

# γ Gamma Controller

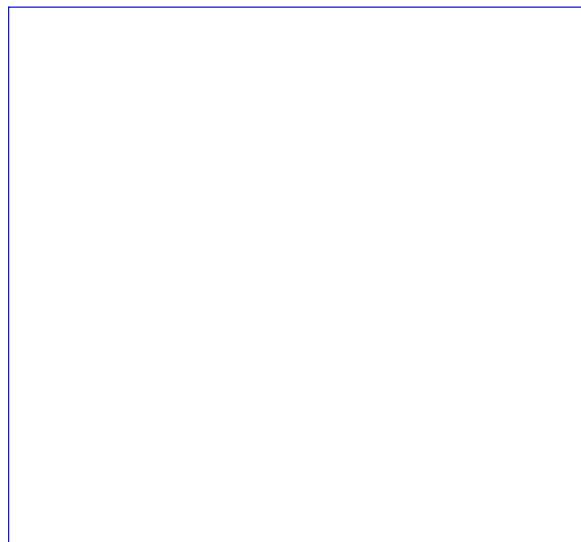
## Variant: Preliminary

2023-12-09

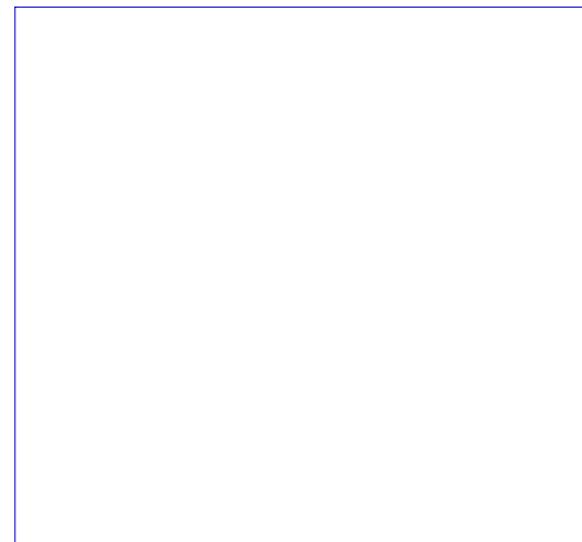
Rev 1.0

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/O	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.

RELEASED 08-DEC-2023

## DESIGN CONSIDERATIONS

DESIGN NOTE:  
Example text for informational design notes.

DESIGN NOTE:  
Example text for debug notes.

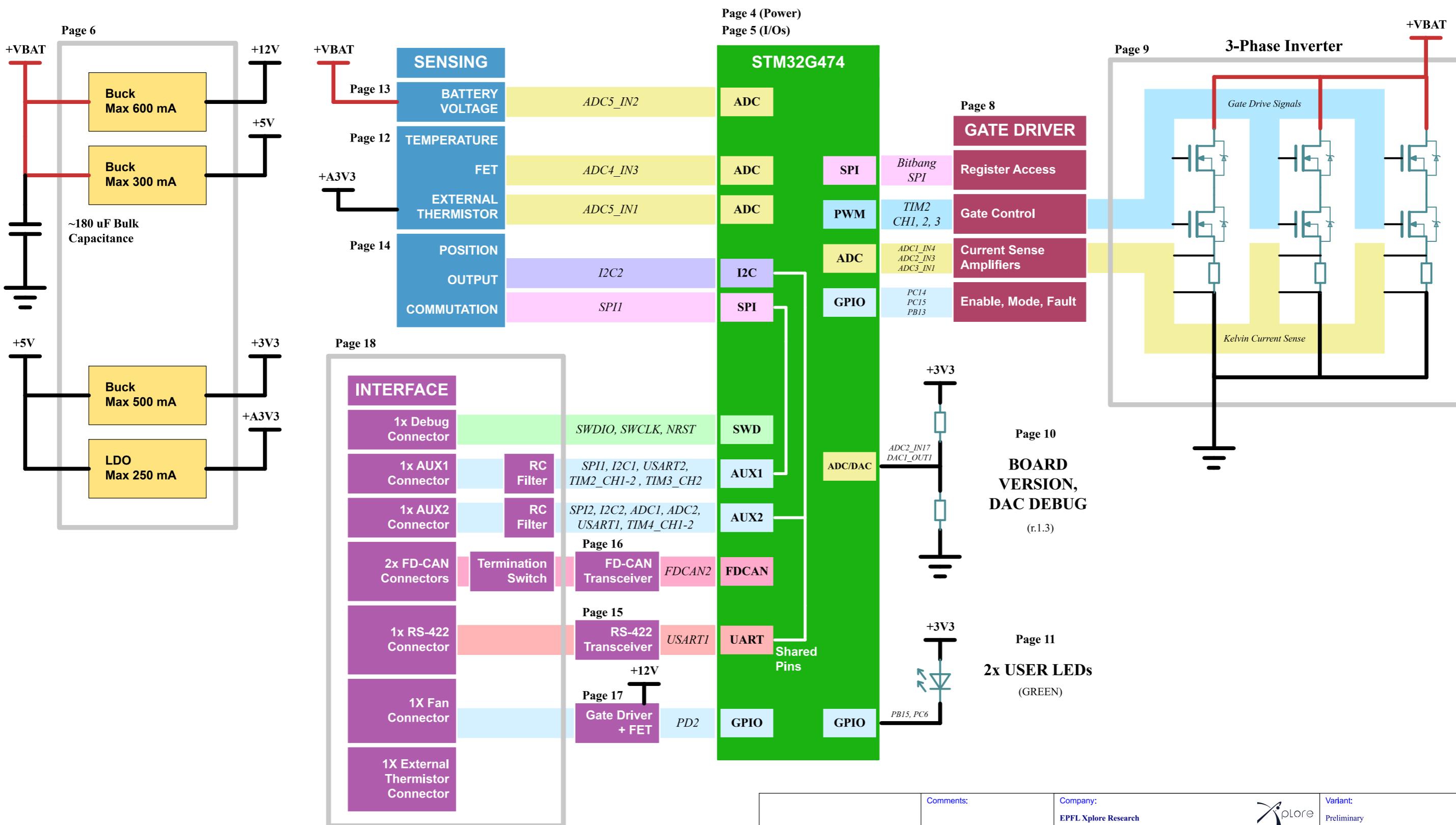
DESIGN NOTE:  
Example text for cautionary design notes.

DESIGN NOTE:  
Example text for critical design notes.

LAYOUT NOTE:  
Example text for critical layout guidelines.

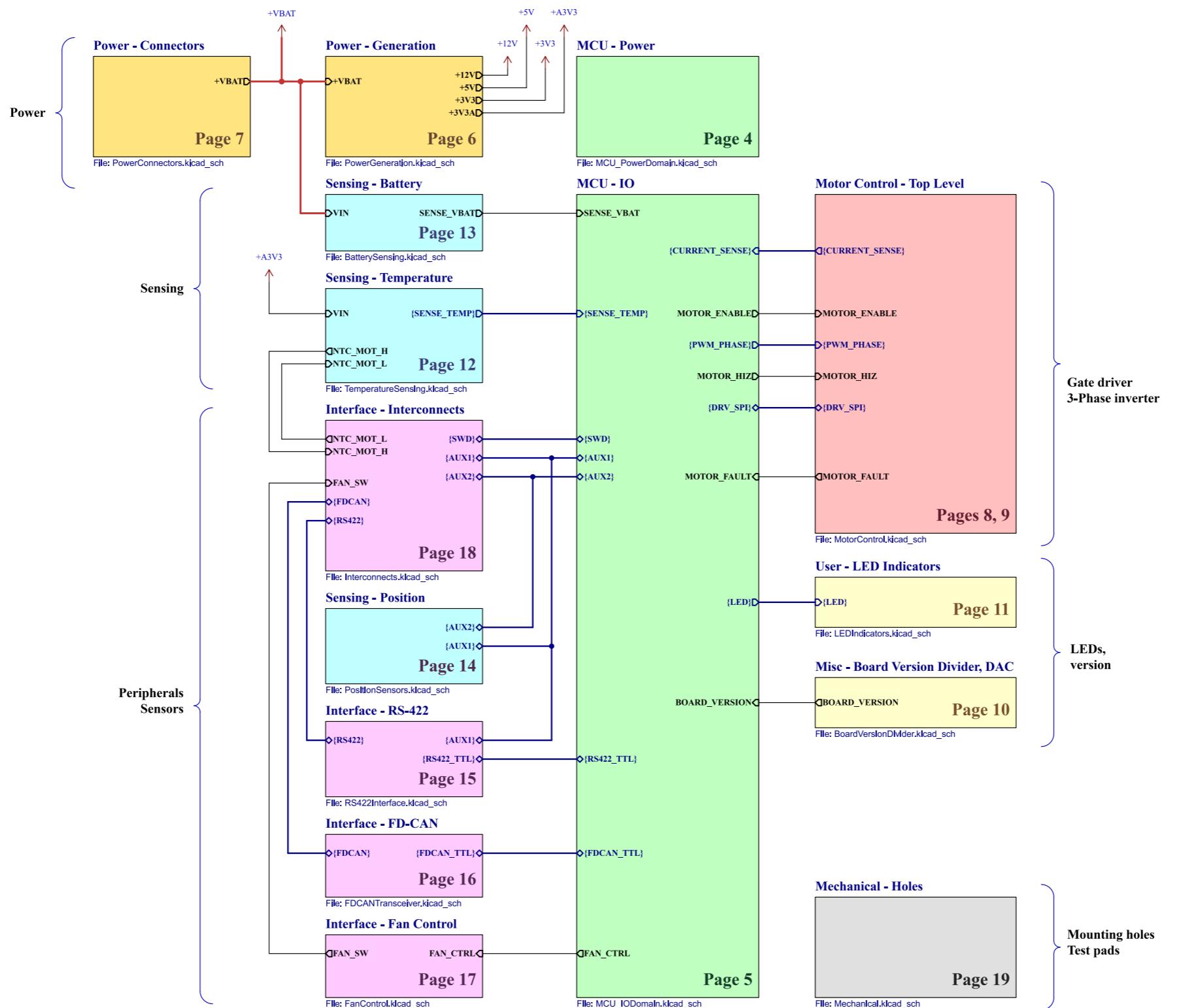
	Comments:	Company: EPFL Xplore Research	Variant: Preliminary
	Project Name: <b>Chienpanzée</b>	Board Name: <b>γ Gamma Controller</b>	
Sheet Title: Cover Page	File Name: bldc_controller.kicad_sch	Designer: Vincent Nguyen	Date: 2023-10-12
Sheet Path: /		Reviewer:	Revision: 1.0
		Size: <b>A3</b>	Sheet: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

