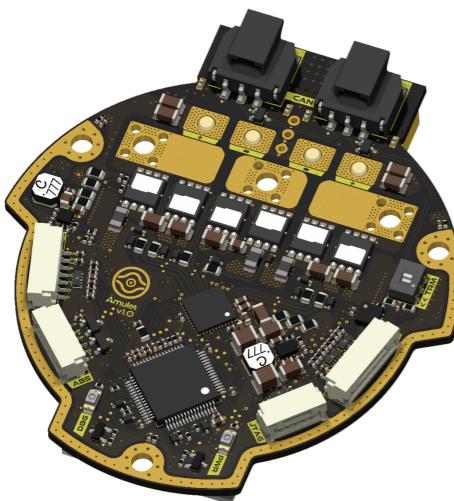
## Variant: Preliminary

2023-12-21

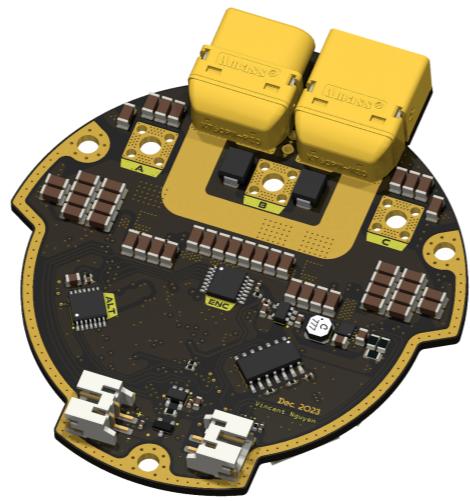
Rev 1.0

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### 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 20 DEC. 2023

### DESIGN CONSIDERATIONS

DESIGN NOTE:  
Example text for informational design notes.

DESIGN NOTE:  
Example text for debug notes.

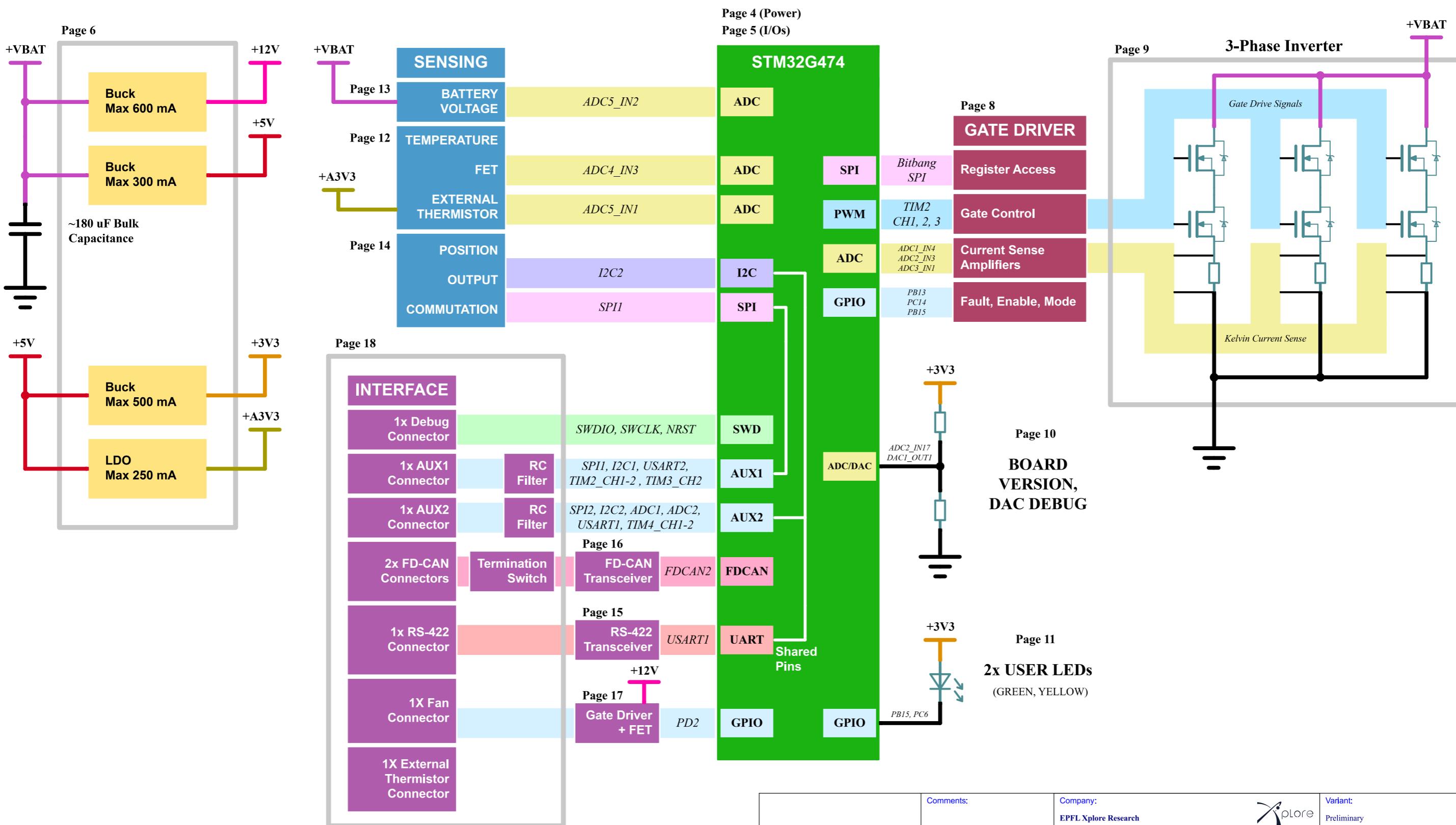
DESIGN NOTE:  
Example text for cautionary design notes.

DESIGN NOTE:  
Example text for critical design notes.

LAYOUT NOTE:  
Example text for critical layout guidelines.

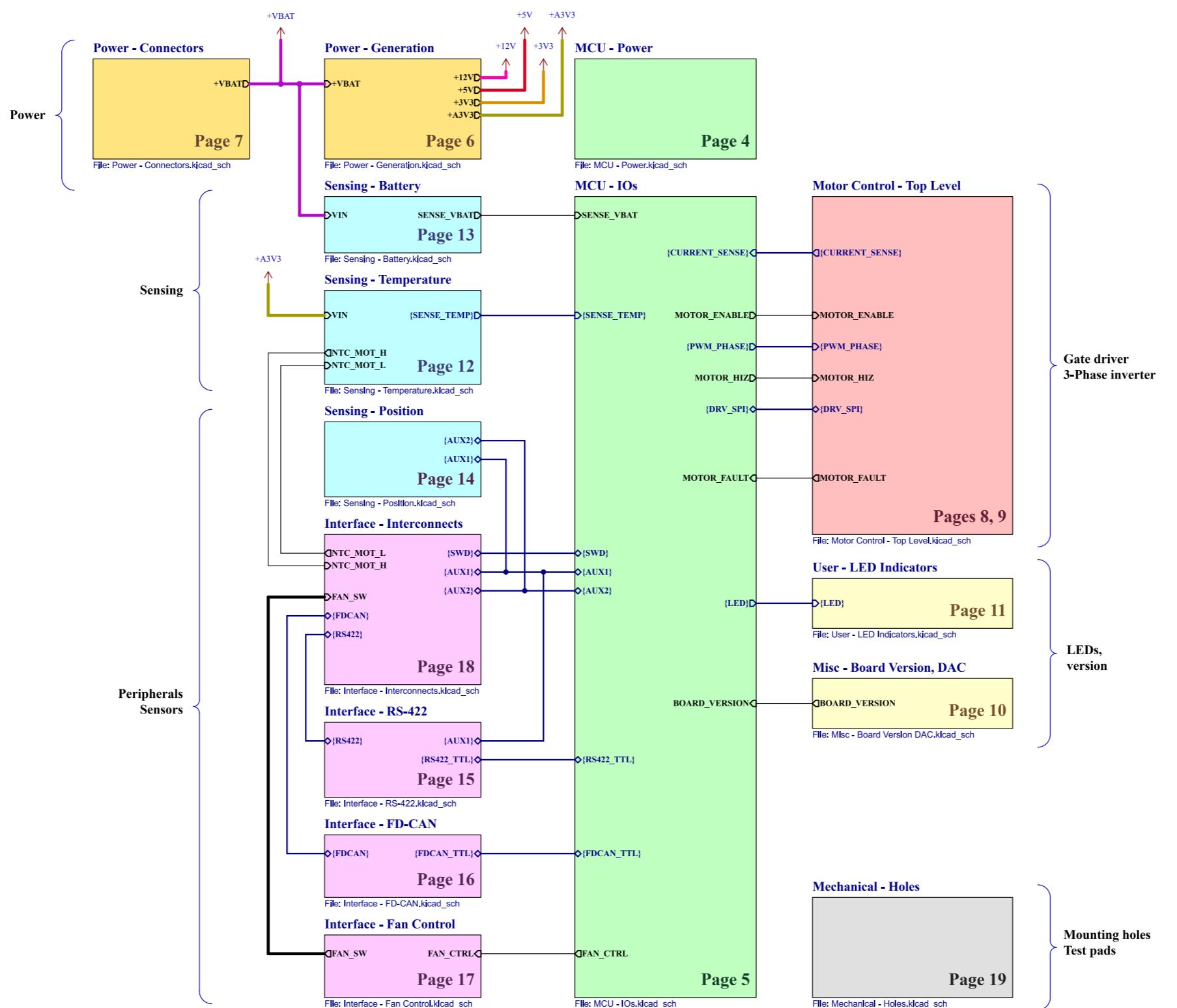
	Comments:	Company: EPFL Xplore Research	Variant: Preliminary
	Board Name: <b>Amulet Motion Controller</b>	Project Name: <b>Chienpanzé</b>	
	Sheet Title: Cover Page	File Name: amulet_controller.kicad_sch	Designer: Vincent Nguyen
	Sheet Path: /	Reviewer:	Date: 2023-12-20 Revision: 1.0
		Size: A3	Sheet: 1 of 21

