

# Amulet Motion Controller

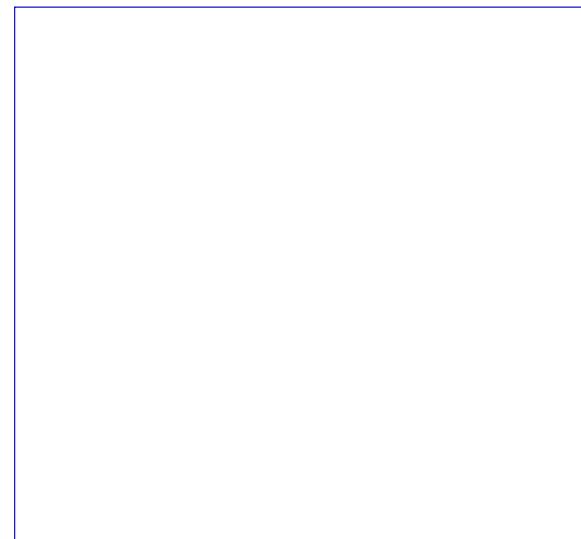
## Variant: Preliminary

2023-12-19

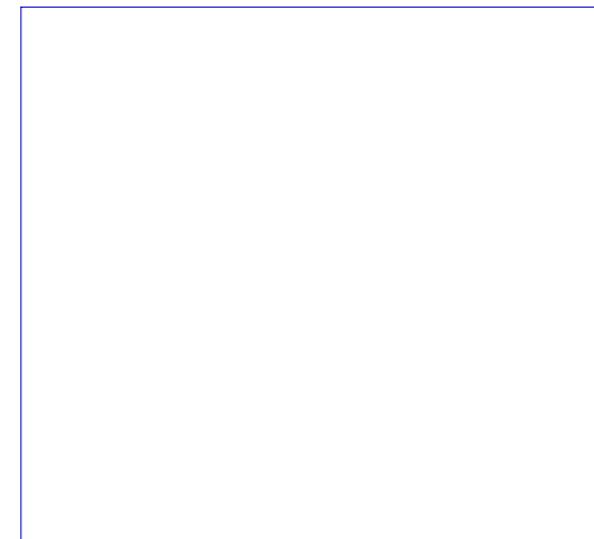
Rev 1.0

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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 XX.XX.XX

## DESIGN CONSIDERATIONS

DESIGN NOTE:  
Example text for informational design notes.

DESIGN NOTE:  
Example text for debug notes.

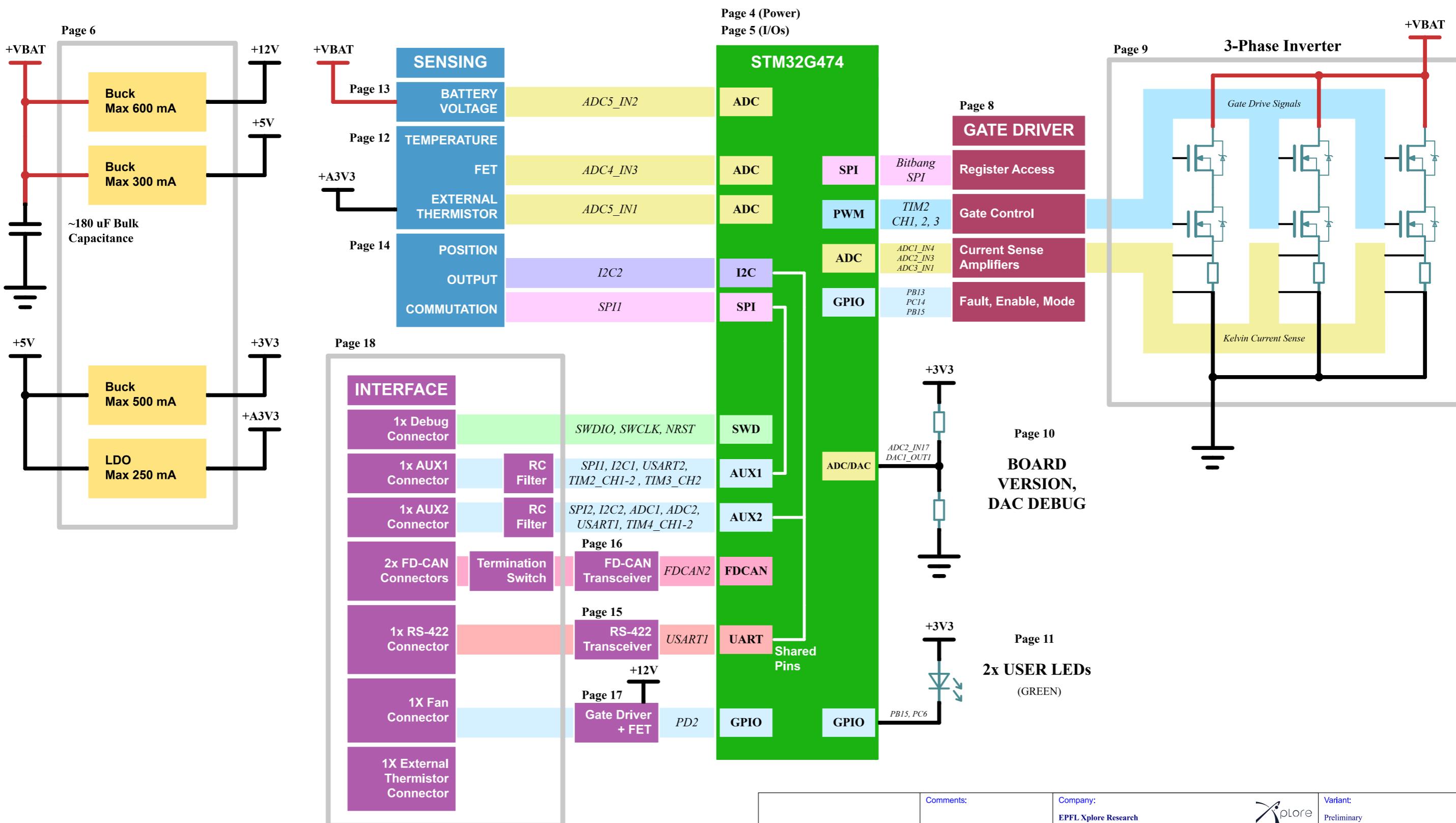
DESIGN NOTE:  
Example text for cautionary design notes.

DESIGN NOTE:  
Example text for critical design notes.

LAYOUT NOTE:  
Example text for critical layout guidelines.

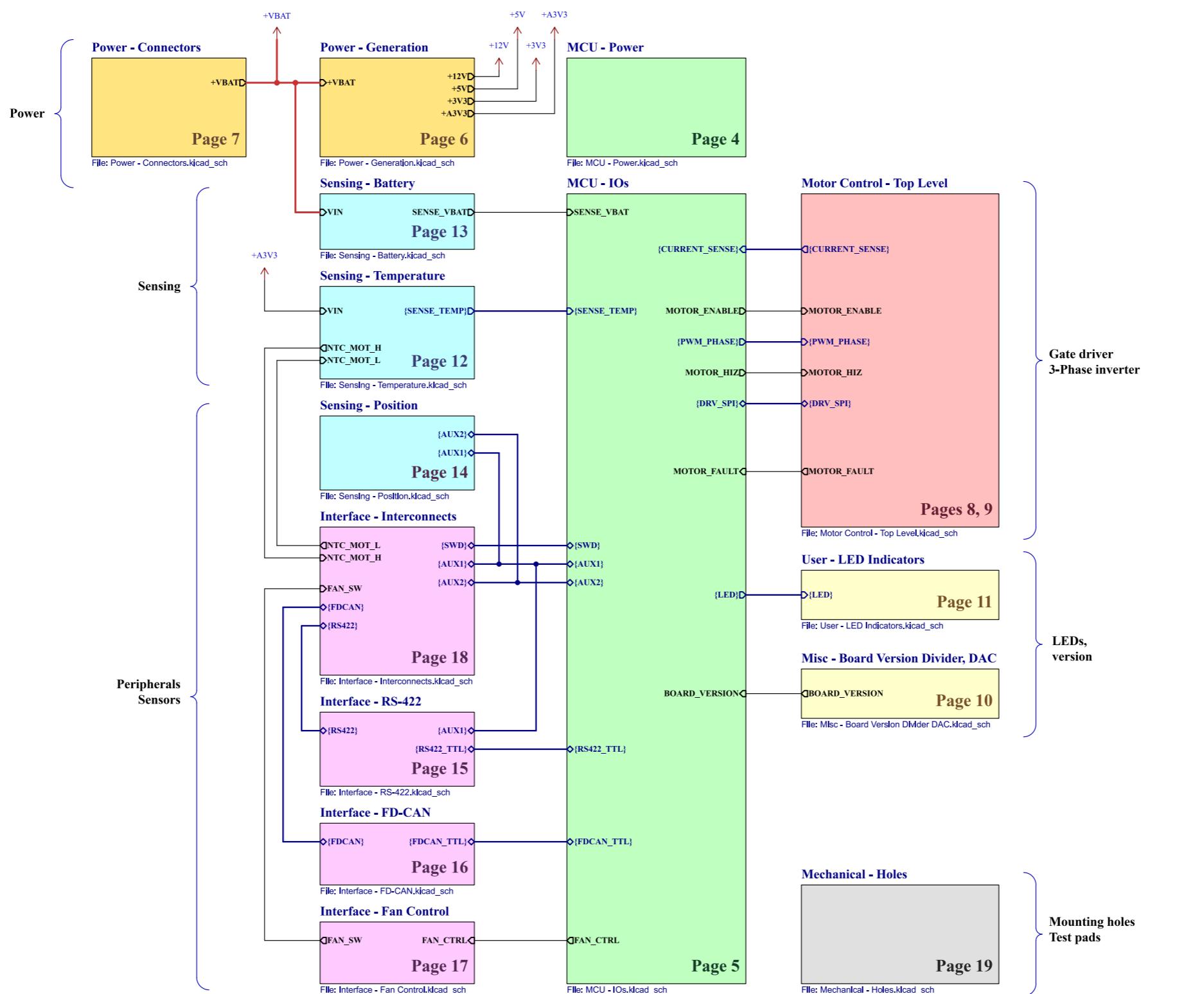
	Comments:	Company: EPFL Xplore Research	Variant: Preliminary
		Board Name: <b>Amulet Motion Controller</b>	Project Name: <b>Chienpanzée</b>
	Sheet Title: Cover Page	File Name: amulet_controller.kicad_sch	Designer: Vincent Nguyen
	Sheet Path: /	Reviewer:	Date: 2023-10-12 Revision: 1.0
		Size: A3	Sheet: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