# [2] Block Diagram



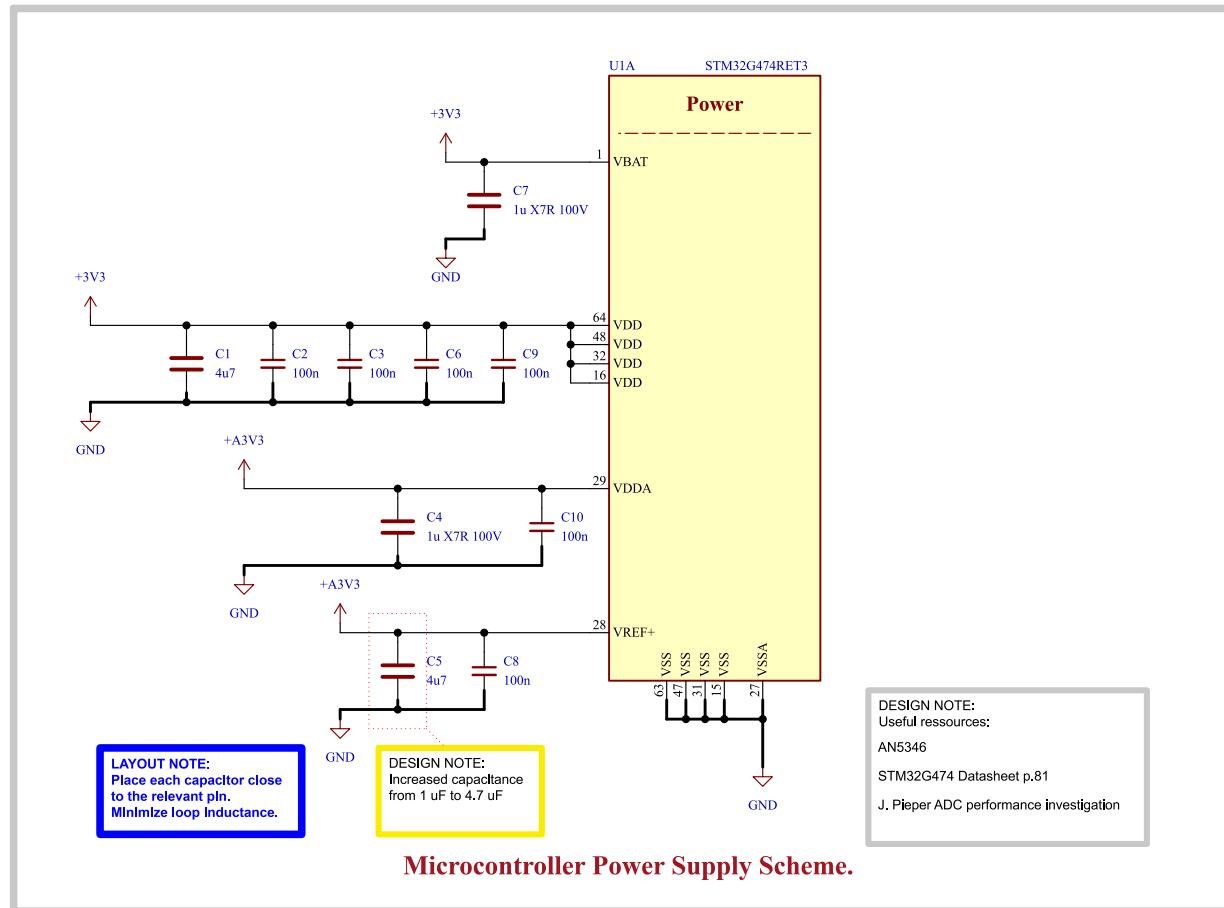
Comments:	Company: EPFL Xplore Research	Variant: Preliminary
Project Name: <b>Chienpanzée</b>	Board Name: <b>y Gamma Controller</b>	
Sheet Title: Block Diagram	File Name: BlockDiagram.kicad_sch	Designer: Vincent Nguyen
Sheet Path: /Block Diagram/	Reviewer:	Date: 2023-11-30
		Revision: 1.0
	Size: <b>A3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

# [3] Project Architecture



	Comments:	Company: EPFL Xplore Research	Variant: Preliminary
	Project Name: <b>Chienpanzée</b>	Board Name: <b>y Gamma Controller</b>	
Sheet Title: Project Architecture	File Name: ProjectArchitecture.kicad_sch	Designer: Vincent Nguyen	Date: 2023-11-25
Sheet Path: /Project Architecture/	Reviewer:	Size: <b>A3</b>	Revision: 1.0