# [2] Block Diagram



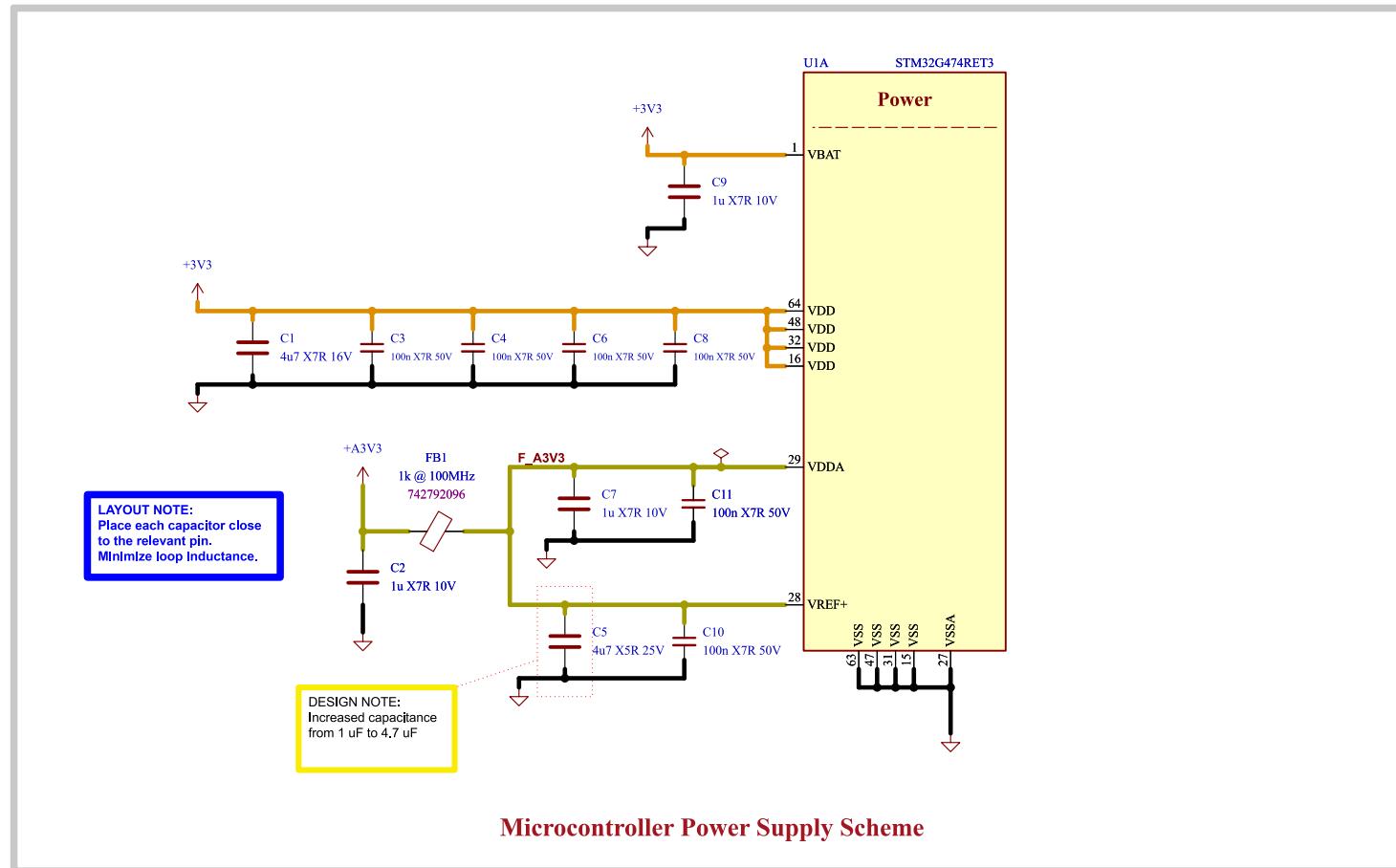
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	Board Name: <b>Amulet Motion Controller</b>		
Sheet Title:	File Name:	Designer:	Date: 2023-12-20
Block Diagram	Block Diagram.kicad_sch	Vincent Nguyen	Revision: 1.0
Sheet Path:	/Block Diagram/	Reviewer:	Size: <b>A3</b>
			Sheet: <b>2</b> of <b>21</b>

# [3] Project Architecture



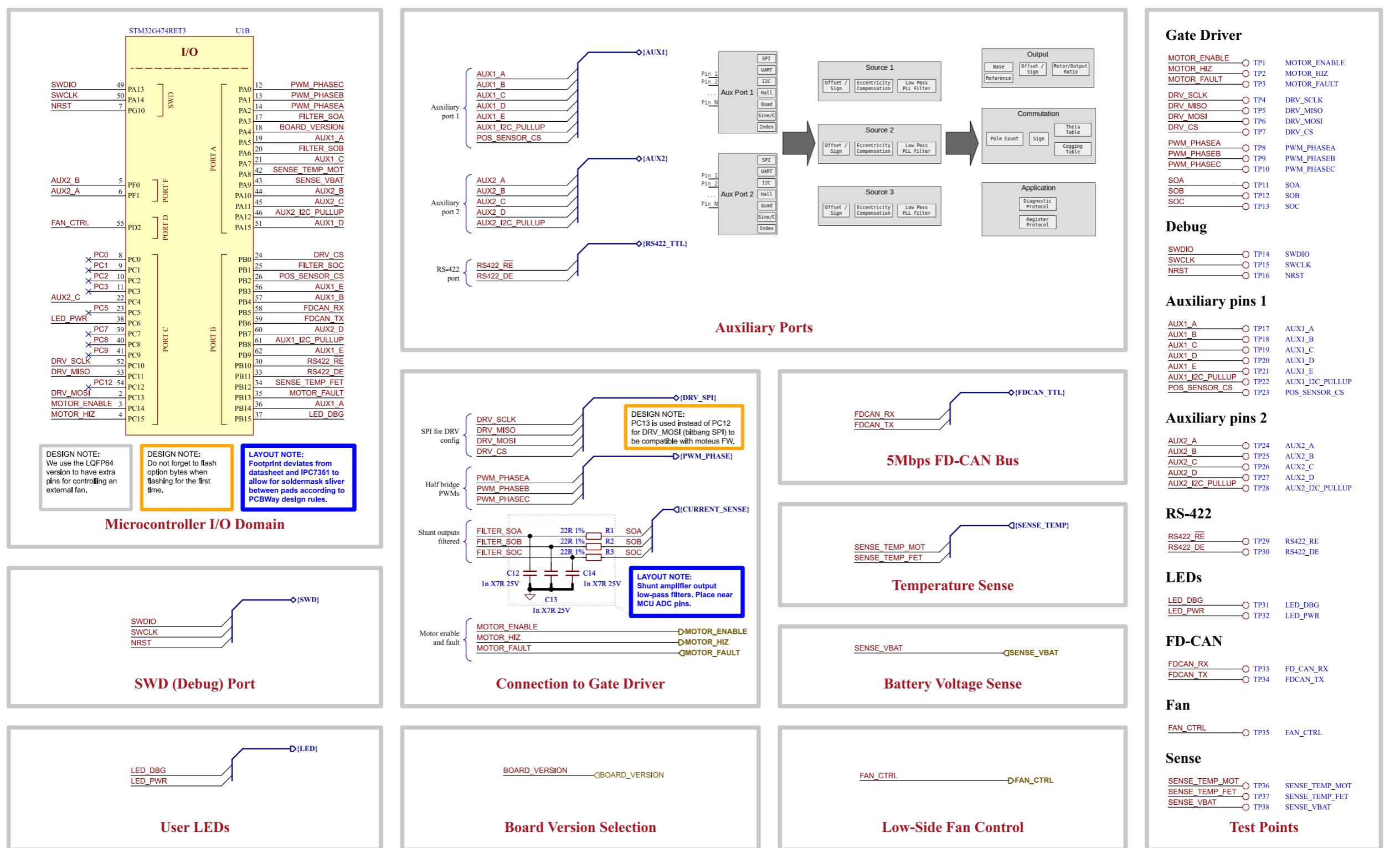
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		EPFL Xplore Research	Variant:	
	Board Name:	<b>Amulet Motion Controller</b>		Project Name:
		<b>Chienpanzé</b>		
	Sheet Title:	File Name:	Designer:	Date: <span style="float: right;">Revision:</span>
	Project Architecture	Project Architecture.kicad_sch	Vincent Nguyen	2023-11-25 <span style="float: right;">1.0</span>
	Sheet Path:	/Project Architecture/		Reviewer:
				Size: <b>A3</b> Sheet: <b>3</b> of <b>21</b>