# [2] Block Diagram



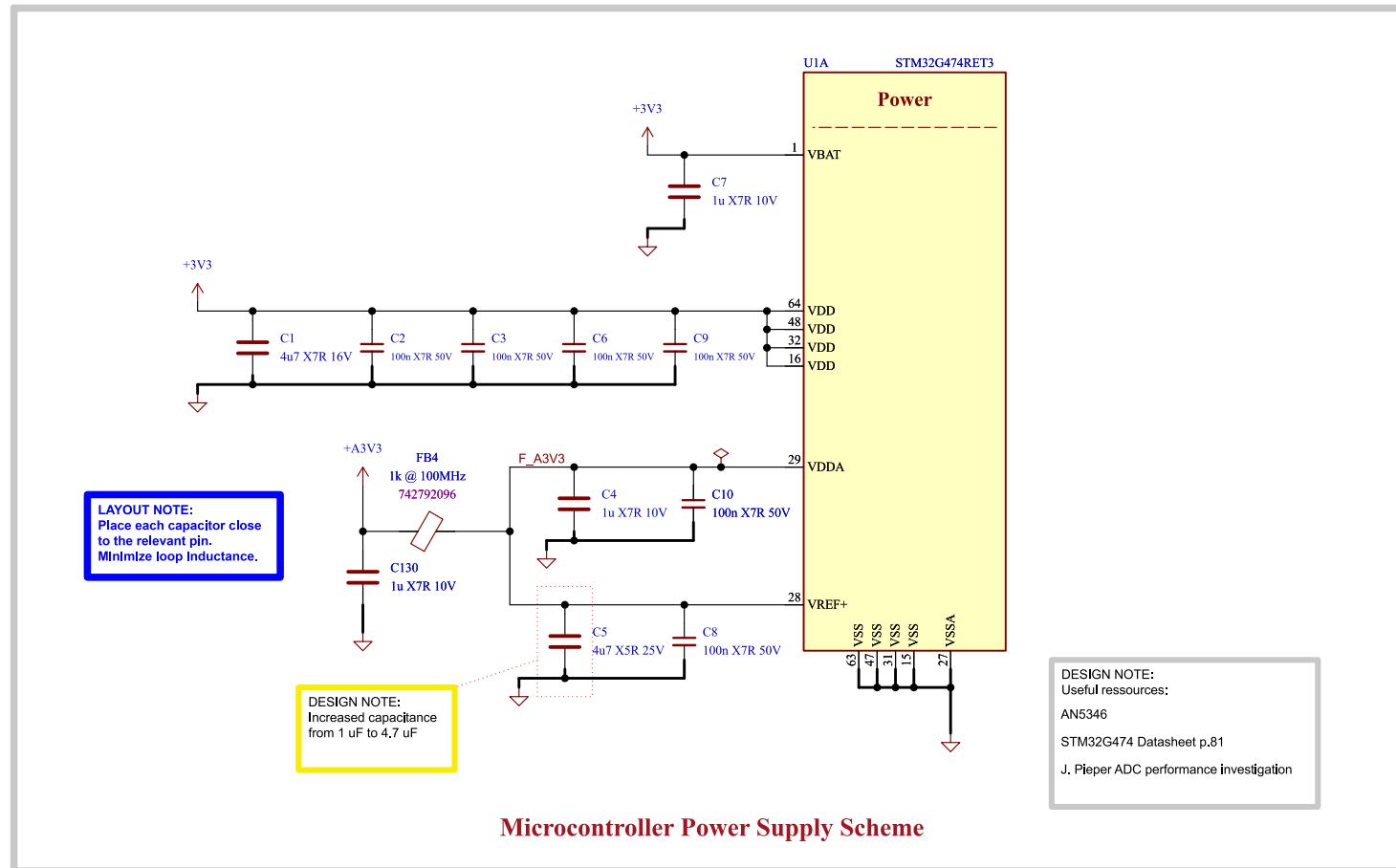
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	Board Name: <b>Amulet Motion Controller</b>	Project Name: <b>Chienpanzée</b>	
Sheet Title: Block Diagram	File Name: Block Diagram.kicad_sch	Designer: Vincent Nguyen	Date: 2023-11-30
Sheet Path: /Block Diagram/		Reviewer:	Revision: 1.0
	Size: <b>A3</b>	Sheet: <b>2</b> of <b>21</b>	

# [3] Project Architecture



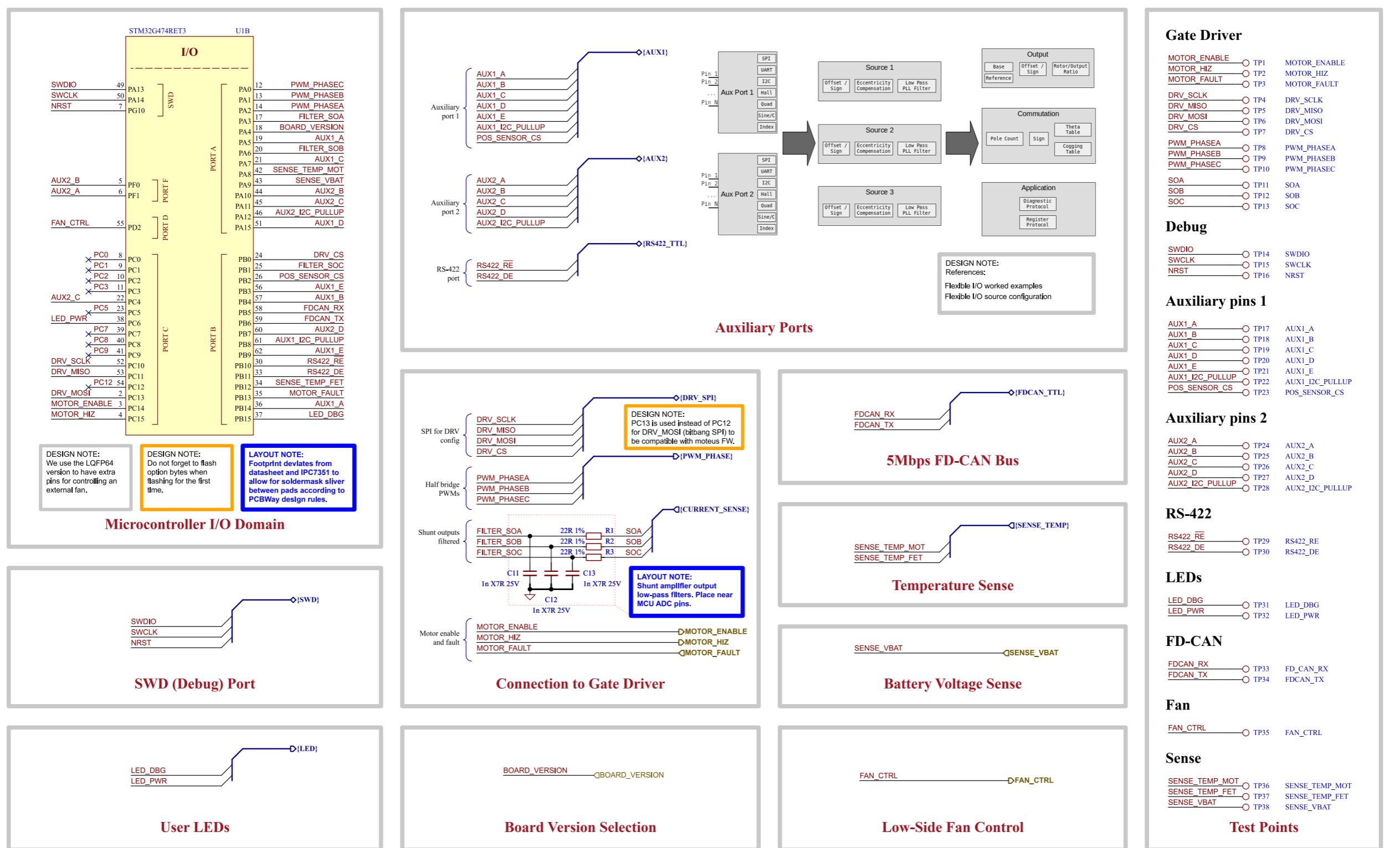
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		EPFL Xplore Research	 Xplore	
	Board Name:	<b>Amulet Motion Controller</b>		Project Name: <b>Chienpanzée</b>
	Sheet Title:	File Name:	Designer:	Date: 2023-11-25
	Project Architecture	Project Architecture.kicad_sch	Vincent Nguyen	Revision: 1.0
	Sheet Path:	Reviewer:		Size: <b>A3</b>
	/Project Architecture/			Sheet: <b>3 of 21</b>