## [4] MCU - Power



A

A

B

B

C

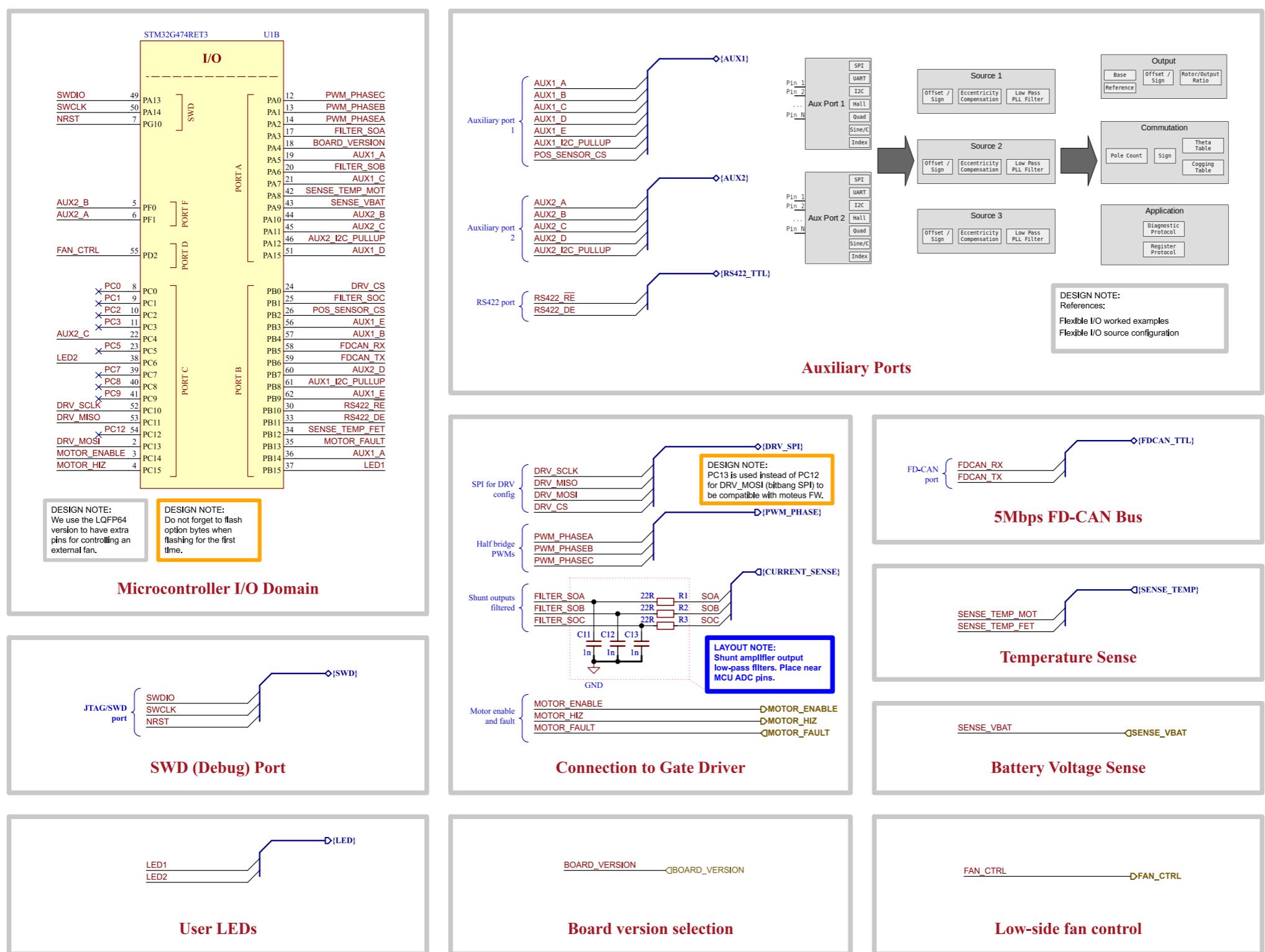
C

D

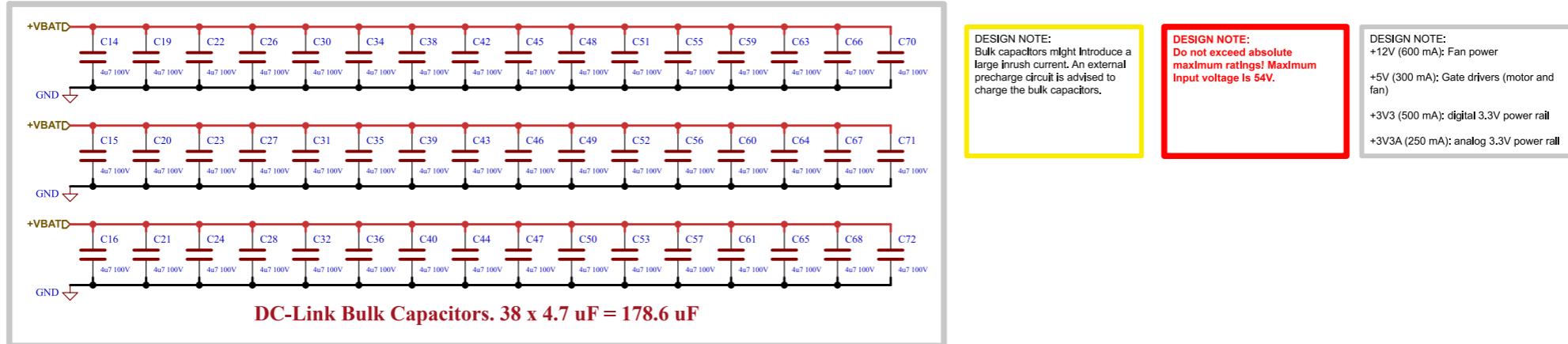
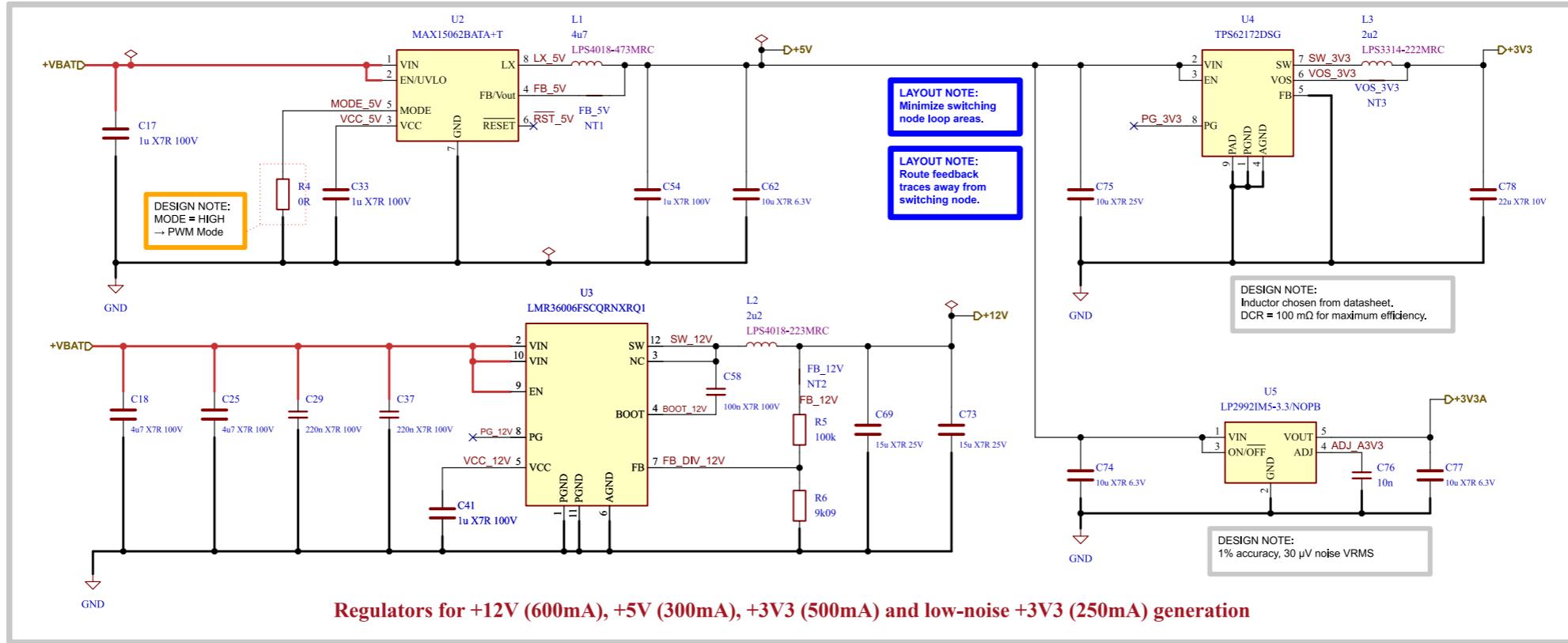
D

		Comments:	Company: EPFL Xplore Research	Variant: Preliminary
		Project Name: <b>Chienpanzée</b>	Board Name: <b>γ Gamma Controller</b>	
		Sheet Title: MCU - Power	File Name: MCU_PowerDomain.kicad_sch	Designer: Vincent Nguyen
		Sheet Path: /Project Architecture/MCU - Power/	Reviewer:	Date: 2023-10-14 Revision: 1.0