# [4] MCU - Power



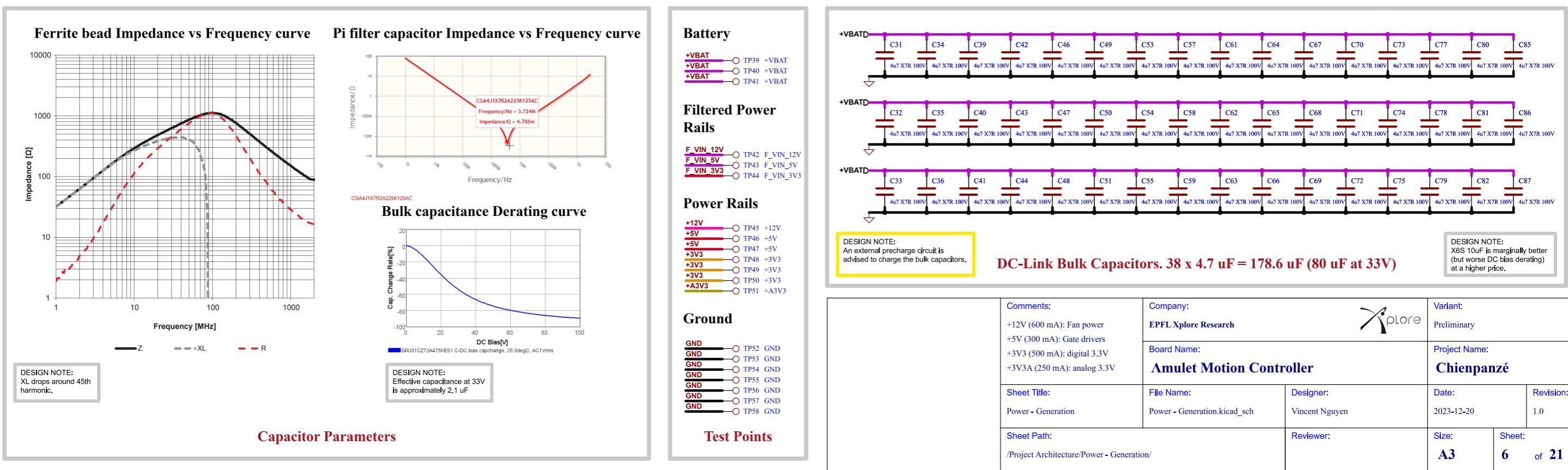
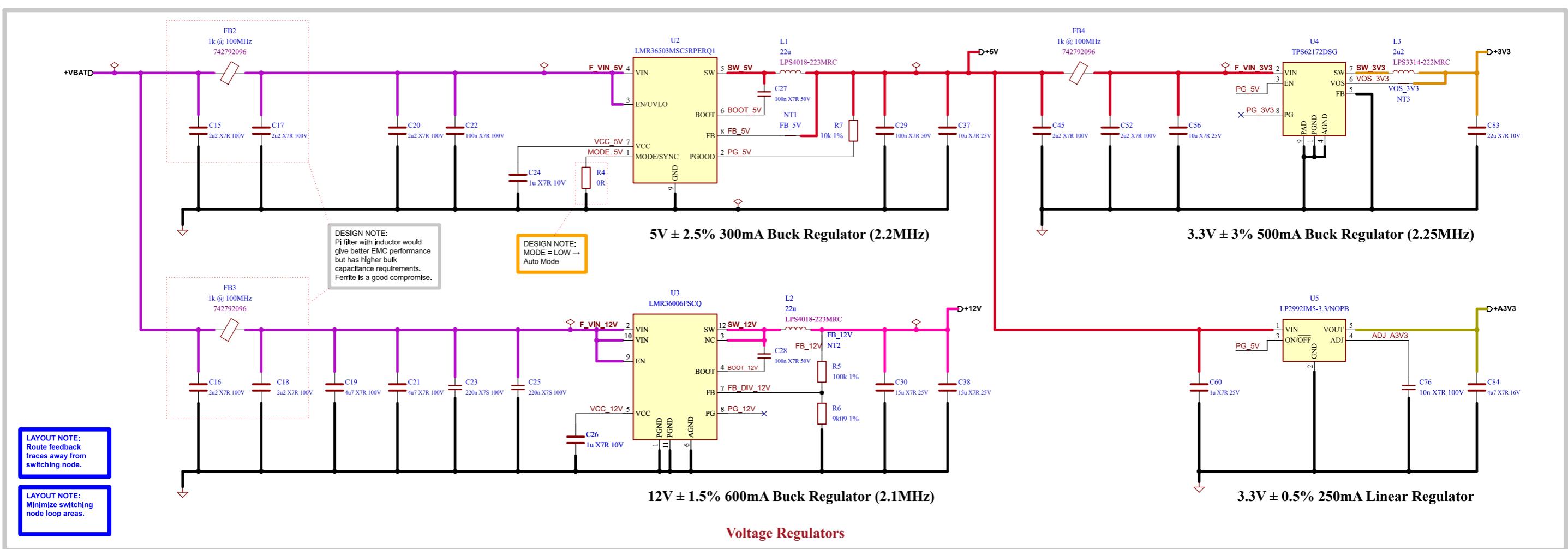
	Comments: AN5346 STM32G474 Datasheet p.81 J. Pieper ADC investigation	Company: EPFL Xplore Research	Variant: Preliminary
	<b>Board Name:</b> <b>Amulet Motion Controller</b>		
	Sheet Title: MCU - Power	File Name: MCU - Power.kicad_sch	Designer: Vincent Nguyen
	Sheet Path: /Project Architecture/MCU - Power/	Reviewer:	Date: 2023-12-18      Revision: 1.0

# [5] MCU - I/Os

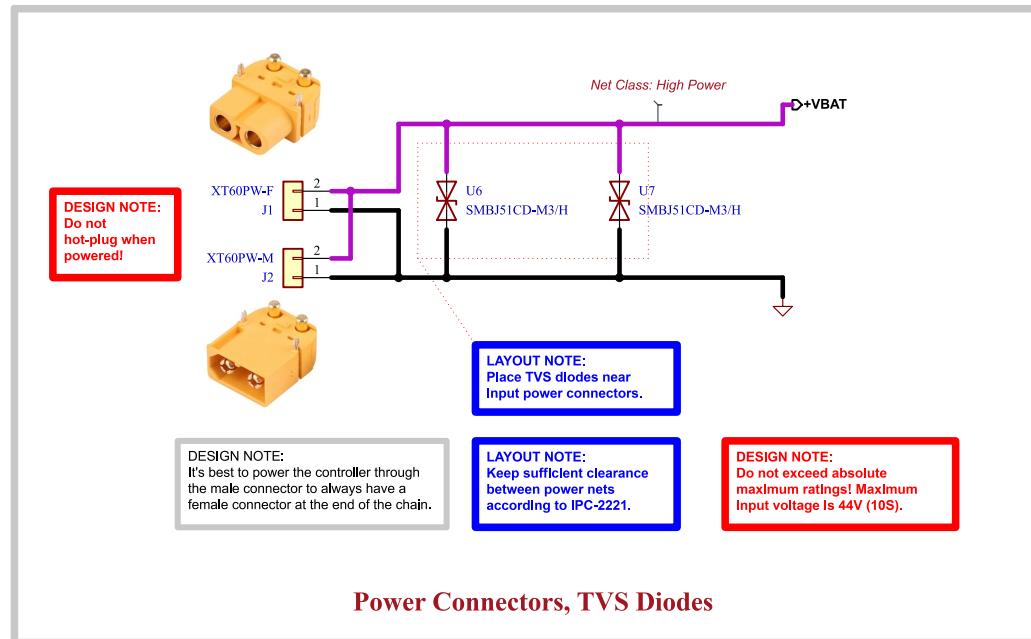


Comments: References: Flexible I/O worked examples Flexible I/O source configuration	Company: EPFL Xplore Research		Variant: Preliminary	
	Board Name: <b>Amulet Motion Controller</b>		Project Name: <b>Chienpanzé</b>	
Sheet Title: MCU - I/Os	File Name: MCU - IOs.kicad_sch	Designer: Vincent Nguyen	Date: 2023-12-20	Revision: 1.0
Sheet Path: /Project Architecture/MCU - IOs/	Reviewer:		Size: <b>A3</b>	Sheet: <b>5</b> of <b>21</b>