# [4] MCU - Power



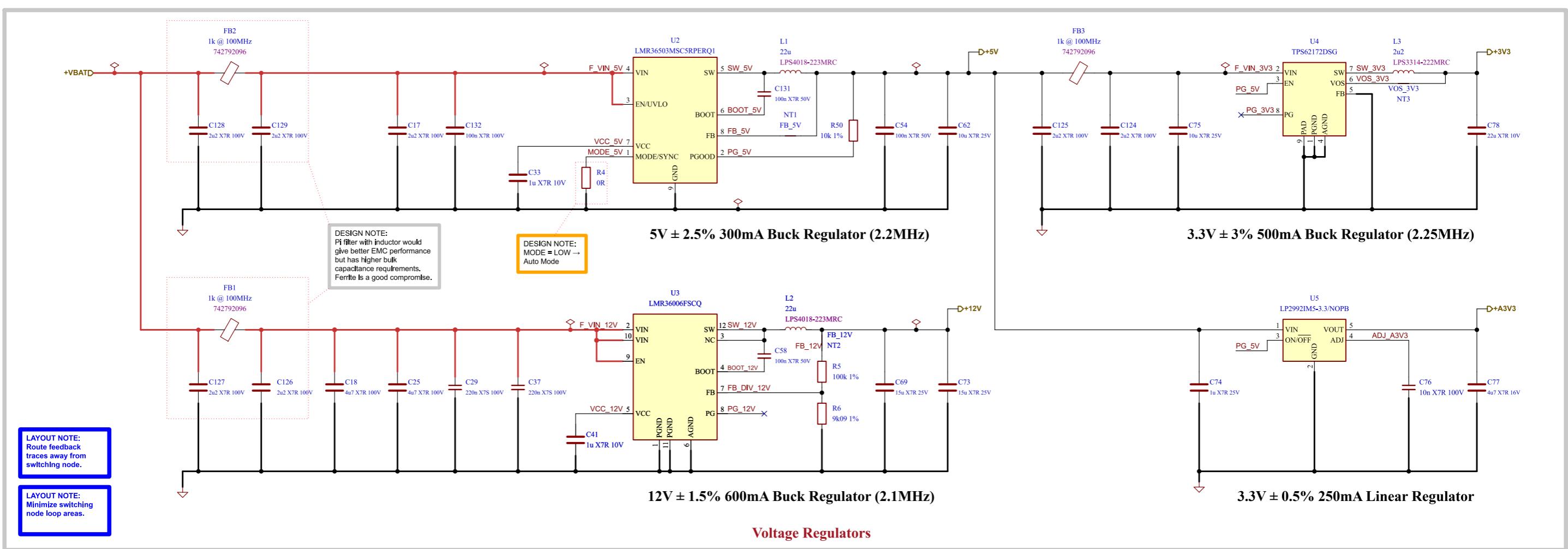
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	Board Name: <b>Amulet Motion Controller</b>		
	Sheet Title: MCU - Power	File Name: MCU - Power.kicad_sch	Designer: Vincent Nguyen
	Sheet Path: /Project Architecture/MCU - Power/	Reviewer:	Date: 2023-10-14      Revision: 1.0

# [5] MCU - I/Os

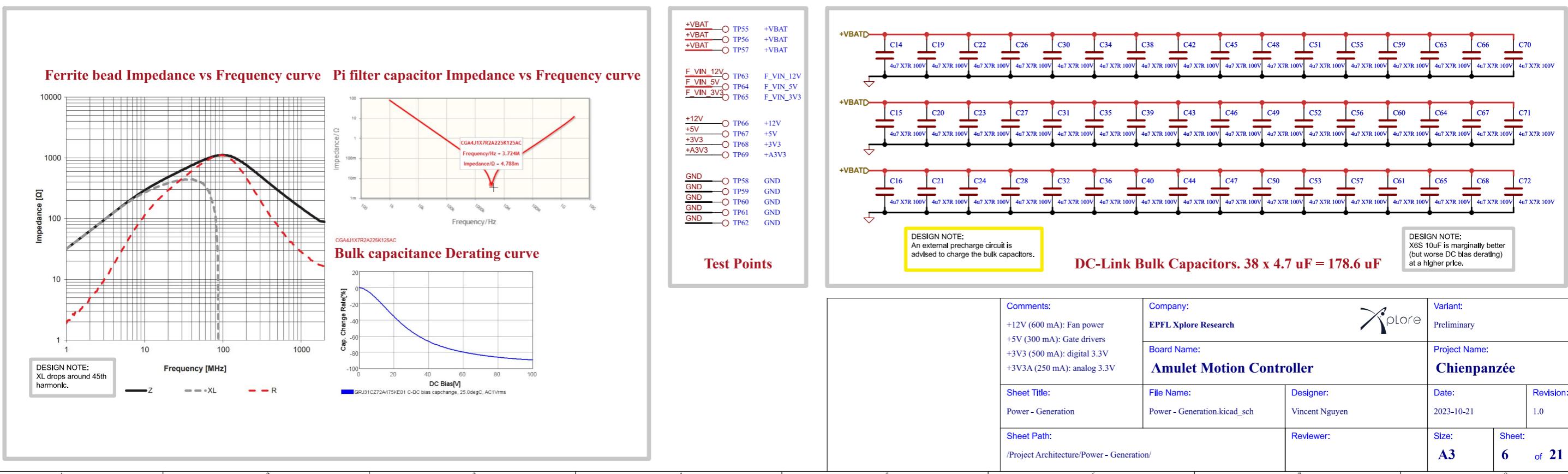


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		EPFL Xplore Research		
	Board Name:	<b>Amulet Motion Controller</b>		Project Name: <b>Chienpanzée</b>
	Sheet Title:	File Name:	Designer:	Date: 2023-10-14 Revision: 1.0
	MCU - I/Os	MCU - IOs.kicad_sch	Vincent Nguyen	
	Sheet Path:	/Project Architecture/MCU - IOs/		Reviewer:
			Size: A3	Sheet: 5 of 21