# [5] MCU - I/O

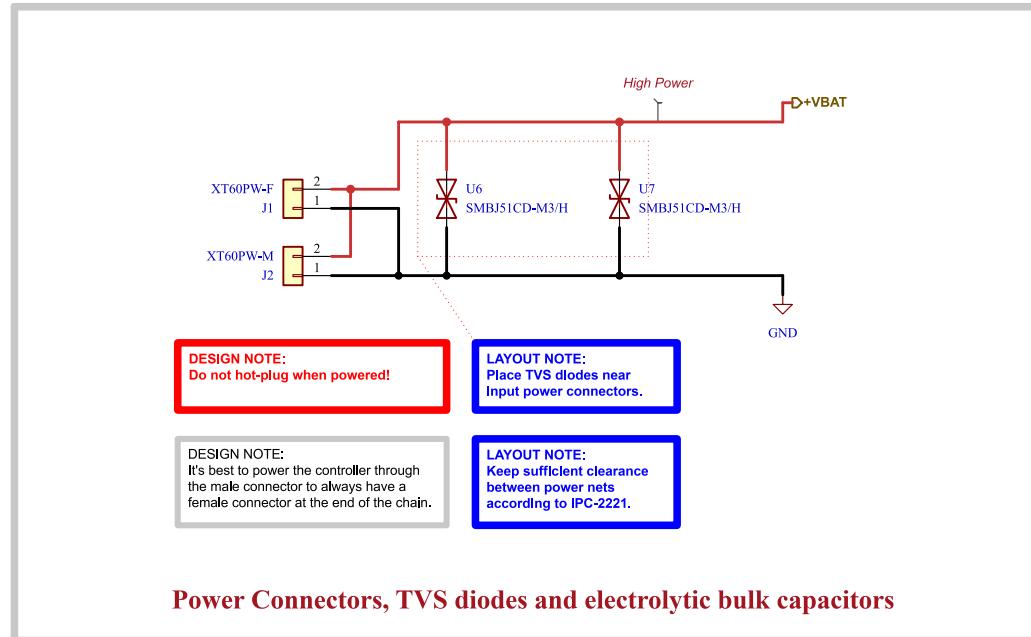


# [6] Power - Generation



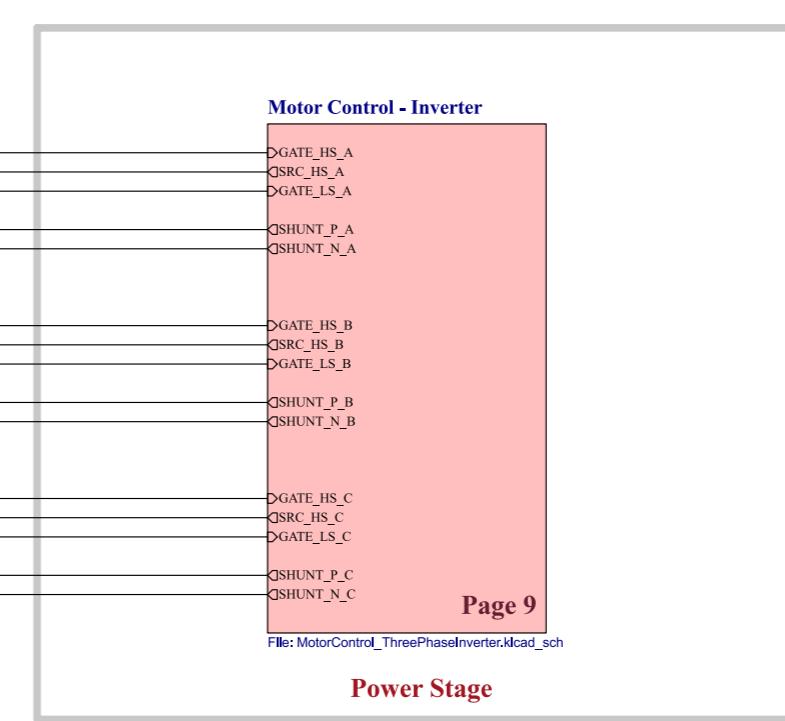
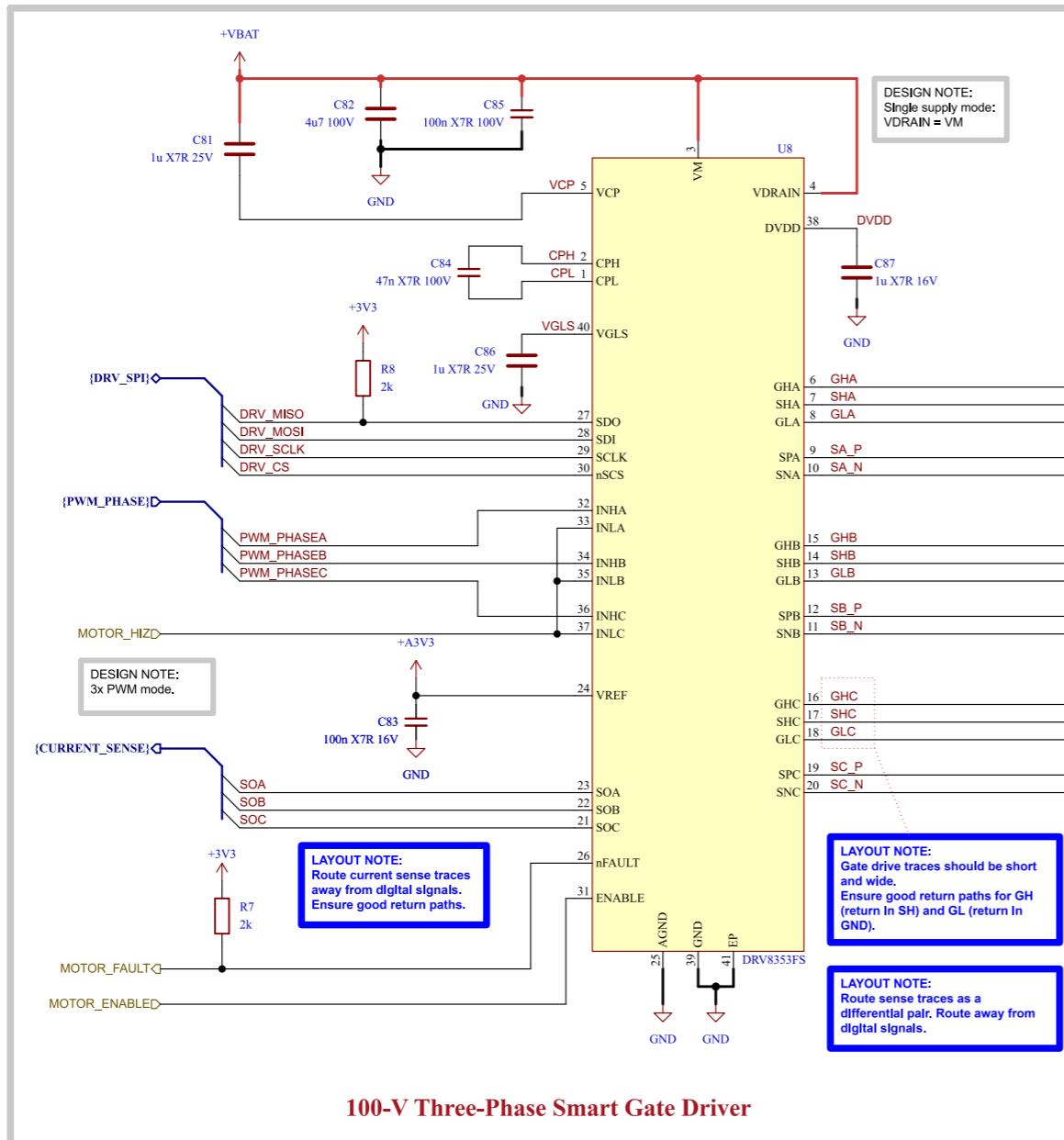
	Comments:	Company:	Variant:	
		EPFL Xplore Research	Preliminary	
	Project Name:	<b>Chienpanzée</b>		Board Name:
	Sheet Title:	File Name:	Designer:	Date: <span style="float: right;">Revision:</span>
	Power - Generation	PowerGeneration.kicad_sch	Vincent Nguyen	2023-10-21 <span style="float: right;">1.0</span>
	Sheet Path:	Reviewer:		Size: <span style="float: right;">Sheet:</span>
	/Project Architecture/Power - Generation/			A3 <span style="float: right;">6 of 21</span>

# [7] Power - Connectors



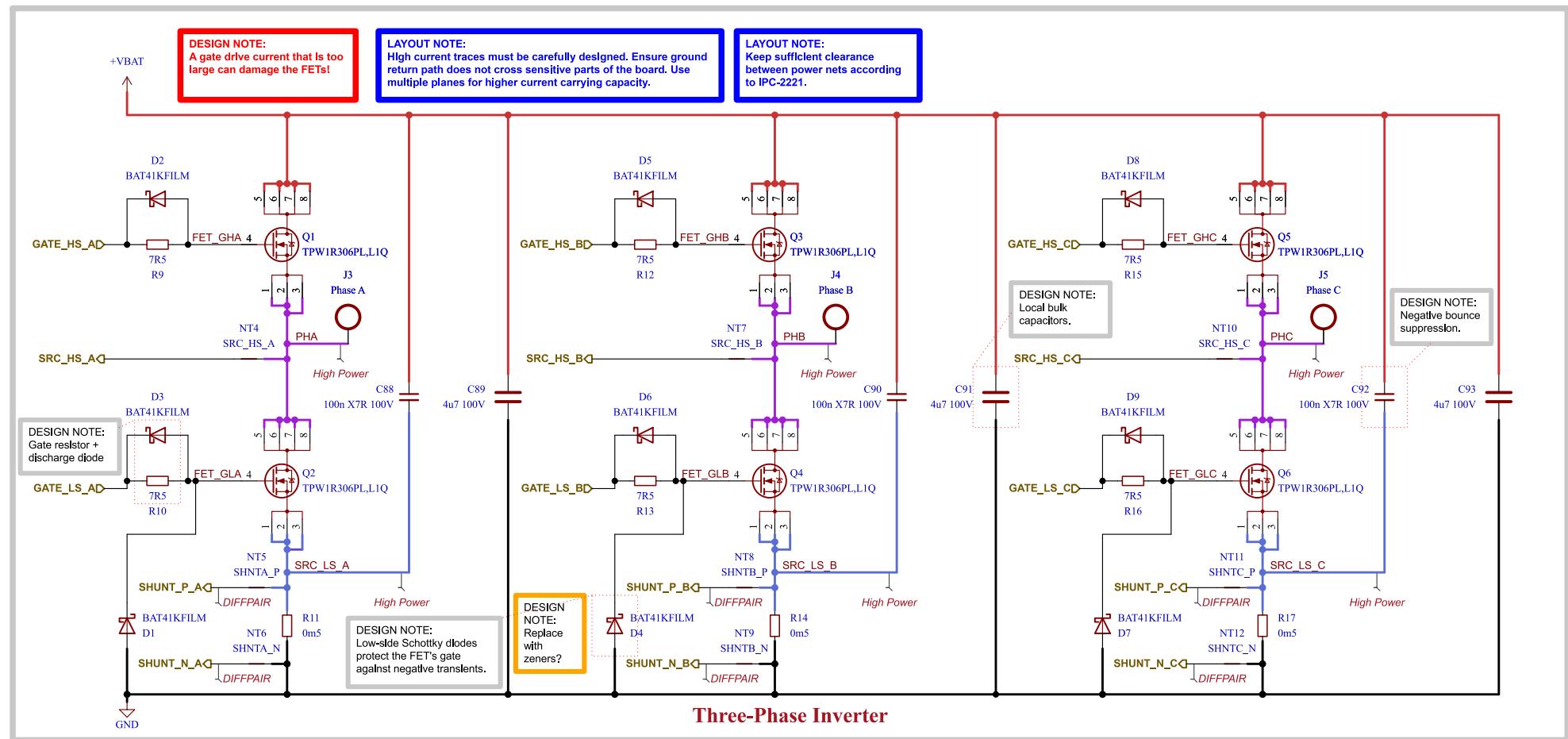
	Comments:   	Company: EPFL Xplore Research 	Variant: Preliminary
	Project Name: <b>Chienpanzée</b>	Board Name: <b>γ Gamma Controller</b>	
	Sheet Title: Power - Connectors	File Name: PowerConnectors.kicad_sch	Designer: Vincent Nguyen
	Sheet Path: /Project Architecture/Power - Connectors/	Reviewer:	Date: 2023-10-14      Revision: 1.0