# [6] Power - Generation

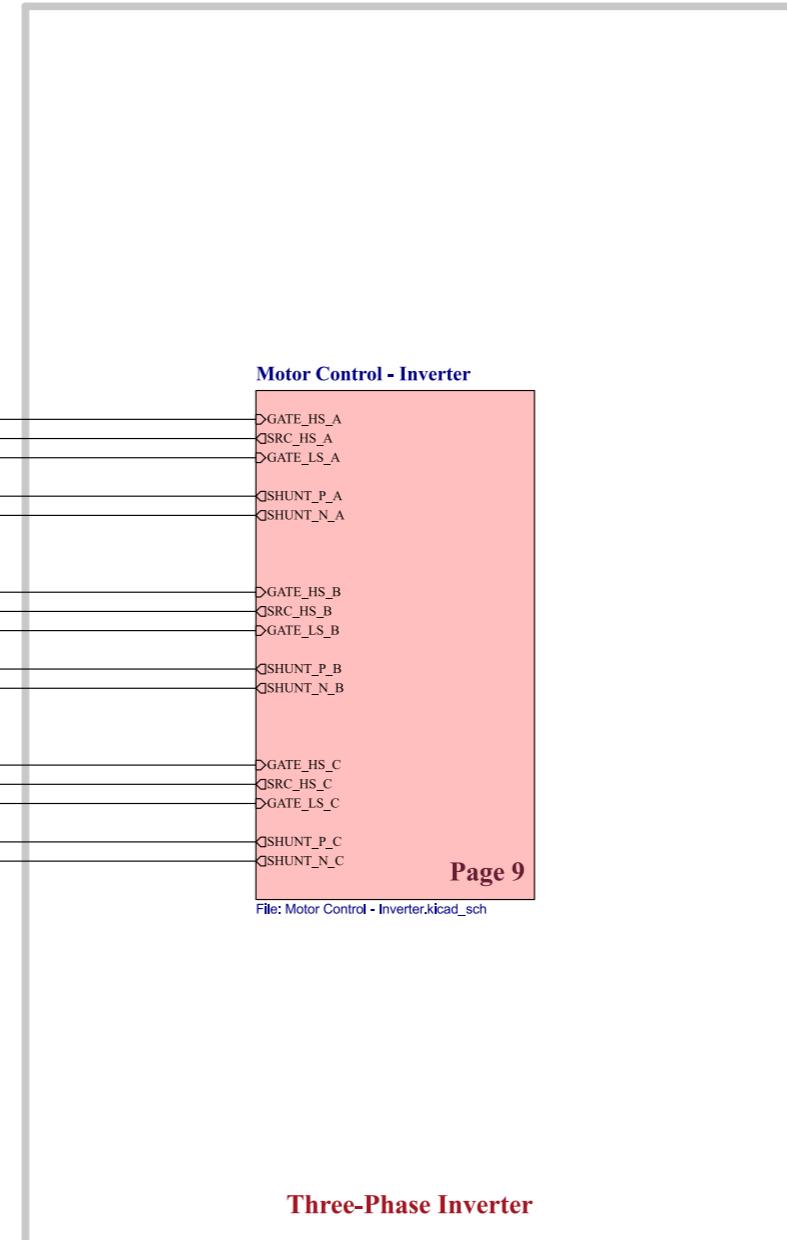
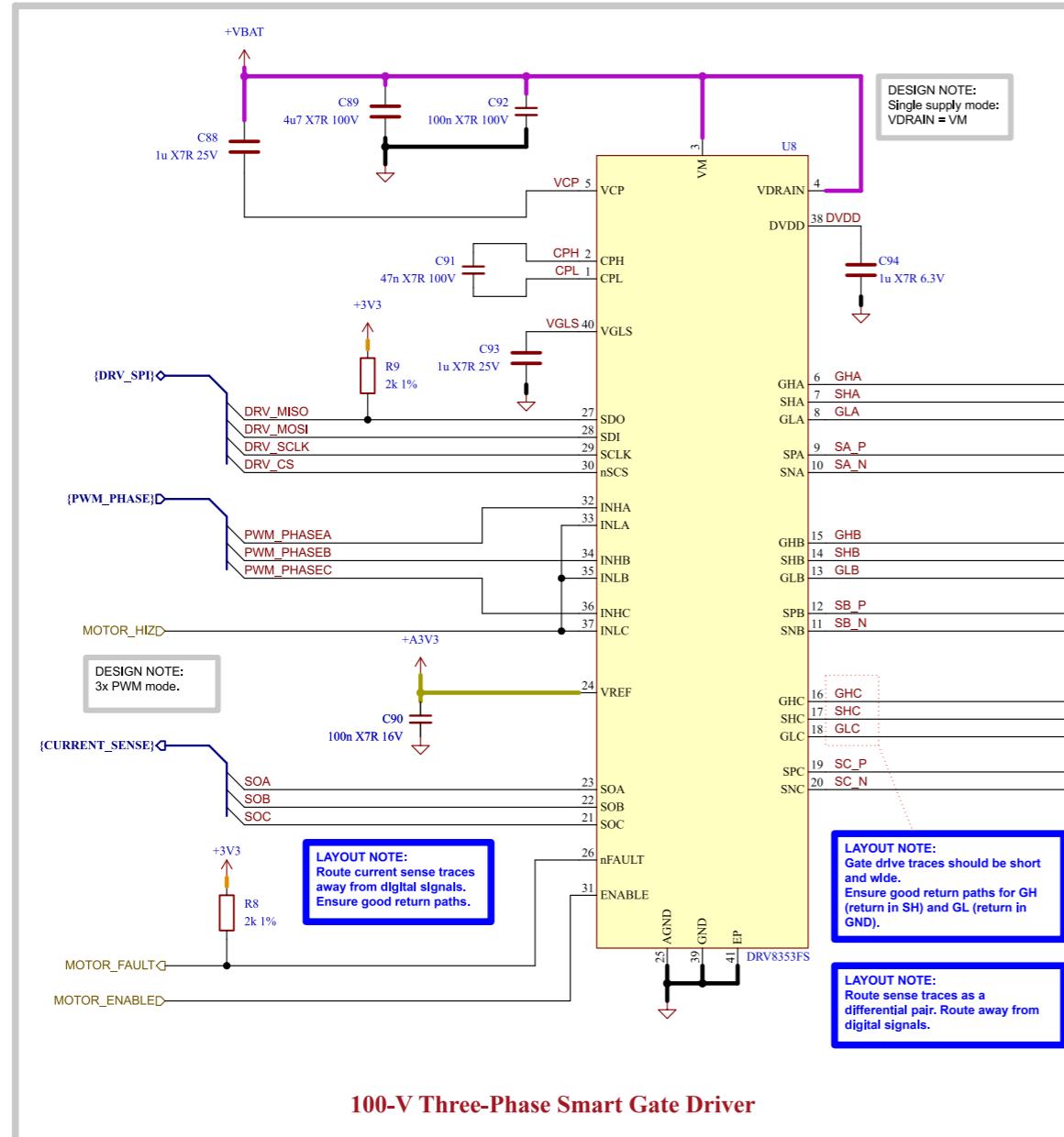


# [7] Power - Connectors



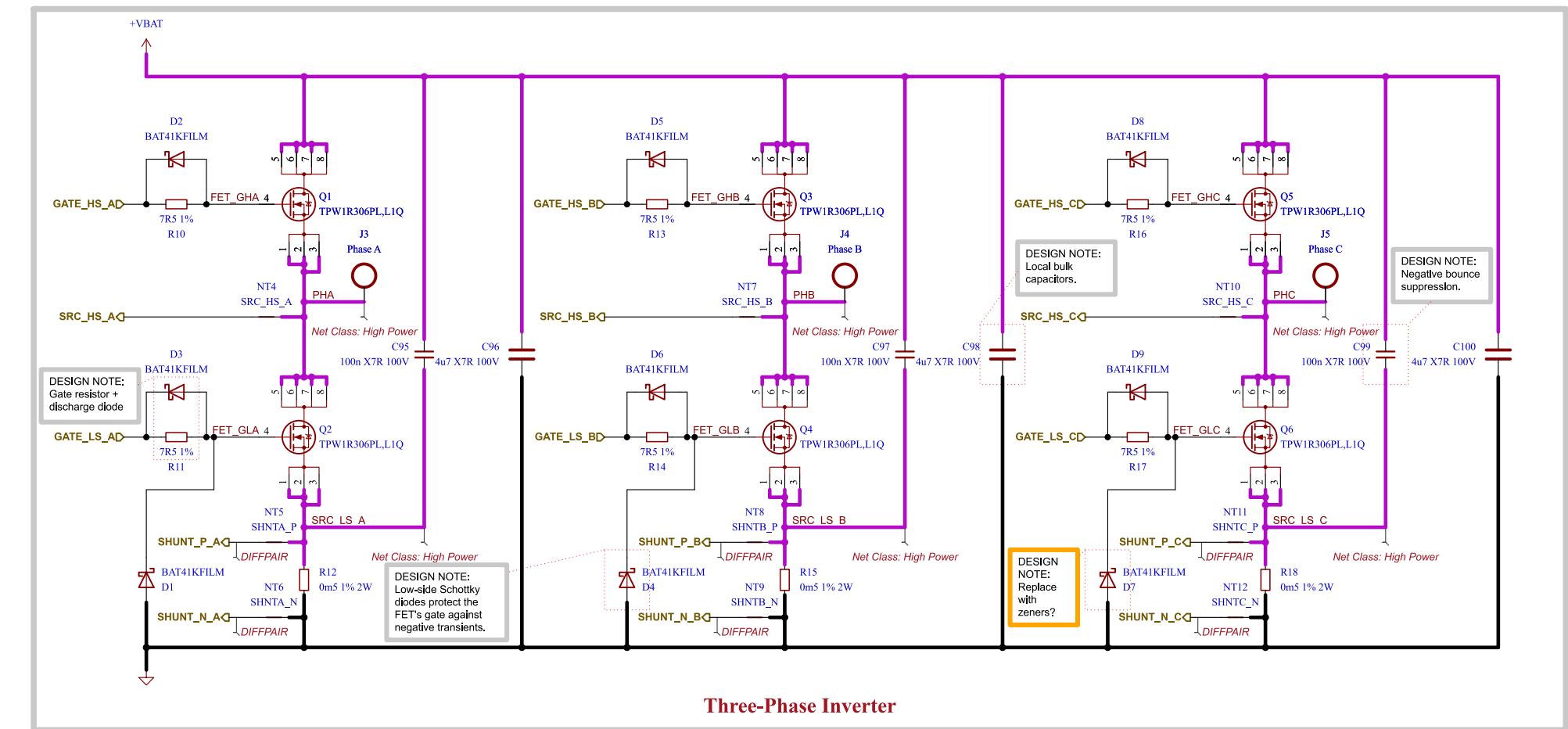
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	Board Name: <b>Amulet Motion Controller</b>		
	Sheet Title: Power - Connectors	File Name: Power - Connectors.kicad_sch	Designer: Vincent Nguyen
	Sheet Path: /Project Architecture/Power - Connectors/	Reviewer:	Date: 2023-10-14 Revision: 1.0

# [8] Motor Control - Top Level



	Comments:	Company:	Variant:	
		EPFL Xplore Research	Preliminary	
	Board Name:	Project Name:		
	<b>Amulet Motion Controller</b>		<b>Chienpanzé</b>	
	Sheet Title:	File Name:	Designer:	Date: Revision:
	Motor Control - Top Level	Motor Control - Top Level.kicad_sch	Vincent Nguyen	2023-12-20 1.0
	Sheet Path:	Reviewer:		Size: Sheet:
	/Project Architecture/Motor Control - Top Level/			A3 8 of 21

# [9] Motor Control - Inverter



**LAYOUT NOTE:**  
High current traces must be carefully designed. Ensure ground return path does not cross sensitive parts of the board. Use multiple planes for higher current carrying capacity.