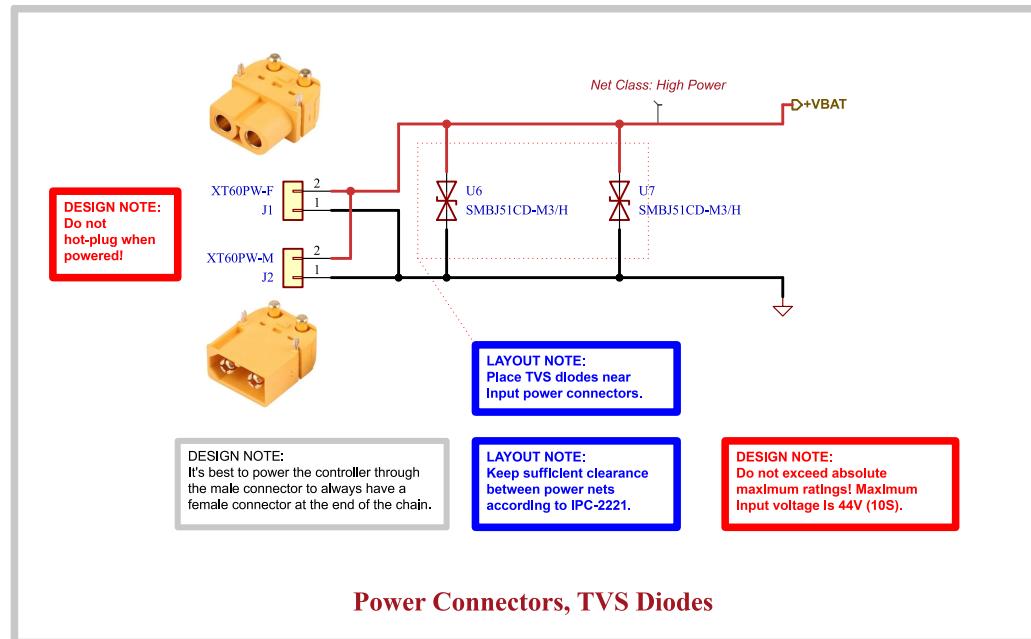
# [6] Power - Generation



Voltage Regulators

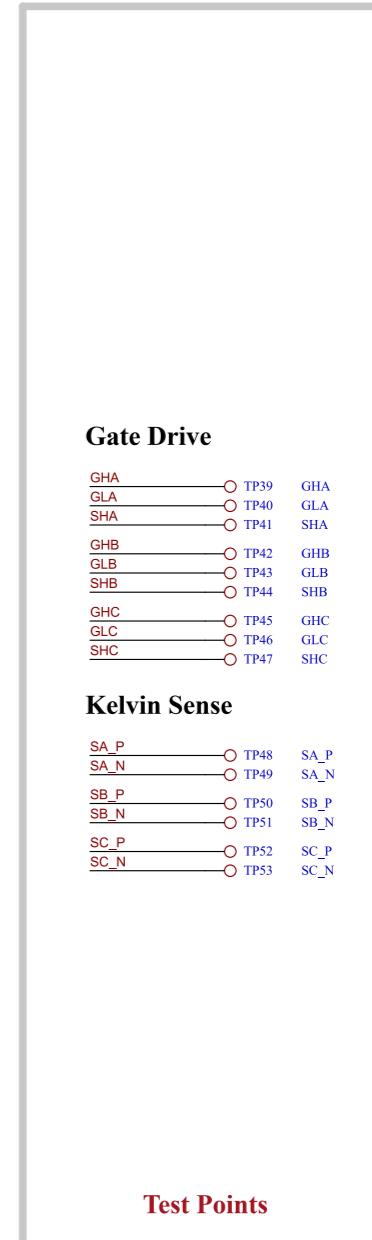
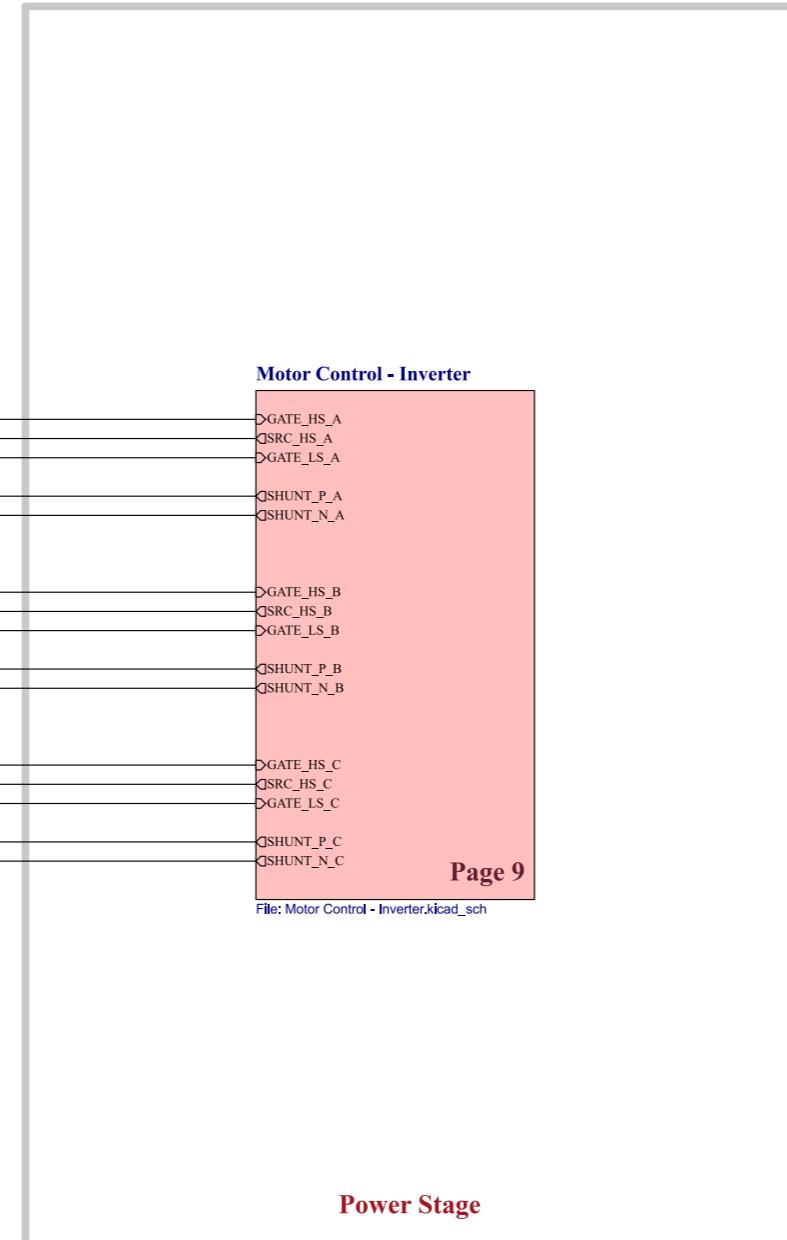
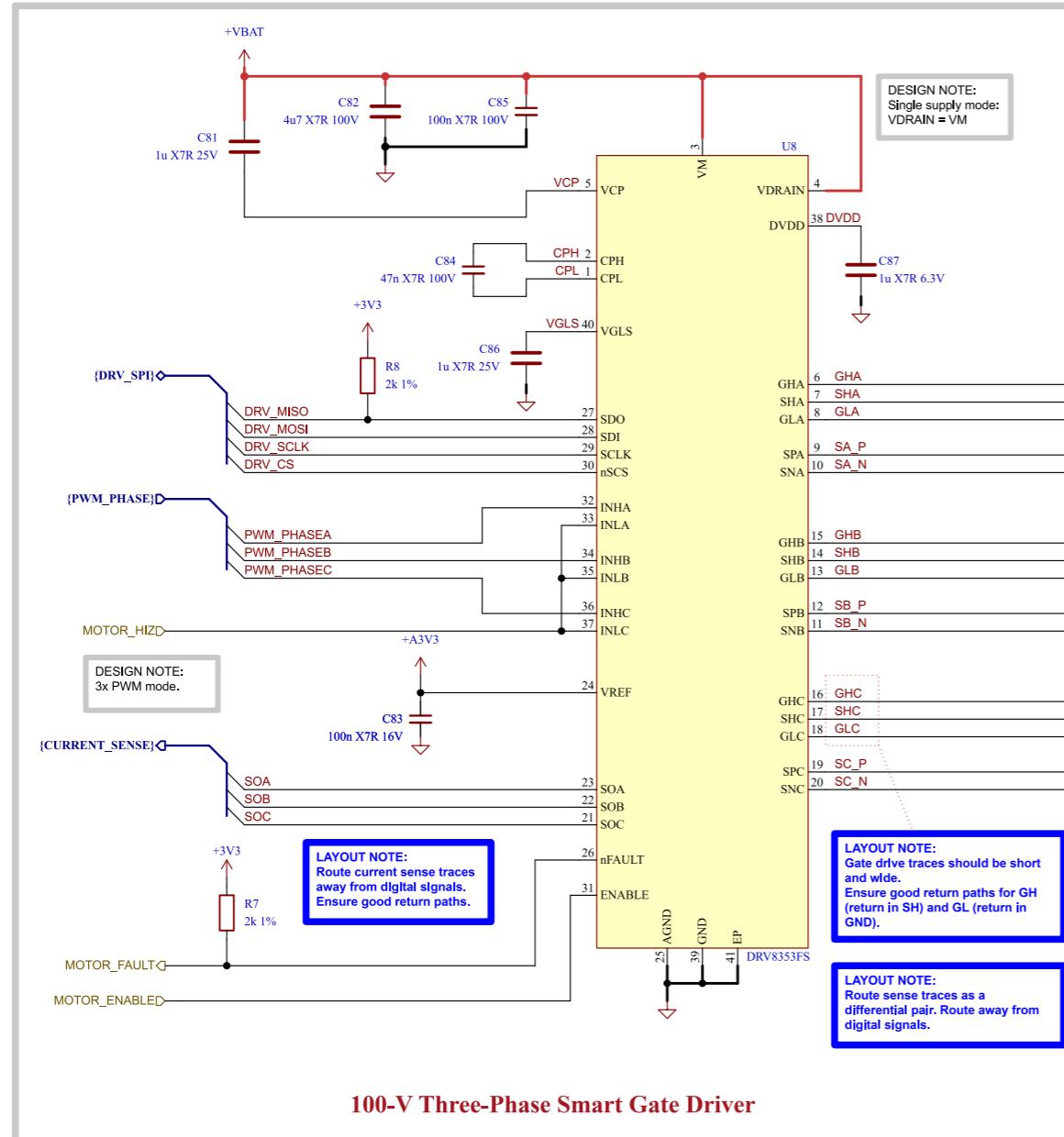