# [8] Motor Control - Top Level



	Comments:	Company: EPFL Xplore Research	Variant: Preliminary
	Project Name: <b>Chienpanzée</b>	Board Name: <b>y Gamma Controller</b>	
	Sheet Title: Motor Control - Top Level	File Name: MotorControl.kicad_sch	Designer: Vincent Nguyen
	Sheet Path: /Project Architecture/Motor Control - Top Level/	Reviewer:	Date: 2023-10-16 Revision: 1.0

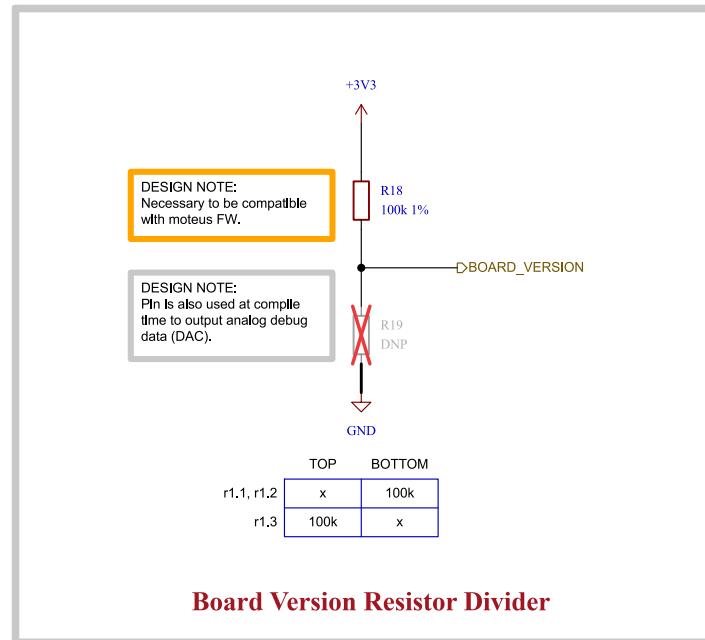
# [9] Motor Control - Inverter



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

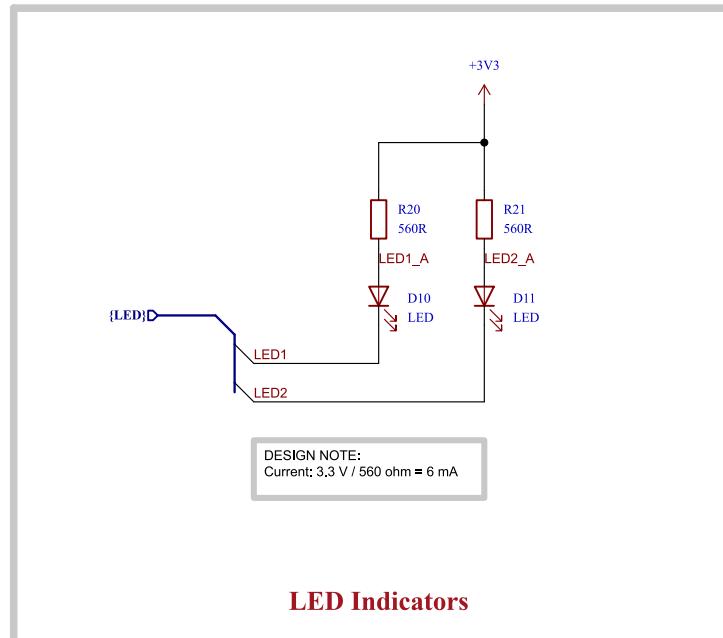
Comments:	Company: EPFL Xplore Research	Variant: Preliminary
Project Name: <b>Chienpanzée</b>	Board Name: <b>y Gamma Controller</b>	
Sheet Title: Motor Control - Inverter	File Name: MotorControl_ThreePhaseInverter.kicad_wl	Designer: Volent Nguyen
Sheet Path: /Project Architecture/Motor Control - Top Level/Motor Control - Inverter/	Reviewer:	Date: 2023-10-18
	Size: <b>A4</b>	Sheet: <b>9</b> of 21

# [10] Misc - Board Version Divider



	Comments:	Company: EPFL Xplore Research		Variant: Preliminary	
		Project Name: <b>Chienpanzée</b>		Board Name: <b>y Gamma Controller</b>	
	Sheet Title: Misc - Board Version Divider	File Name: BoardVersionDivider.kicad_sch	Designer: Vincent Nguyen	Date: 2023-10-14	Revision: 1.0
	Sheet Path: <i>/Project Architecture/Misc - Board Version Divider, DAC/</i>		Reviewer:	Size: <b>A4</b>	Sheet: <b>10 of 21</b>

# [11] User - LED Indicators



	Comments:	Company: EPFL Xplore Research	Variant: Preliminary
	Project Name: <b>Chienpanzée</b>	Board Name: <b>γ Gamma Controller</b>	
	Sheet Title: User - LED Indicators	File Name: LEDIndicators.kicad_sch	Designer: Vincent Nguyen
	Sheet Path: <a href="/Project Architecture/User - LED Indicators/">/Project Architecture/User - LED Indicators/</a>	Reviewer:	Date: 2023-10-15 Revision: 1.0

# [12] Sensing - Temperature

A

B

C

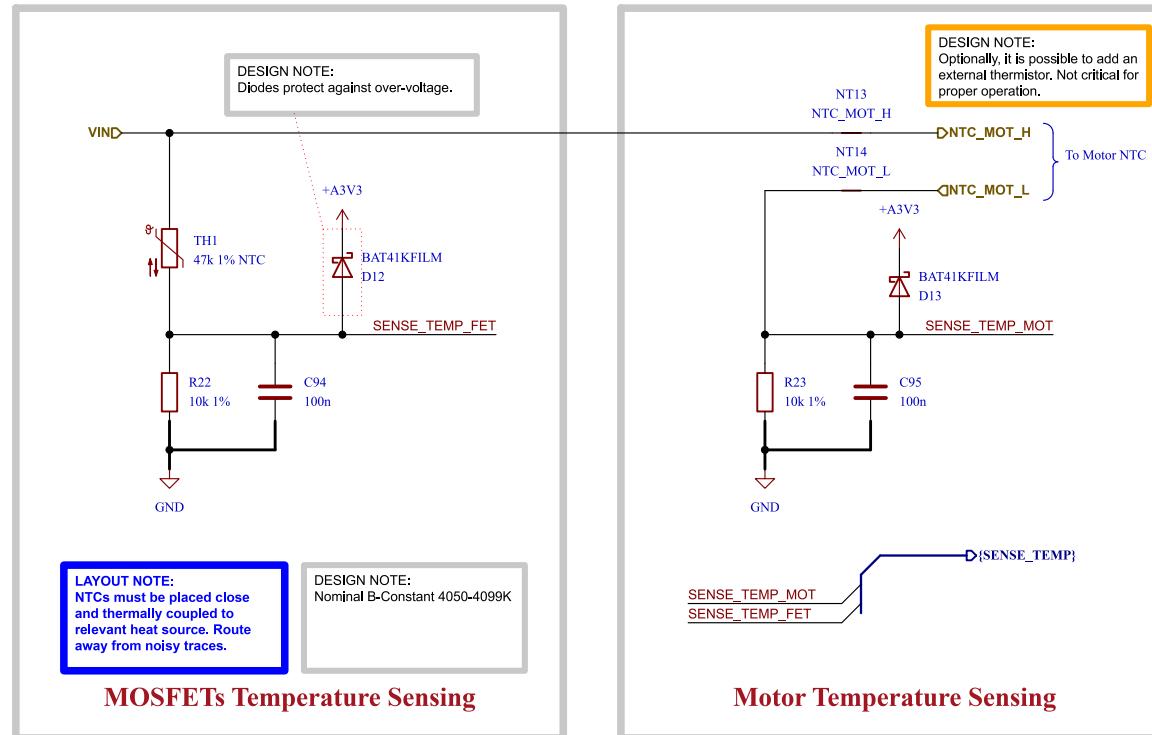
D

A

B

C

D



	Comments:	Company: EPFL Xplore Research	Variant: Preliminary
	Project Name: <b>Chienpanzée</b>	Board Name: <b>γ Gamma Controller</b>	
	Sheet Title: Sensing - Temperature	File Name: TemperatureSensing.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