**LAYOUT NOTE:**  
Keep sufficient clearance between power nets according to IPC-2221.

**DESIGN NOTE:**  
A gate drive current that is too large can damage the FETs!

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

**Company:**  
EPFL Xplore Research



**Variant:**  
Preliminary

**Board Name:**  
**Amulet Motion Controller**

**Project Name:**  
**Chienpanzé**

**Sheet Title:**  
Motor Control - Inverter

**File Name:**  
Motor Control - Inverter.kicad\_sch

**Designer:**  
Vincent Nguyen

**Date:**  
2023-12-20

**Revision:**  
1.0

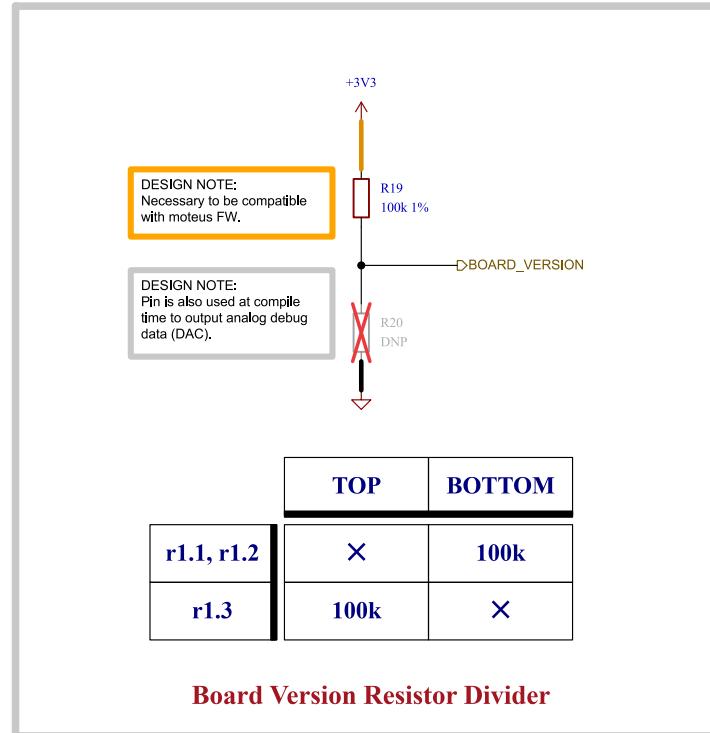
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/Project Architecture/Motor Control - Top Level/Motor Control - Inverter/

**Reviewer:**

**Size:**  
**A4**

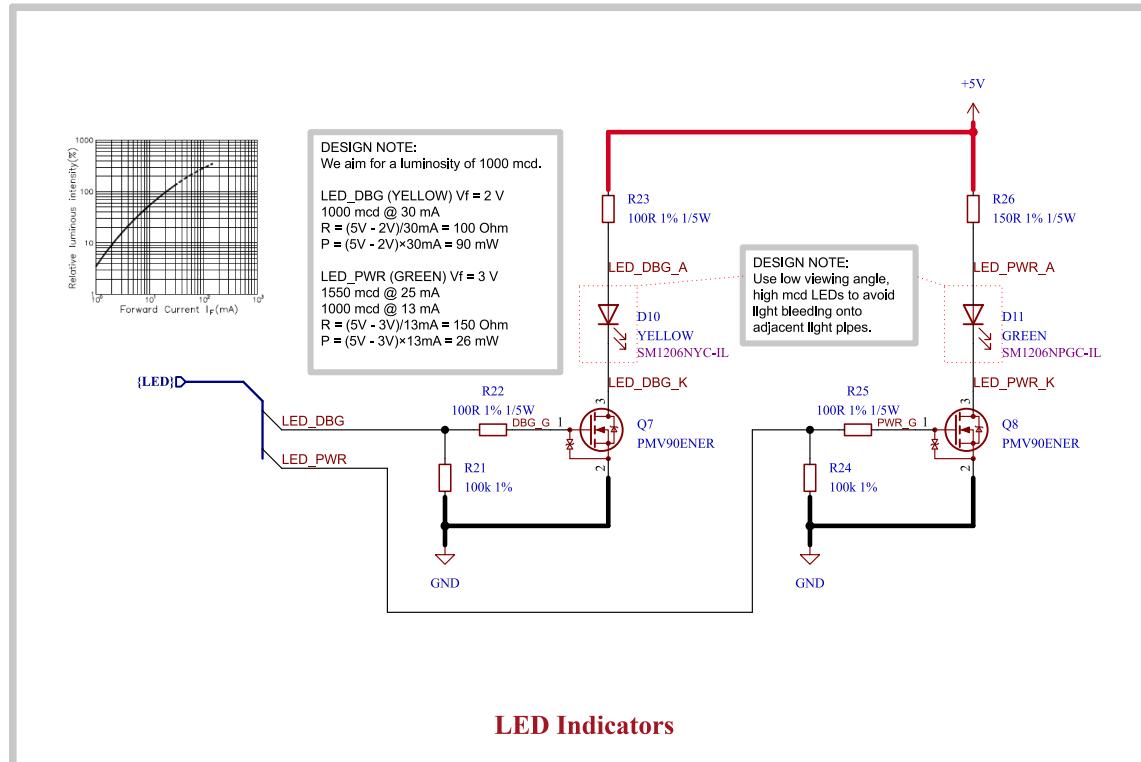
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**9** of **21**

# [10] Misc - Board Version, DAC



	Comments:	Company: EPFL Xplore Research	Variant: Preliminary
	Board Name: <b>Amulet Motion Controller</b>	Project Name: <b>Chienpanzé</b>	
	Sheet Title: Misc - Board Version, DAC	File Name: Misc - Board Version DAC.kicad_sch	Designer: Vincent Nguyen
	Sheet Path: <a href="#">/Project Architecture/Misc - Board Version, DAC/</a>	Reviewer:	Date: 2023-10-14 Revision: 1.0

# [11] User - LED Indicators



	Comments:	Company: EPFL Xplore Research	Variant: Preliminary
	Board Name: <b>Amulet Motion Controller</b>	Project Name: <b>Chienpanzé</b>	
	Sheet Title: User - LED Indicators	File Name: User - LED Indicators.kicad_sch	Designer: Vincent Nguyen
	Sheet Path: <a href="#">/Project Architecture/User - LED Indicators/</a>	Reviewer:	Date: 2023-12-19 Revision: 1.0

# [12] Sensing - Temperature

A

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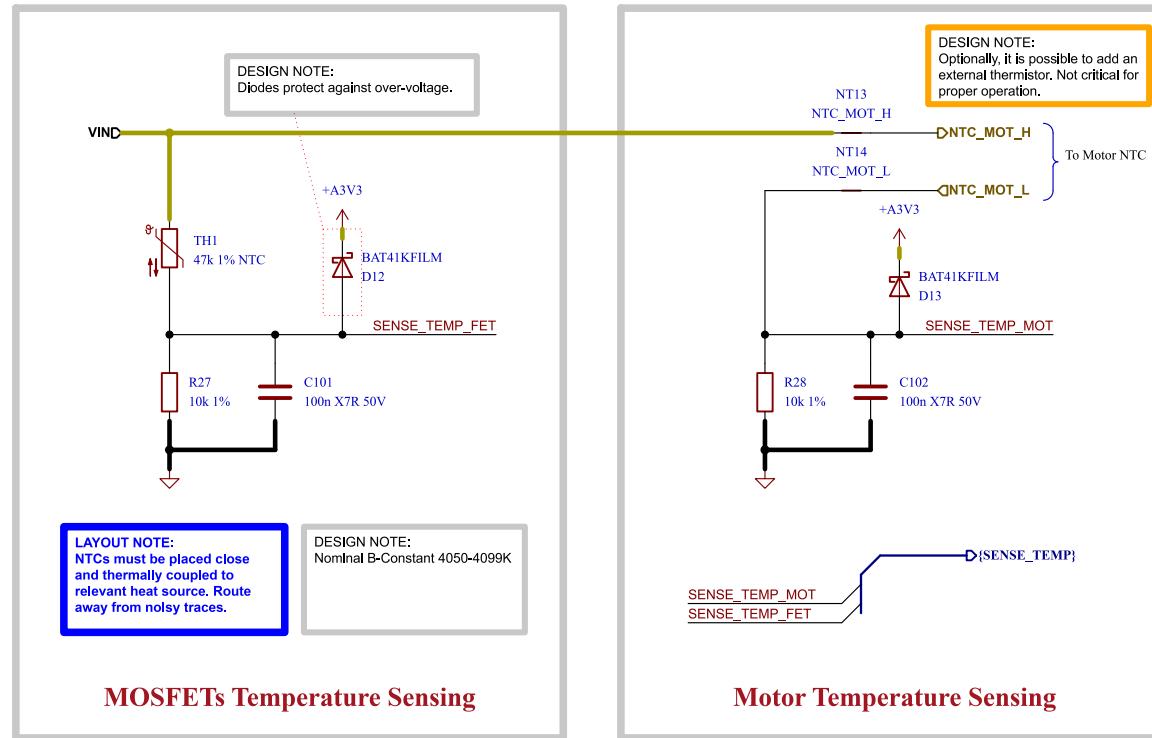
D