# [7] Power - Connectors



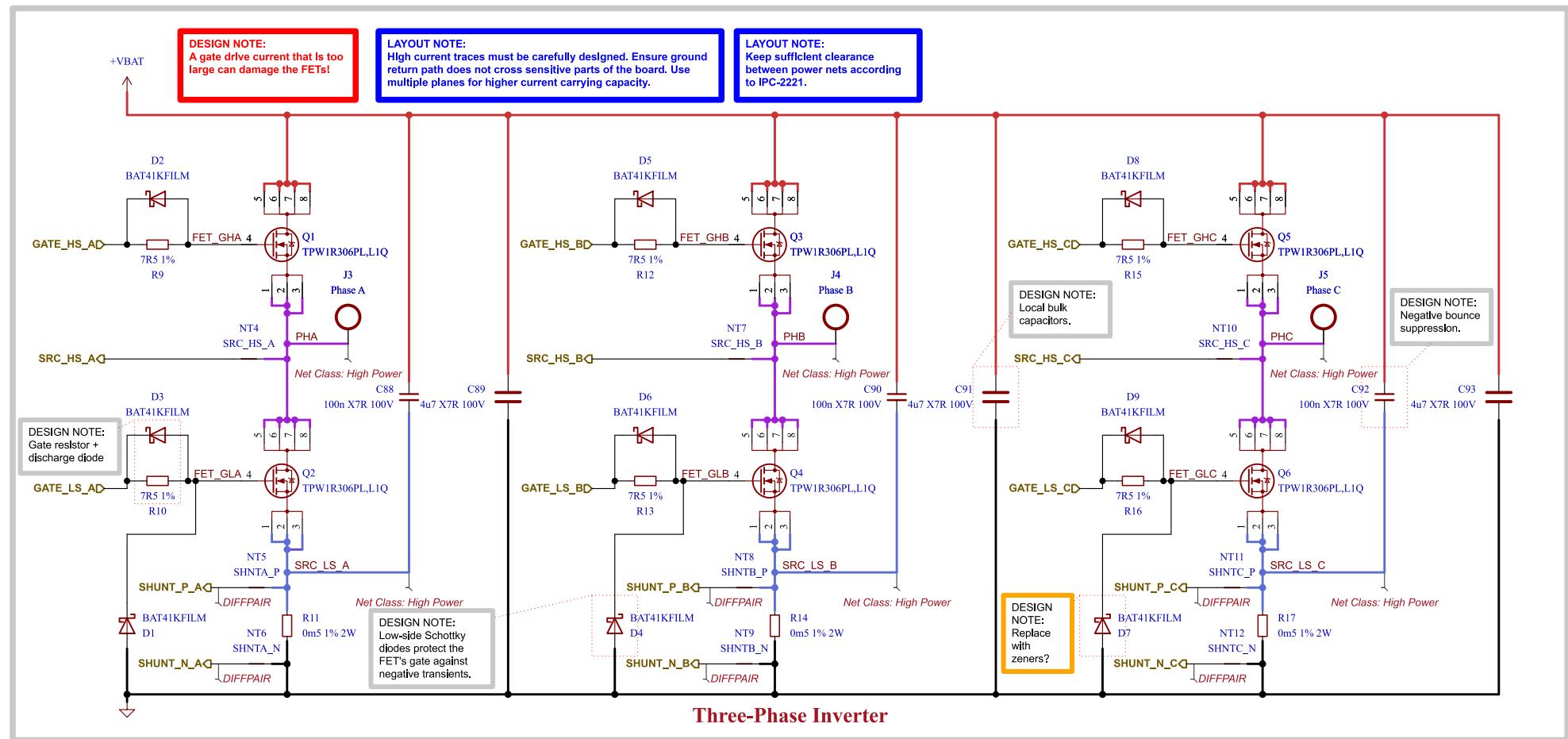
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	Board Name: <b>Amulet Motion Controller</b>		Project Name: <b>Chienpanzée</b>
	Sheet Title: Power - Connectors	File Name: Power - Connectors.kicad_sch	Designer: Vincent Nguyen
	Sheet Path:  /Project Architecture/Power - Connectors/	Reviewer:  	Date: 2023-10-14
		Size: <b>A4</b>	Revision: 1.0
		Sheet: <b>7</b>	of <b>21</b>

# [8] Motor Control - Top Level



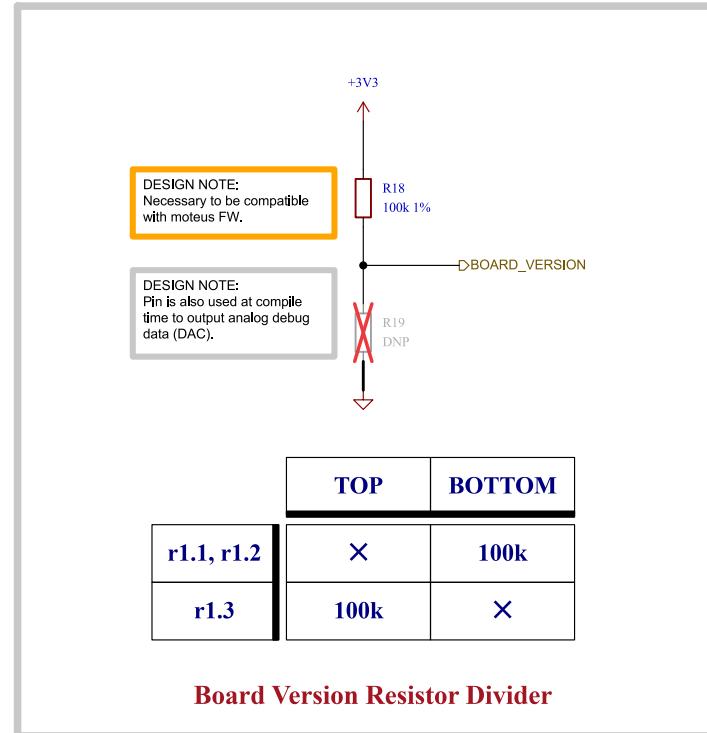
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		EPFL Xplore Research	Preliminary	
	Board Name:	Project Name:		
	<b>Amulet Motion Controller</b>		<b>Chienpanzée</b>	
	Sheet Title:	File Name:	Designer:	Date: Revision:
	Motor Control - Top Level	Motor Control - Top Level.kicad_sch	Vincent Nguyen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

# [9] Motor Control - Inverter



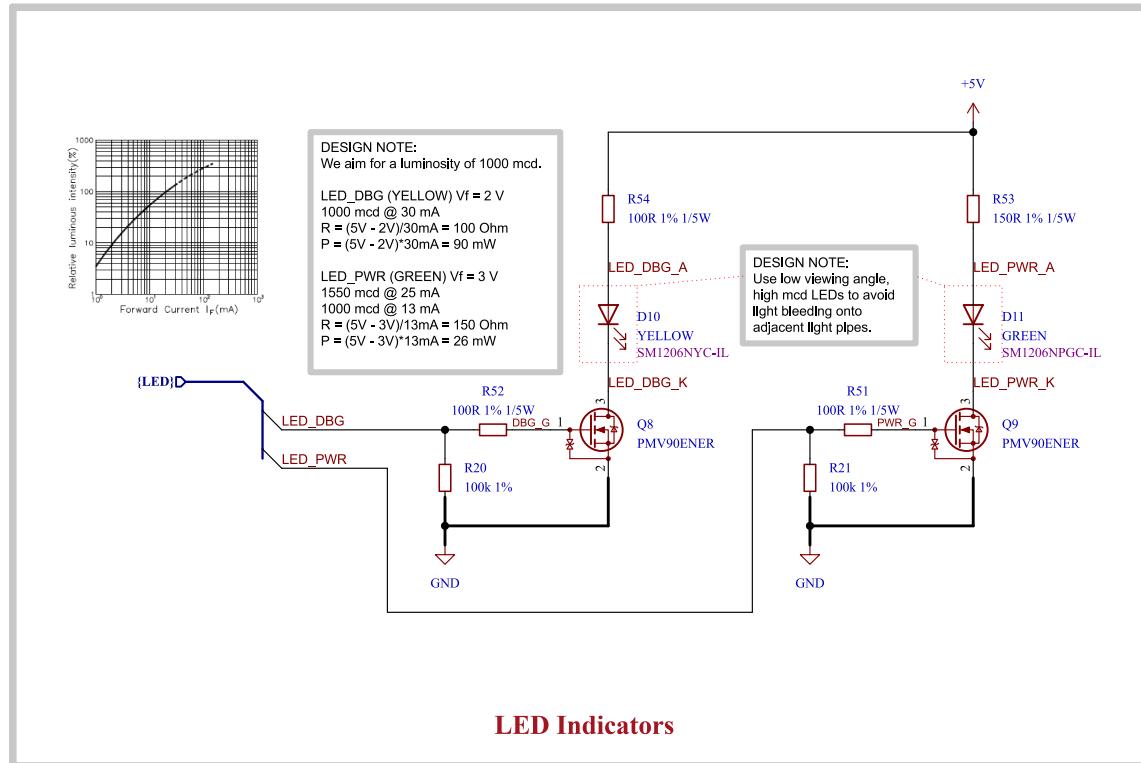
D		Comments:  DESIGN NOTE: References: System Design Considerations for High-Power Motor Driver Applications Best Practices for Board Layout of Motor Drivers	Company: EPFL Xplore Research	Variant: Preliminary
		Board Name: <b>Amulet Motion Controller</b>	Project Name: <b>Chienpanzée</b>	
		Sheet Title: Motor Control - Inverter	File Name: Motor Control - Inverter.kicad_sch	Designer: Vincent Nguyen
		Sheet Path: /Project Architecture/Motor Control - Top Level/Motor Control - Inverter/	Reviewer: 	Date: 2023-10-18      Revision: 1.0