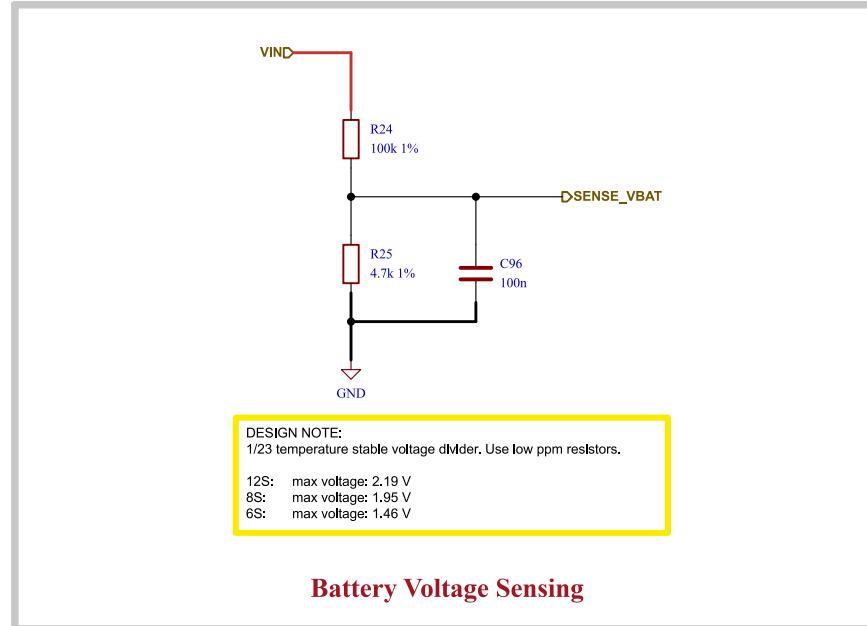
D

A

B

C

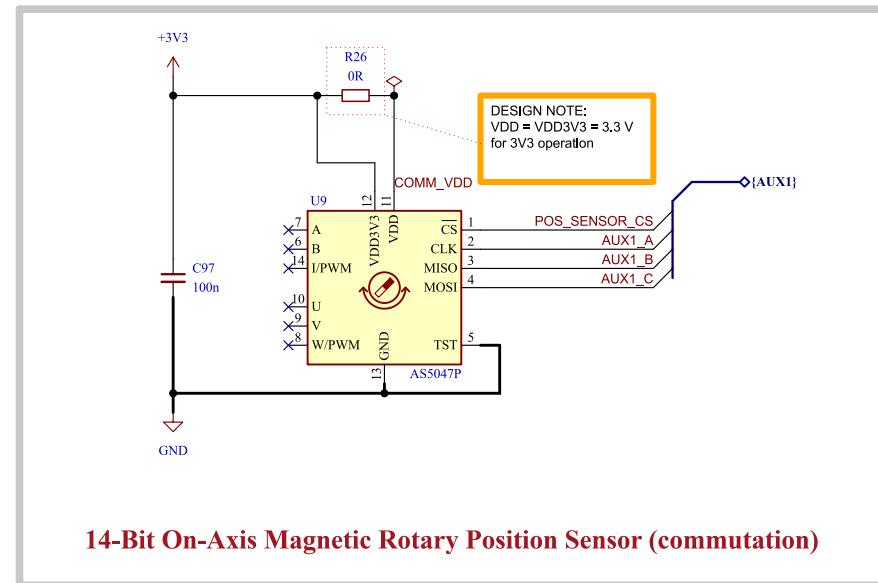
D



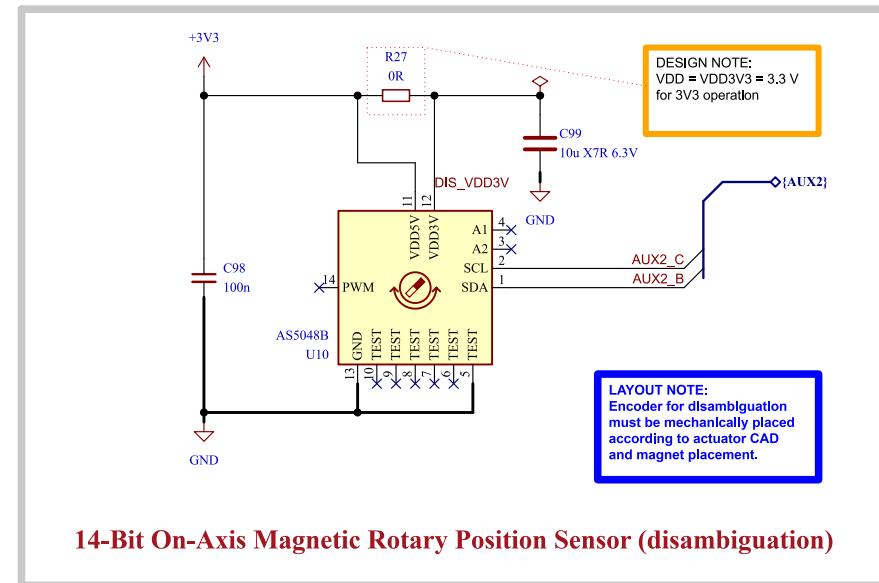
	Comments:	Company: EPFL Xplore Research	Variant: Preliminary
	Project Name: <b>Chienpanzée</b>		
	Sheet Title: Sensing - Battery	File Name: BatterySensing.kicad_sch	Designer: Vincent Nguyen
	Sheet Path: /Project Architecture/Sensing - Battery/	Reviewer:	Date: 2023-10-14 Revision: 1.0

# [14] Sensing - Position

A



B



C

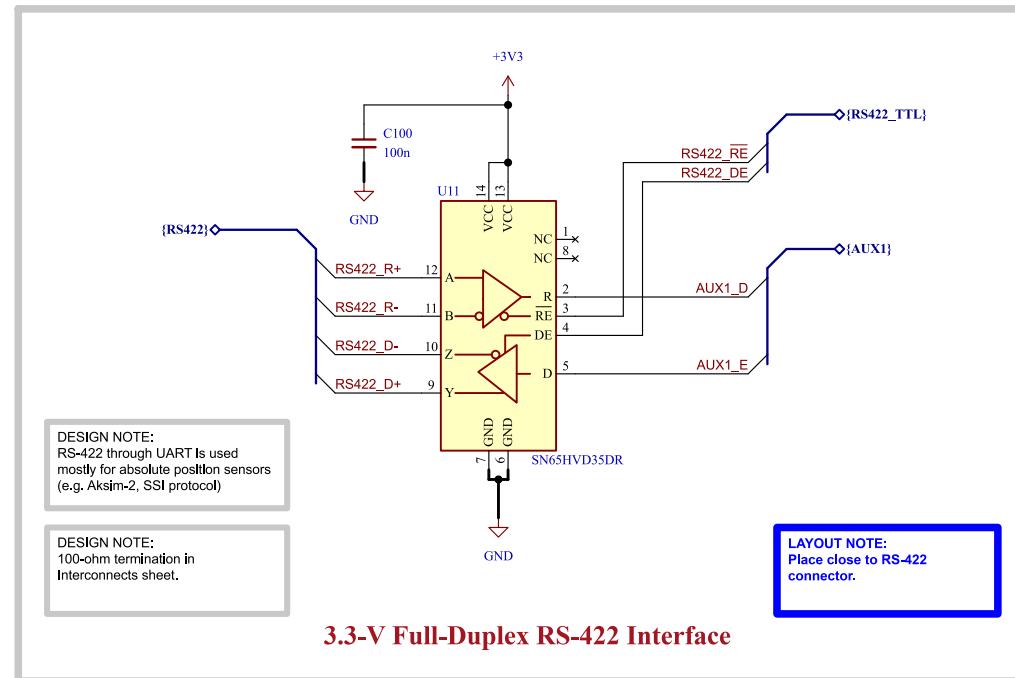
**DESIGN NOTE:**  
AS5047P senses magnet mounted on planetary sun gear, for commutation.  
AS5048B senses magnet mounted on shaft with same reduction factor as planetary gearbox for disambiguation.

**DESIGN NOTE:**  
The encoder for disambiguation cannot be used to estimate backlash!

D

Comments:	Company: EPFL Xplore Research	Variant: Preliminary	
Project Name: <b>Chienpanzée</b>	Board Name: <b>γ Gamma Controller</b>		
Sheet Title: Sensing - Position	File Name: PositionSensors.kicad_sch	Designer: Vincent Nguyen	Date: 2023-10-14
Sheet Path: /Project Architecture/Sensing - Position/	Reviewer:	Size: <b>A4</b>	Revision: 1.0