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D



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

# [13] Sensing - Battery

A

B

C

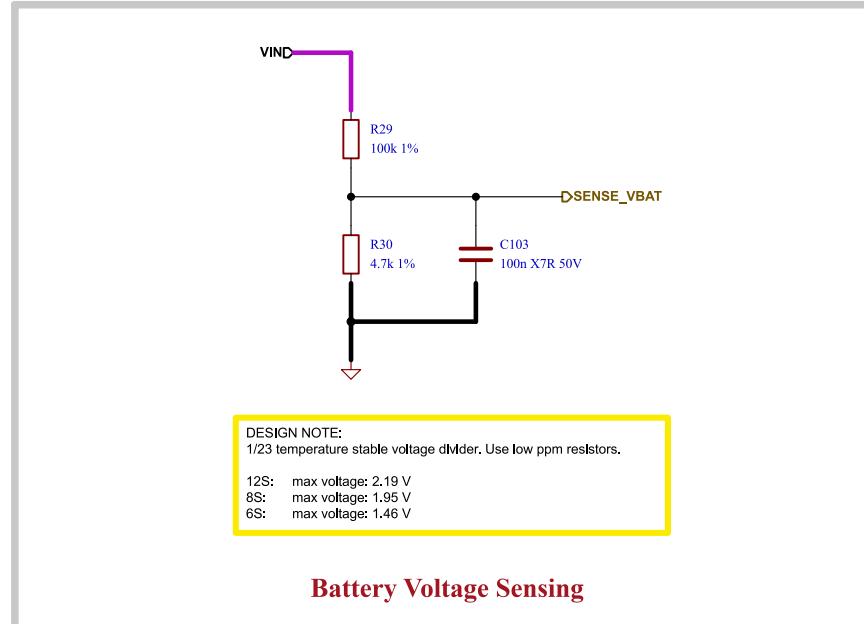
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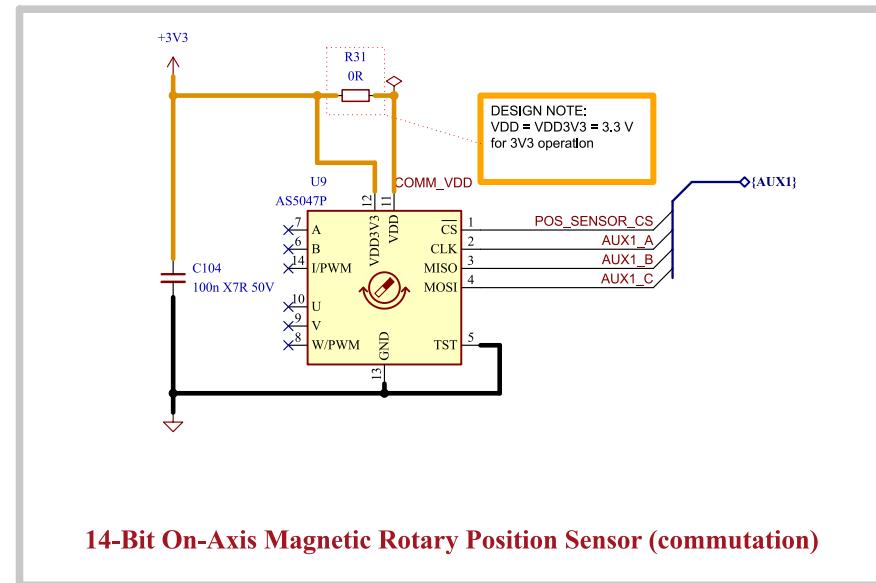
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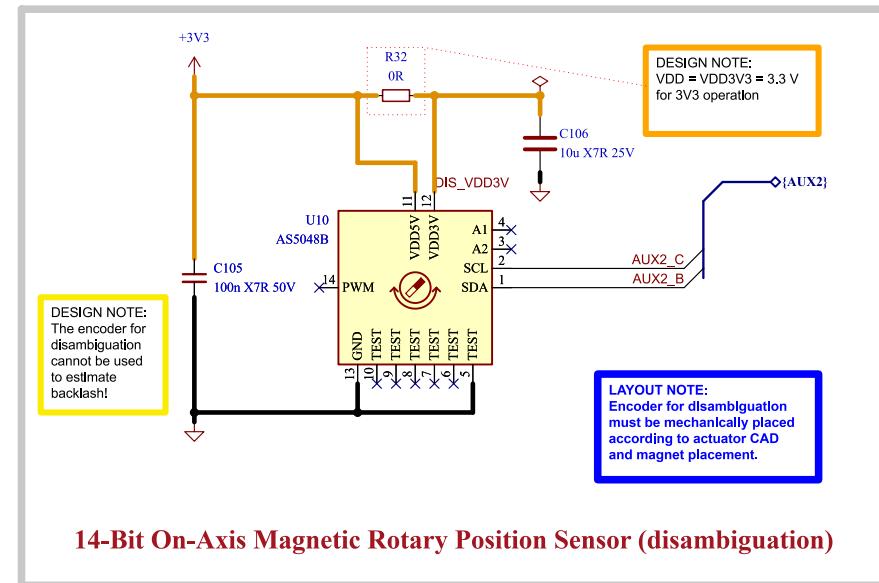
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	Board Name: <b>Amulet Motion Controller</b>		
	Sheet Title: Sensing - Battery	File Name: Sensing - Battery.kicad_sch	Designer: Vincent Nguyen
	Sheet Path: /Project Architecture/Sensing - Battery/	Reviewer:	Date: 2023-10-14 Revision: 1.0
		Size: A4	Sheet: 13 of 21

# [14] Sensing - Position

A



**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.

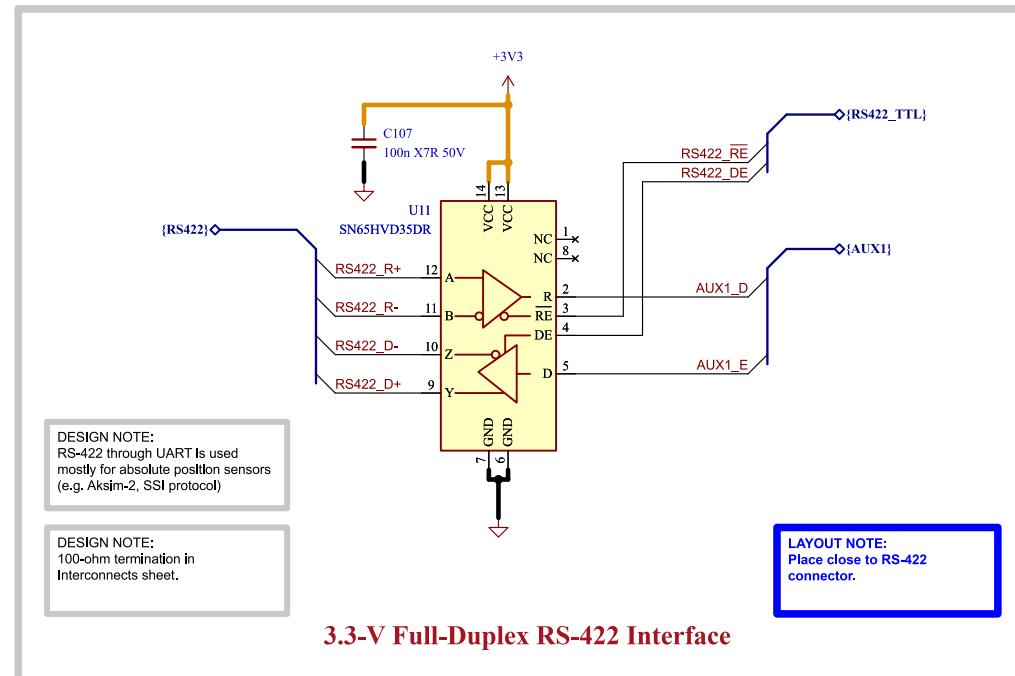


C

D

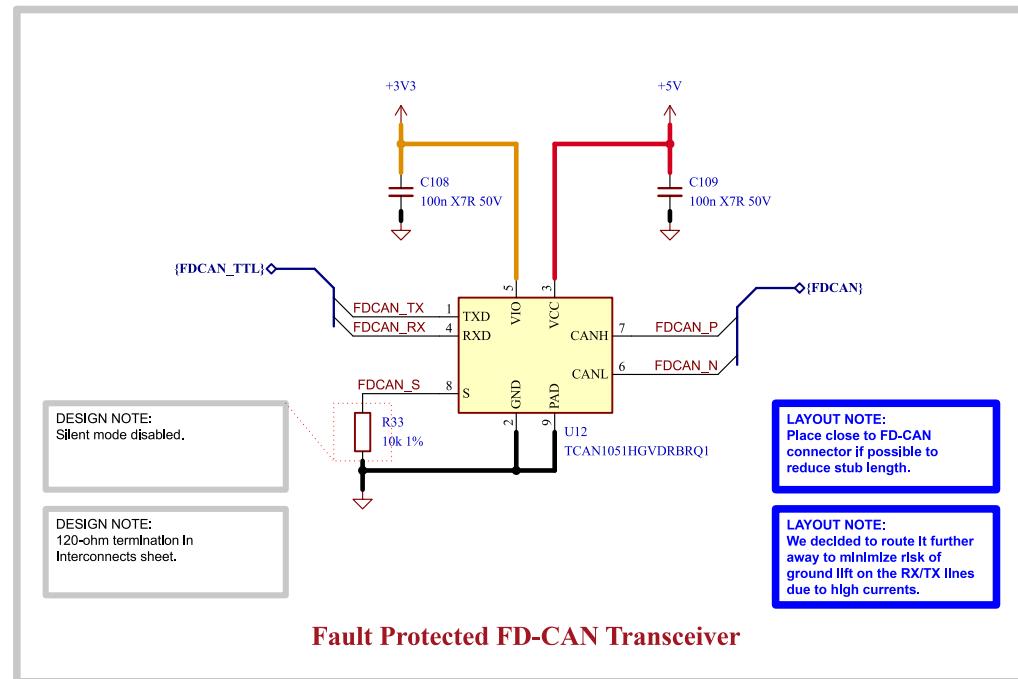
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Board Name: <b>Amulet Motion Controller</b>	Project Name: <b>Chienpanzé</b>	
Sheet Title: Sensing - Position	File Name: Sensing - Position.kicad_sch	Designer: Vincent Nguyen
Sheet Path: /Project Architecture/Sensing - Position/	Reviewer:	Date: 2023-10-14 Revision: 1.0

# [15] Interface - RS-422



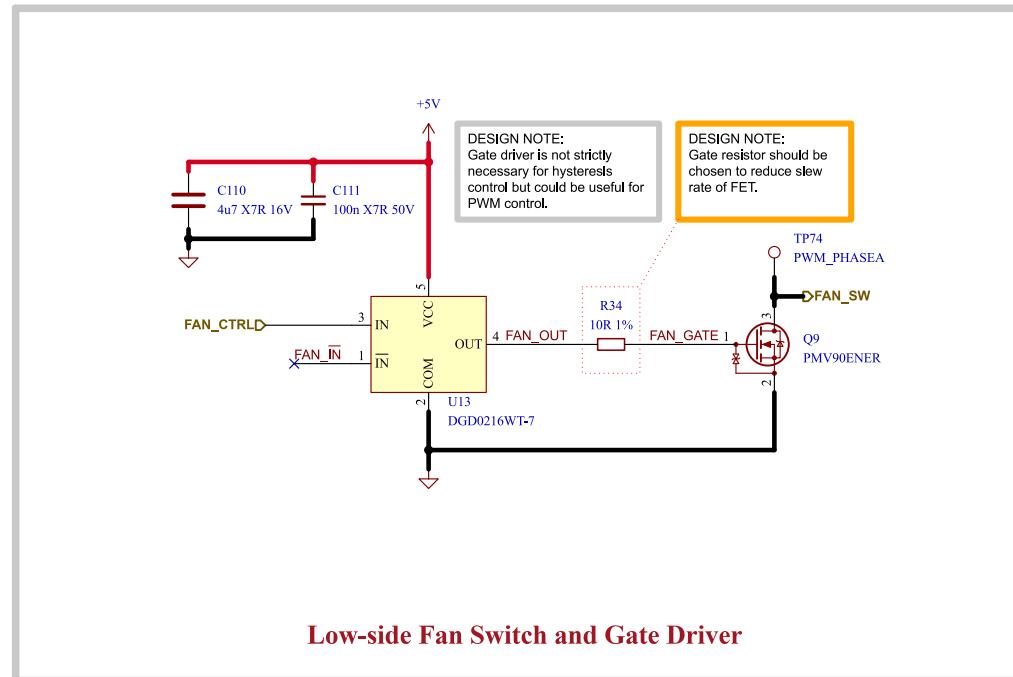
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	Board Name: <b>Amulet Motion Controller</b>		
	Sheet Title: Interface - RS-422	File Name: Interface - RS-422.kicad_sch	Designer: Vincent Nguyen
	Sheet Path: /Project Architecture/Interface - RS-422/	Reviewer:	Date: 2023-10-15 Revision: 1.0