# [10] Misc - Board Version Divider, DAC



	Comments:	Company: EPFL Xplore Research	Variant: Preliminary
	<b>Board Name:</b> <b>Amulet Motion Controller</b>		
	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
			Size: A4 Sheet: 10 of 21

# [11] User - LED Indicators



	Comments:	Company: EPFL Xplore Research	Variant: Preliminary
	Board Name: <b>Amulet Motion Controller</b>	Project Name: <b>Chienpanzée</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: 2023-10-15 Revision: 1.0

# [12] Sensing - Temperature

A

B

C

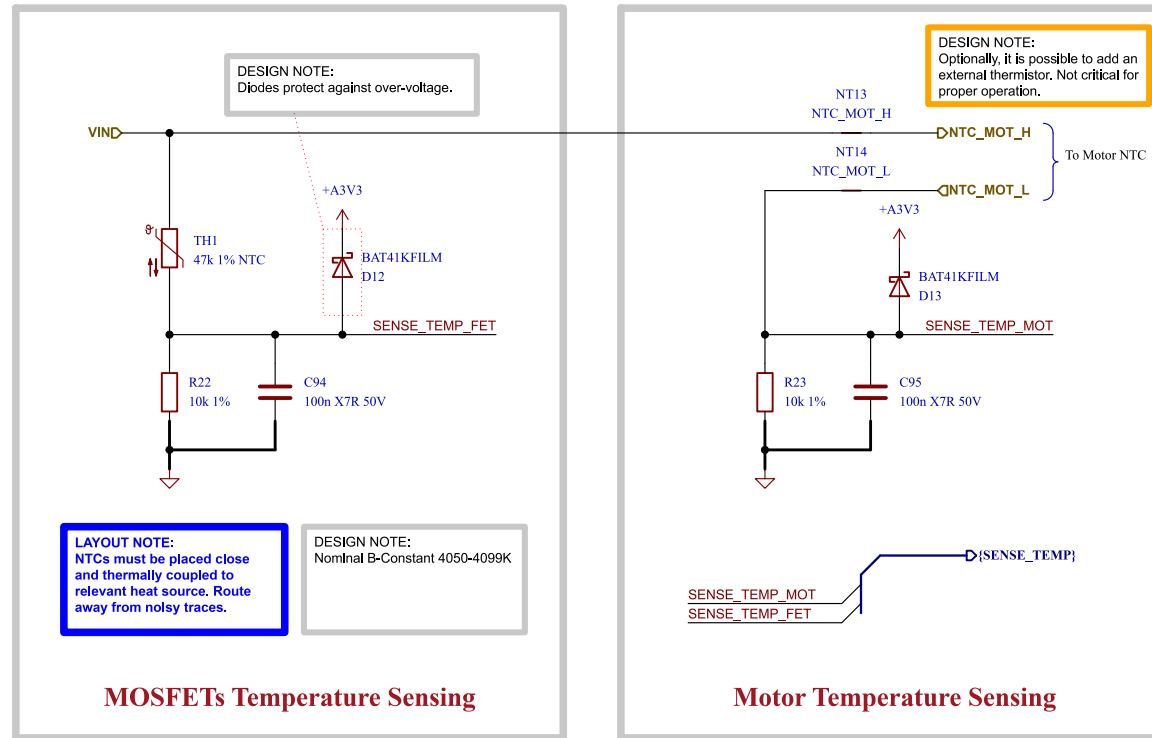
D

A

B

C

D



	Comments:	Company: EPFL Xplore Research	Variant: Preliminary
	Board Name: <b>Amulet Motion Controller</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