# [15] Interface - RS-422



A

A

B

B

C

C

D

D

1

2

3

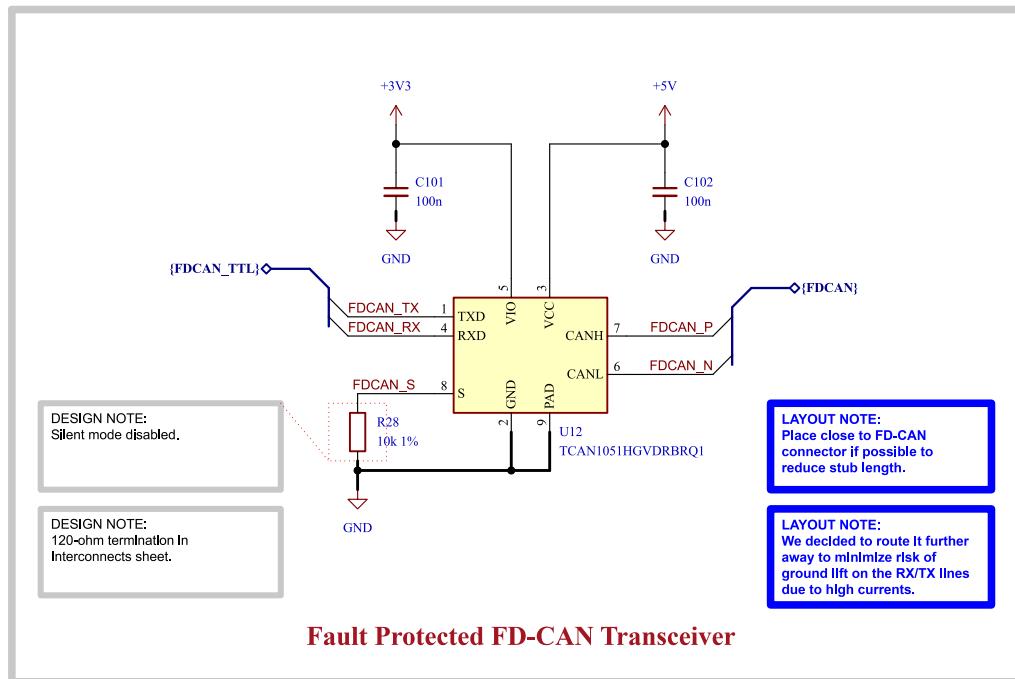
4

5

6

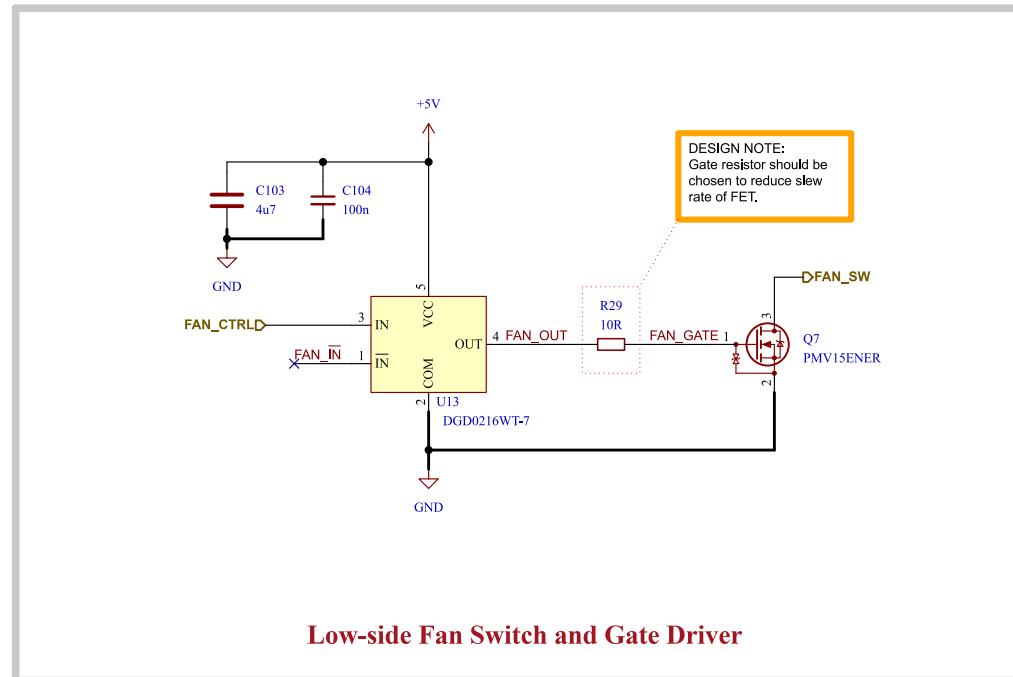
	Comments:	Company: EPFL Xplore Research	Variant: Preliminary
	Project Name: <b>Chienpanzée</b>	Board Name: <b>γ Gamma Controller</b>	
	Sheet Title: Interface - RS-422	File Name: RS422Interface.kicad_sch	Designer: Vincent Nguyen
	Sheet Path: /Project Architecture/Interface - RS-422/	Reviewer:	Date: 2023-10-15 Revision: 1.0