# [16] Interface - FD-CAN



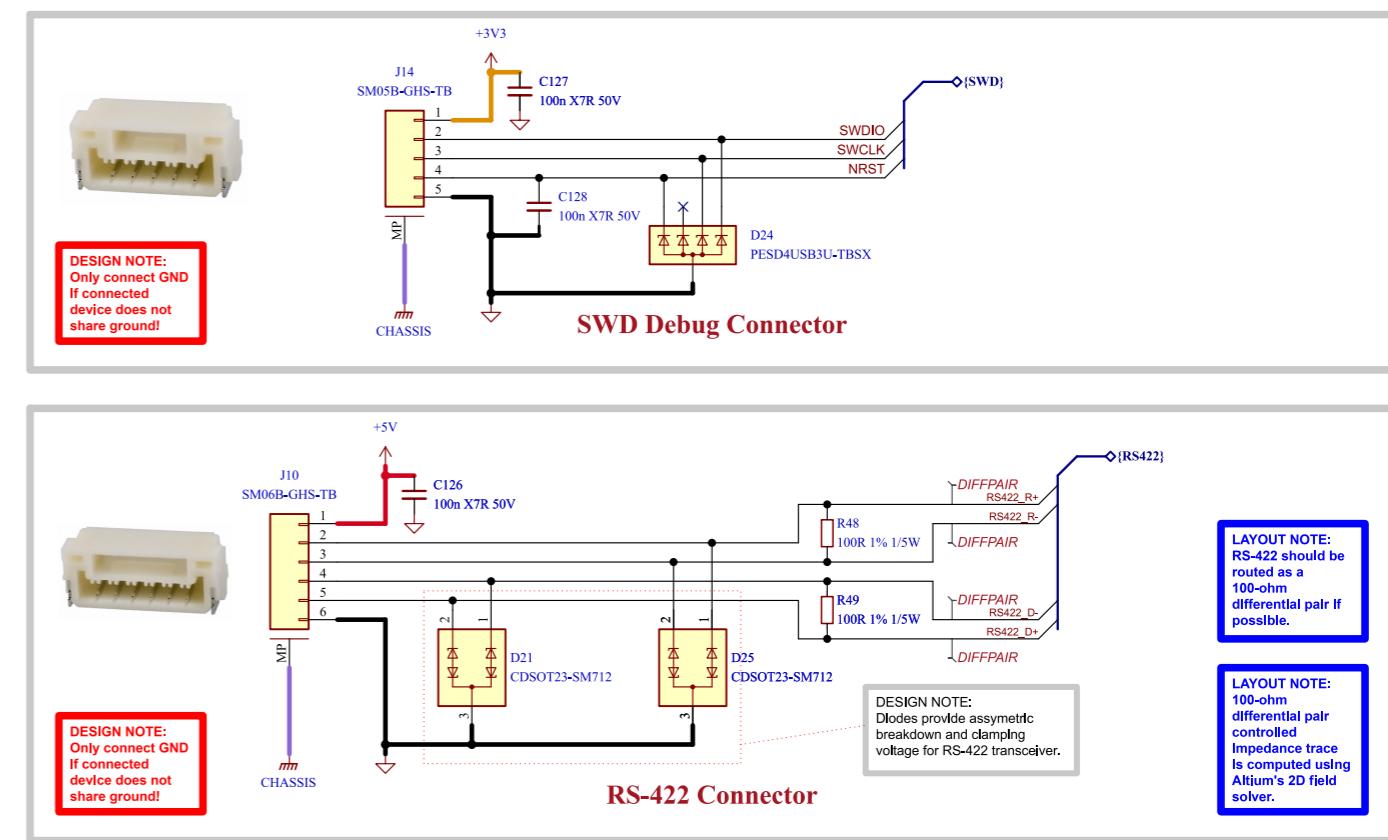
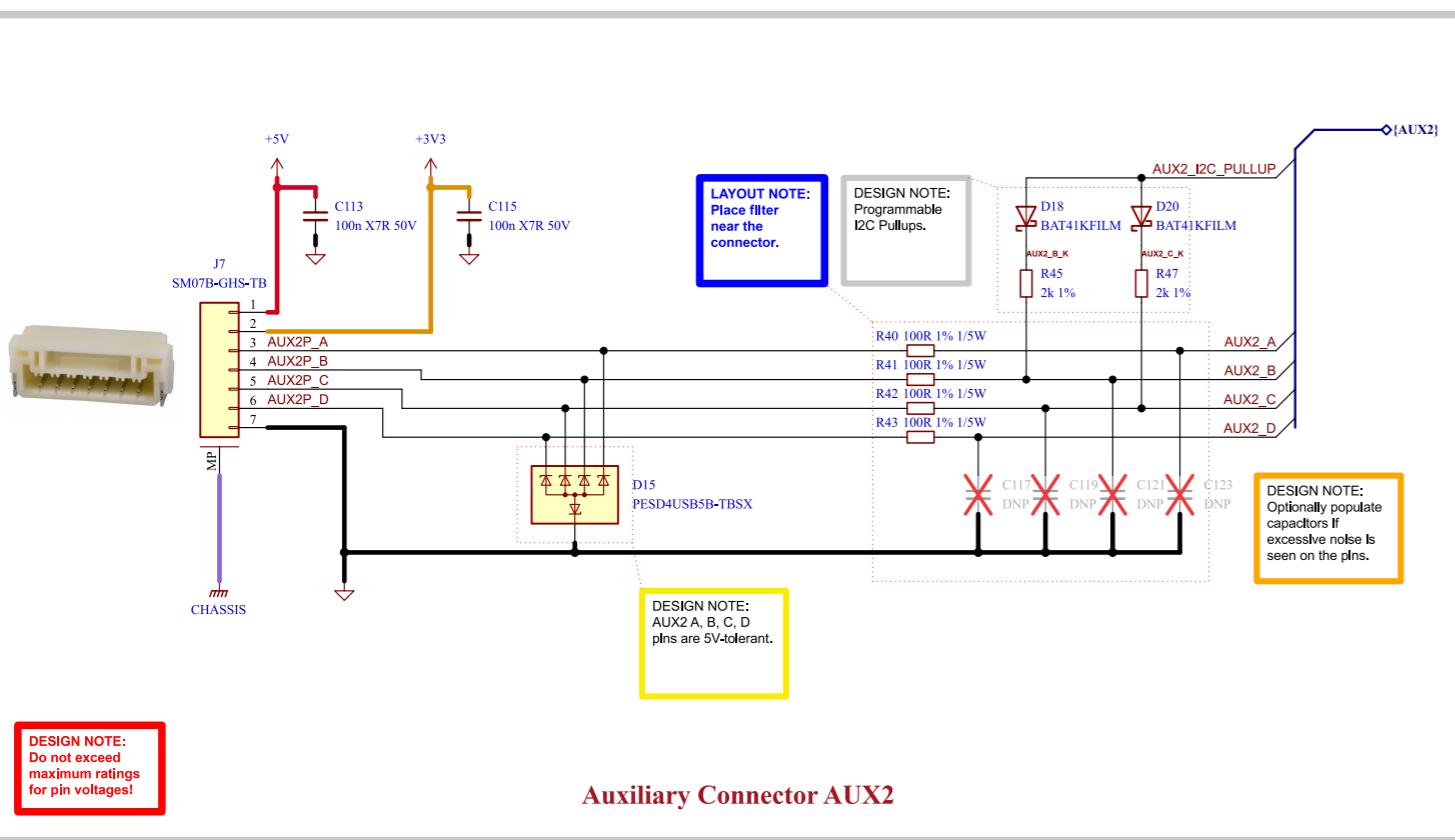
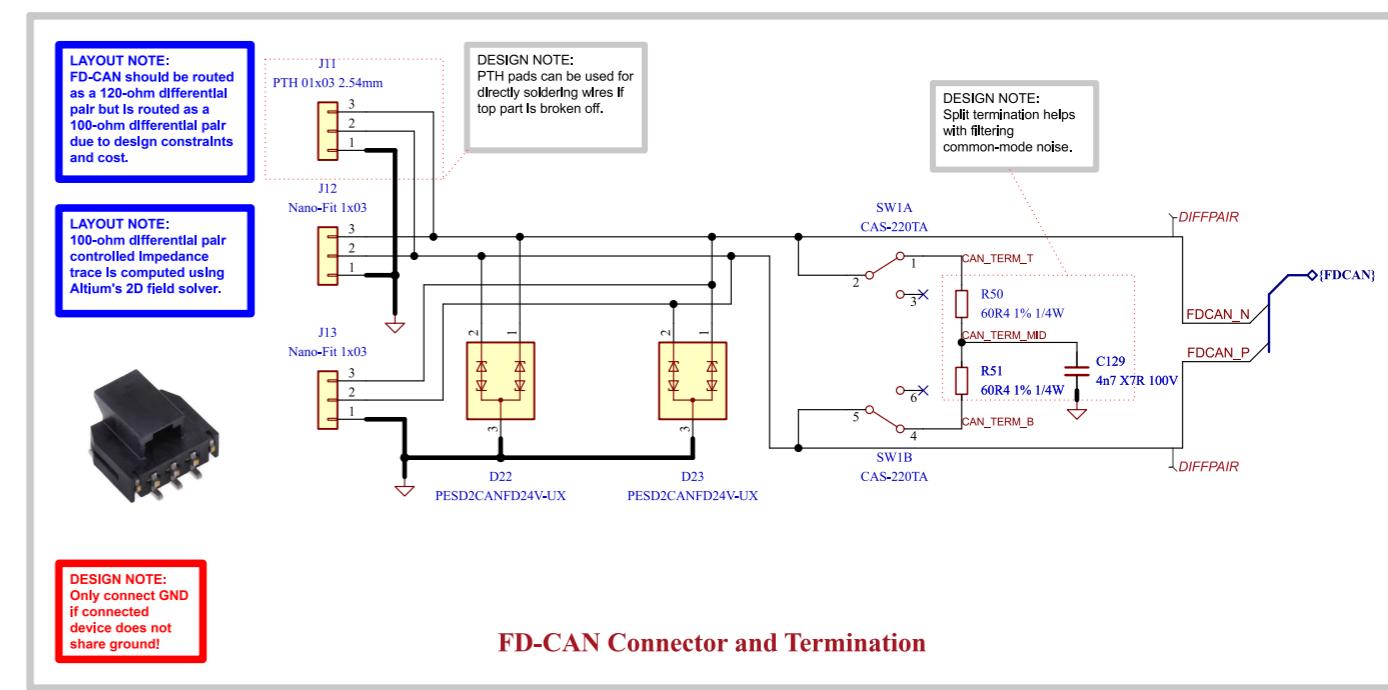
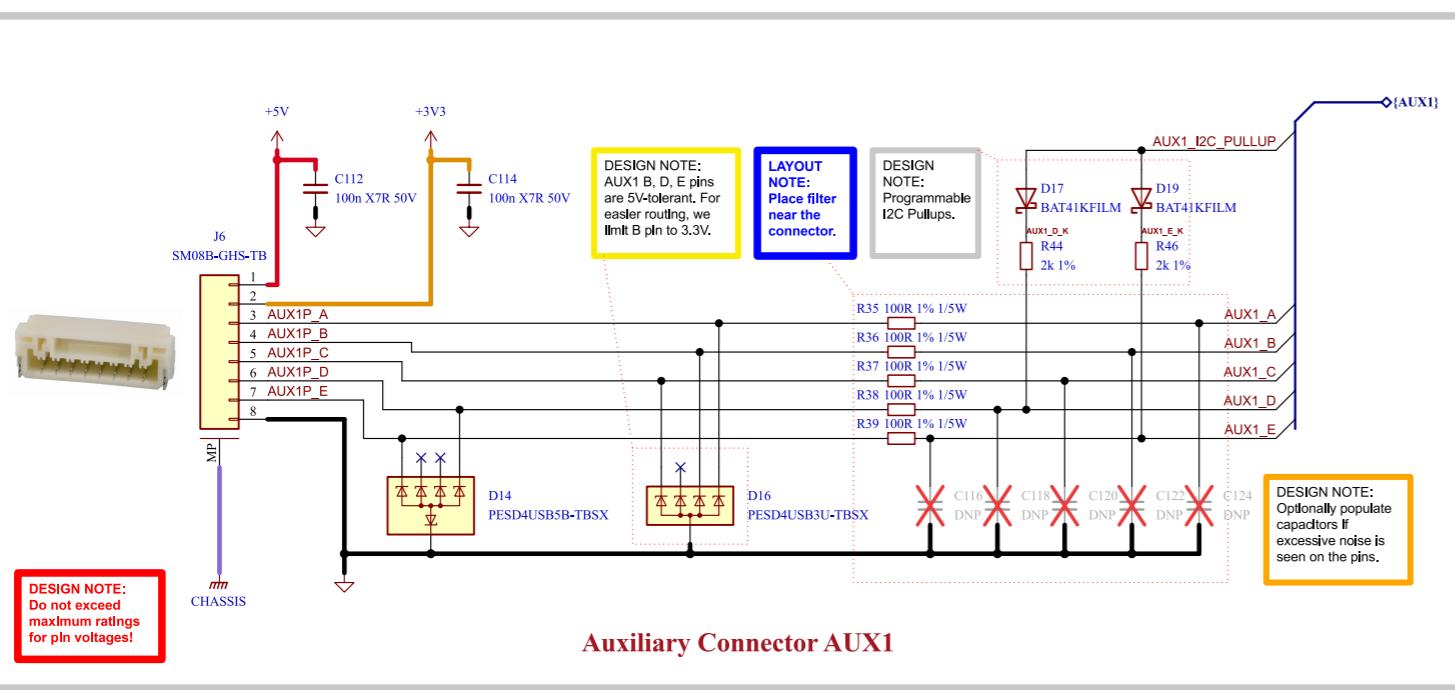
	Comments:	Company: EPFL Xplore Research	Variant: Preliminary
	Board Name: <b>Amulet Motion Controller</b>		
	Sheet Title: Interface - FD-CAN	File Name: Interface - FD-CAN.kicad_sch	Designer: Vincent Nguyen
	Sheet Path: /Project Architecture/Interface - FD-CAN/	Reviewer:	Date: 2023-10-15 Revision: 1.0