Project Name:  
**Chienpanzée**

Size: A4 Sheet: 12 of 21

# [13] Sensing - Battery

A

B

C

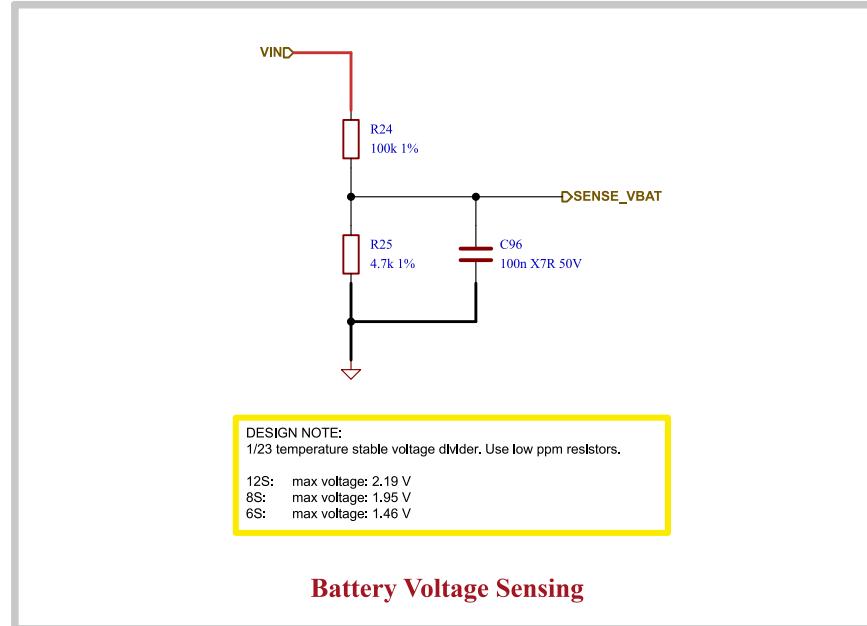
D

A

B

C

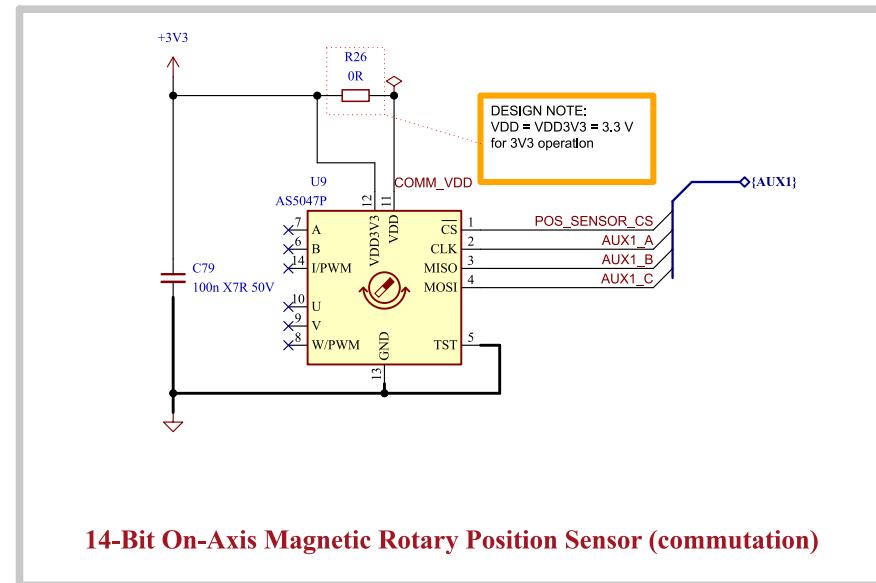
D



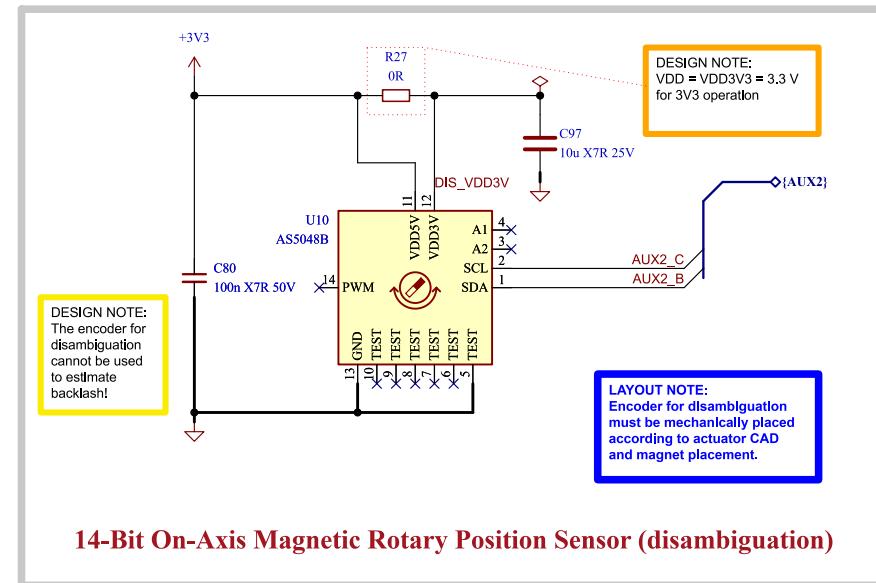
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	Board Name: <b>Amulet Motion Controller</b>		
	Sheet Title: Sensing - Battery	File Name: Sensing - Battery.kicad_sch	Designer: Vincent Nguyen
	Sheet Path: /Project Architecture/Sensing - Battery/	Reviewer:	Date: 2023-10-14 Revision: 1.0
		Size: <b>A4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

# [14] Sensing - Position

A



B



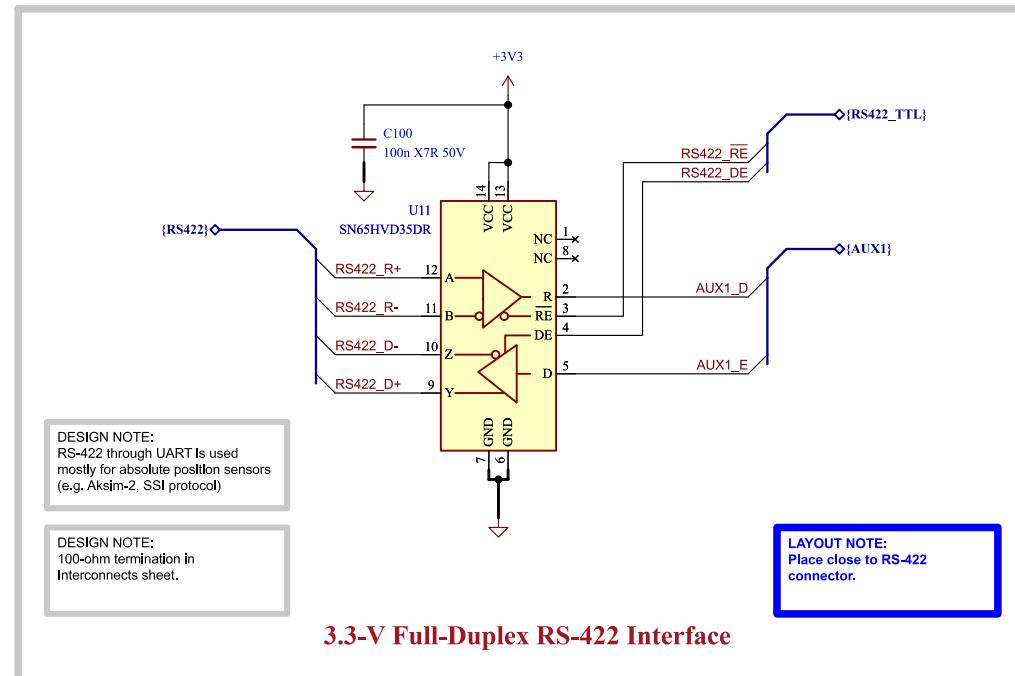
C

**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

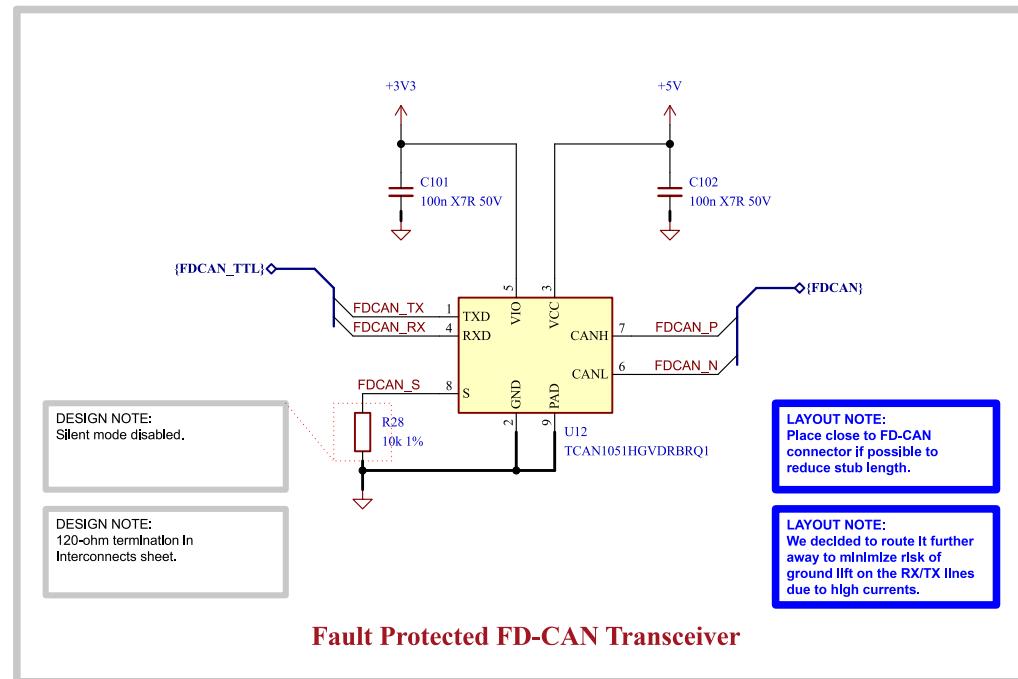
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	<b>Board Name:</b> <b>Amulet Motion Controller</b>		
	Sheet Title: Sensing - Position	File Name: Sensing - Position.kicad_sch	Designer: Vincent Nguyen
	Sheet Path: /Project Architecture/Sensing - Position/	Reviewer:	Date: 2023-10-14    Revision: 1.0

# [15] Interface - RS-422



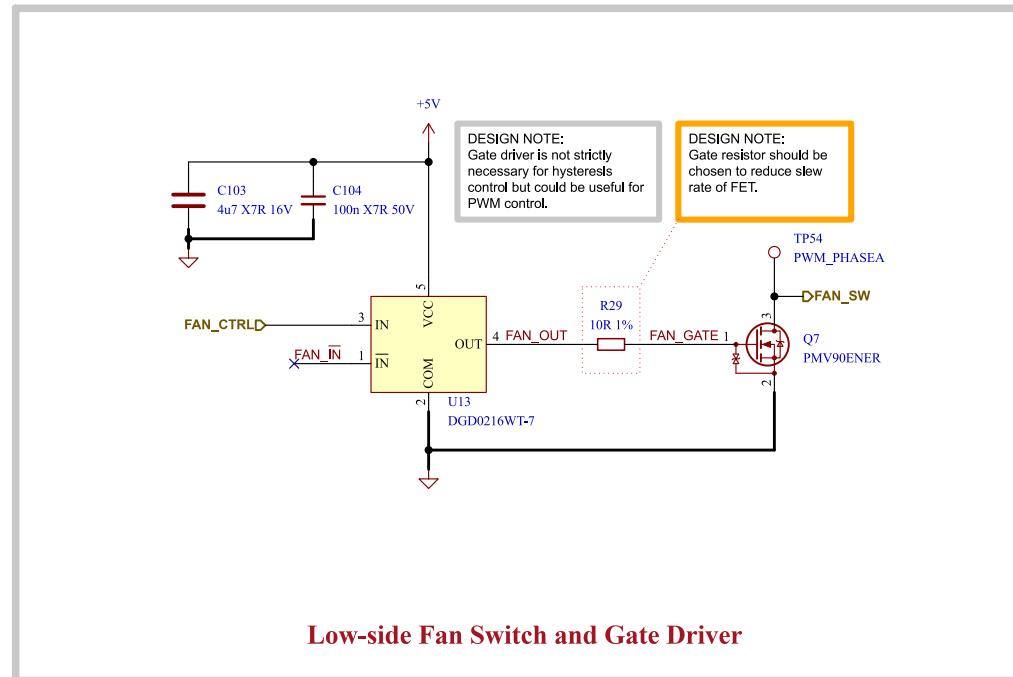
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	Board Name: <b>Amulet Motion Controller</b>		
	Sheet Title: Interface - RS-422	File Name: Interface - RS-422.kicad_sch	Designer: Vincent Nguyen
	Sheet Path: /Project Architecture/Interface - RS-422/	Reviewer:	Date: 2023-10-15 Revision: 1.0

# [16] Interface - FD-CAN



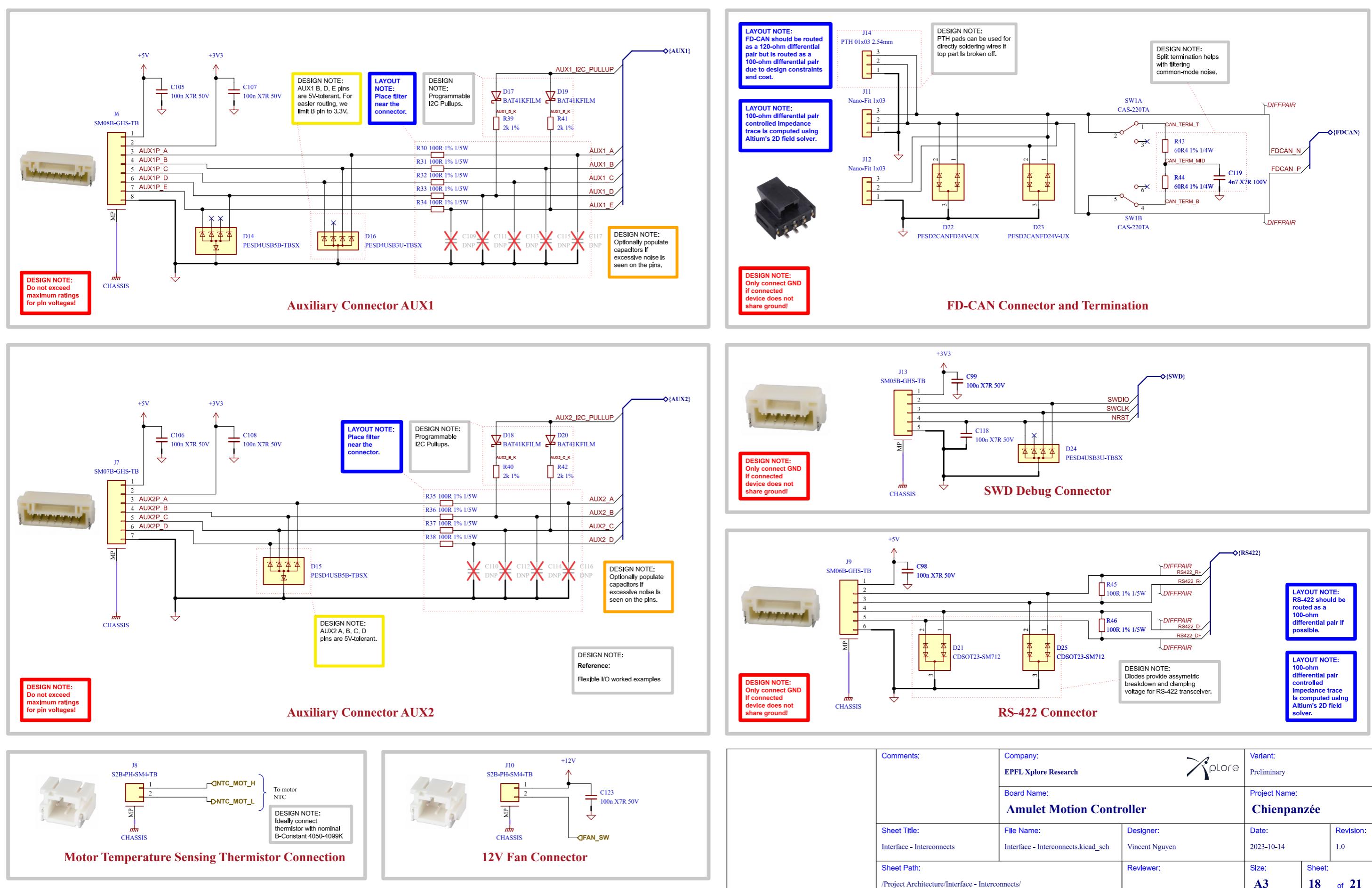
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	Sheet Path: /Project Architecture/Interface - FD-CAN/	Reviewer:	Date: 2023-10-15 Revision: 1.0

# [17] Interface - Fan Control

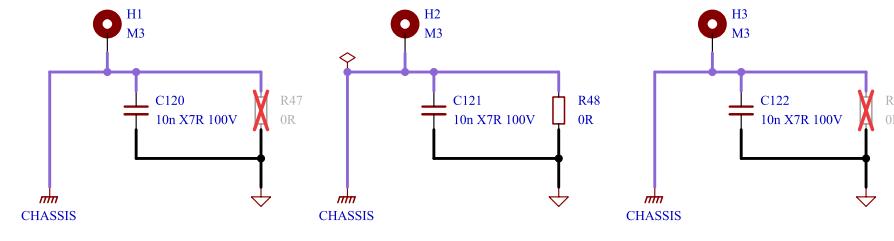


	Comments:	Company: EPFL Xplore Research	Variant: Preliminary
	Board Name: <b>Amulet Motion Controller</b>		
	Sheet Title: Interface - Fan Control	File Name: Interface - Fan Control.kicad_sch	Designer: Vincent Nguyen
	Sheet Path: <a href="#">/Project Architecture/Interface - Fan Control/</a>	Reviewer: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

# [18] Interface - Interconnects



# [19] Mechanical - Holes



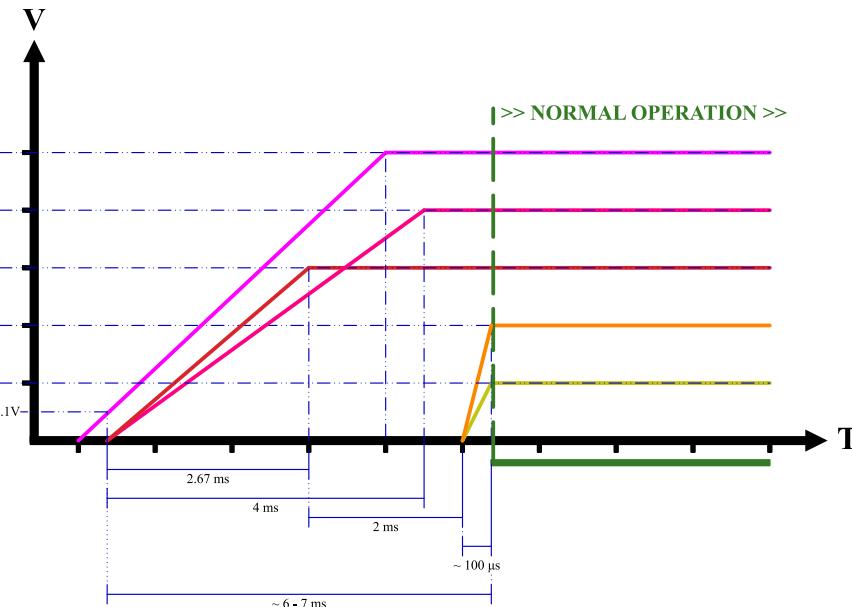
**DESIGN NOTE:**  
Optional RC filter for chassis  
grounding. Capacitors offer multi-point  
low-impedance connections at  
high-frequencies.

**Mounting Holes and Chassis Connection**

	Comments:	Company: EPFL Xplore Research	Variant: Preliminary
	Board Name: <b>Amulet Motion Controller</b>		
	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%



DESIGN NOTE:  
Graph is not to scale!

DESIGN NOTE:  
Power sequencing to verify  
experimentally.

			Comments:	Company:	EPFL Xplore Research		Variant:		
				Board Name:			Preliminary		
				<b>Amulet Motion Controller</b>		Project Name:			
			Sheet Title:	File Name:	Designer:	Date:	Revision:		
Power - Sequencing				Power - Sequencing.kicad_sch	Vincent Nguyen	1.0			
Sheet Path: <a href="#">/Power - Sequencing/</a>				Reviewer:	Size:	Sheet:			
					A4	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: <b>EPFL Xplore Research</b> 	Variant: <b>Preliminary</b>
	Board Name: <b>Amulet Motion Controller</b>		
	Sheet Title: Revision History	File Name: Revision History.kicad_sch	Designer: Vincent Nguyen Date: 2023-10-15 Revision: 1.0
	Sheet Path: <a href="#">/Revision History/</a>	Reviewer:	Size: <b>A4</b> Sheet: <b>21 of 21</b>

2

3

4

5

6