# [17] Interface - Fan Control

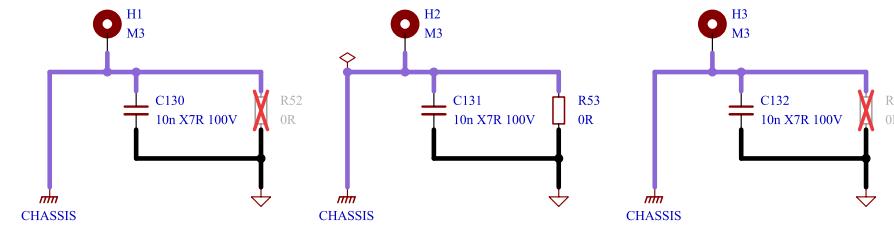


	Comments:	Company: EPFL Xplore Research	Variant: Preliminary
	Board Name: <b>Amulet Motion Controller</b>		
	Sheet Title: Interface - Fan Control	File Name: Interface - Fan Control.kicad_sch	Designer: Vincent Nguyen
	Sheet Path: <a href="#">/Project Architecture/Interface - Fan Control/</a>	Reviewer: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

# [18] Interface - Interconnects



# [19] Mechanical - Holes



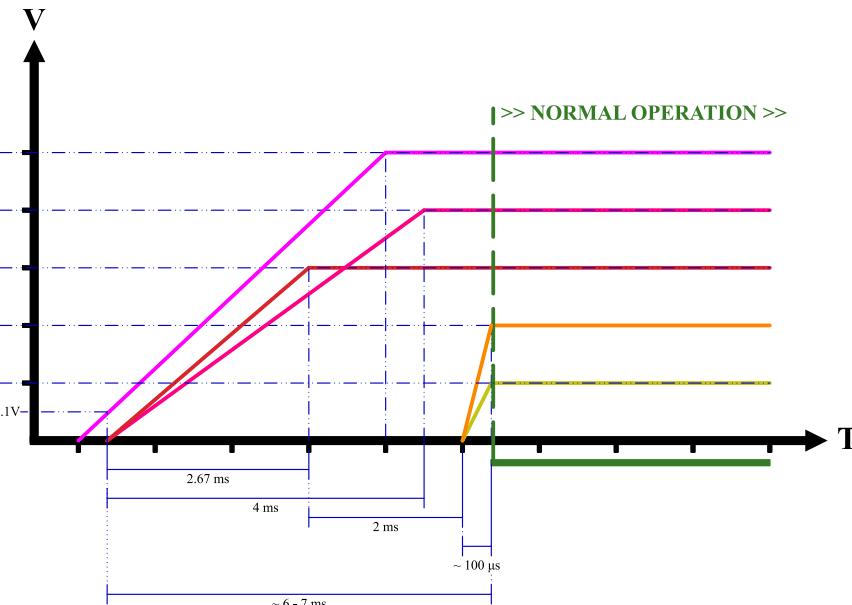
**DESIGN NOTE:**  
Optional RC filter for chassis  
grounding. Capacitors offer multi-point  
low-impedance connections at  
high-frequencies.

**Mounting Holes and Chassis Connection**

	Comments:	Company: EPFL Xplore Research	Variant: Preliminary
	Board Name: <b>Amulet Motion Controller</b>	Project Name: <b>Chienpanzé</b>	
	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	Xplore	Variant: Preliminary		
				Board Name:					
				<b>Amulet Motion Controller</b>		Project Name:	<b>Chienpanzé</b>		
			Sheet Title:	File Name:	Designer:	Date:			
Power - Sequencing				Power - Sequencing.kicad_sch	Vincent Nguyen	2023-12-17	1.0		
Sheet Path: <a href="#">/Power - Sequencing/</a>				Reviewer:	Size:	Sheet: <b>A4</b> <b>20</b> of <b>21</b>			

# [21] Revision History

A

## 12 December 2023 - Initial Release

- Changed CPH-CPL capacitor to 47nF (gate driver).
- Changed FD-CAN transceiver IC.
- Changed FETs for top cooled variant.
- 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.
- 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 to optimize for low noise.
- Added Pi filters to inputs of buck regulators and MCU analog supply.
- Added decoupling caps next to power pins of connectors.

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	Comments:	Company: EPFL Xplore Research 	Variant: Preliminary
	Board Name: <b>Amulet Motion Controller</b>		
	Sheet Title: Revision History	File Name: Revision History.kicad_sch	Designer: Vincent Nguyen
	Sheet Path: /Revision History/	Reviewer:	Date: 2023-12-20
			Revision: 1.0
		Size: <b>A4</b>	Sheet: <b>21 of 21</b>