# [16] Interface - FD-CAN



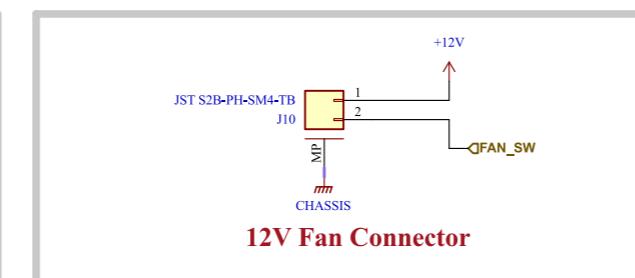
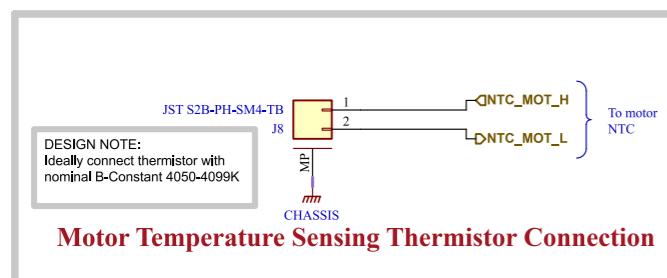
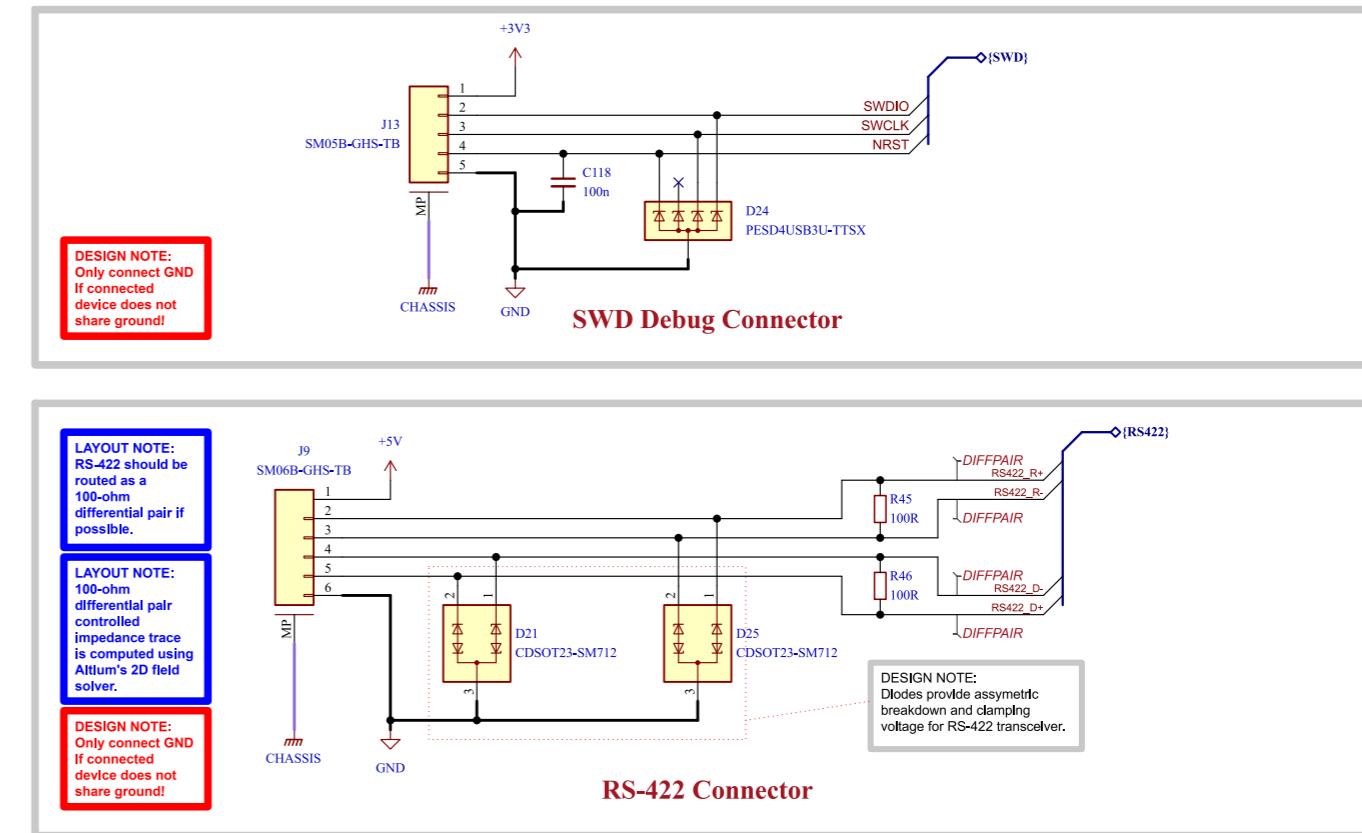
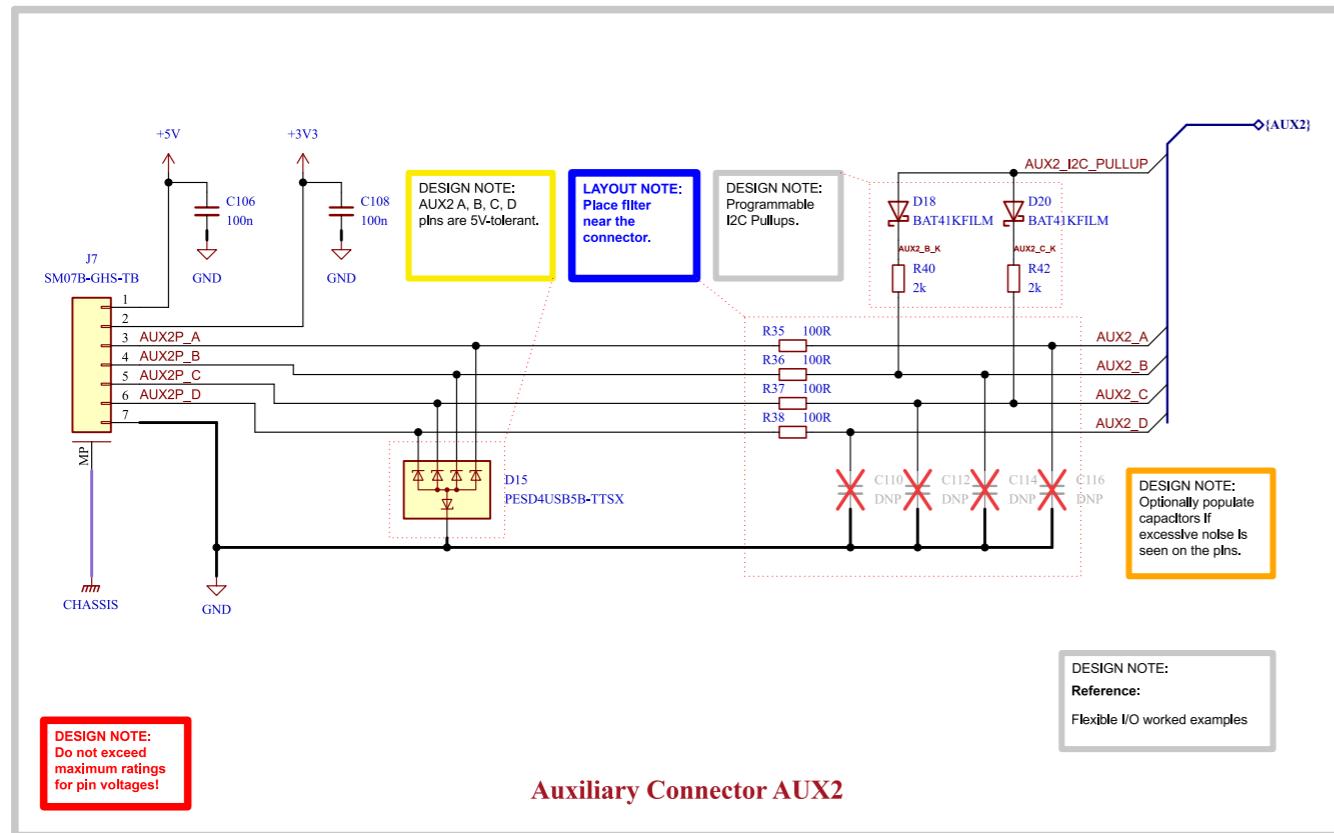
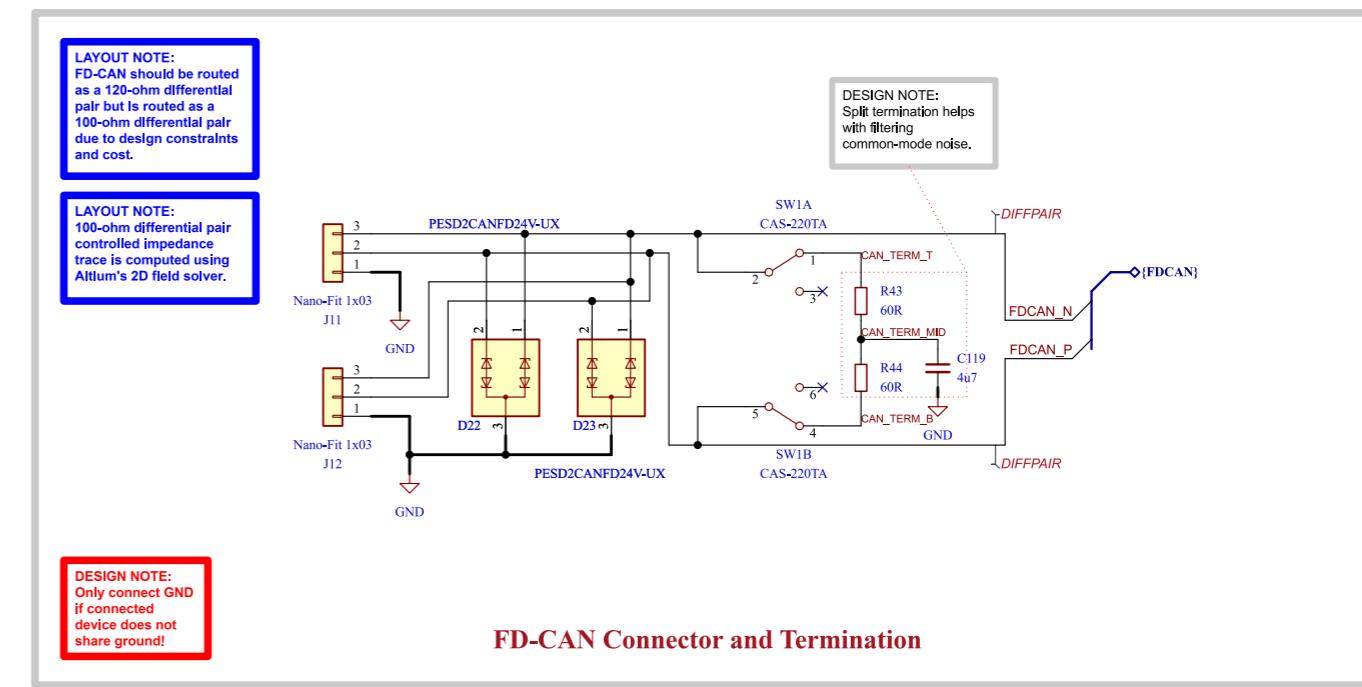
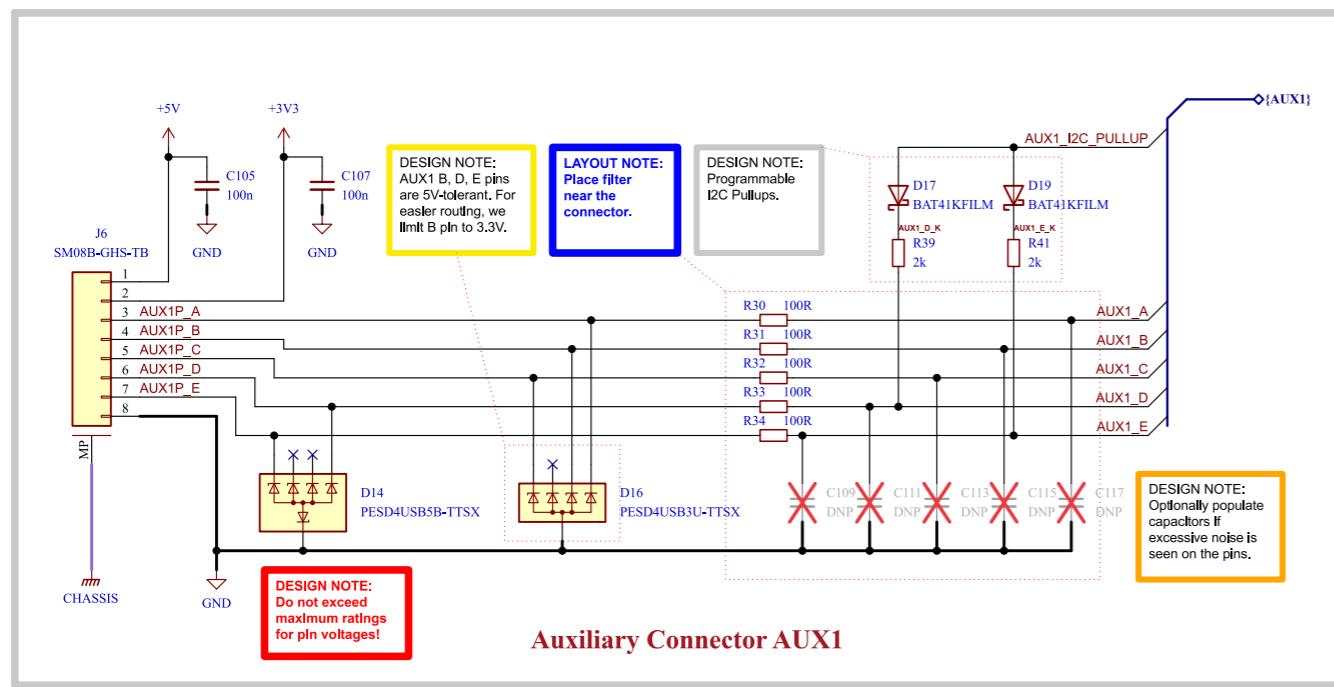
	Comments:	Company: EPFL Xplore Research	Variant: Preliminary
	Project Name: <b>Chienpanzée</b>	Board Name: <b>γ Gamma Controller</b>	
	Sheet Title: Interface - FD-CAN	File Name: FDCANTransceiver.kicad_sch	Designer: Vincent Nguyen
	Sheet Path: /Project Architecture/Interface - FD-CAN/	Reviewer:	Date: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

# [17] Interface - Fan Control



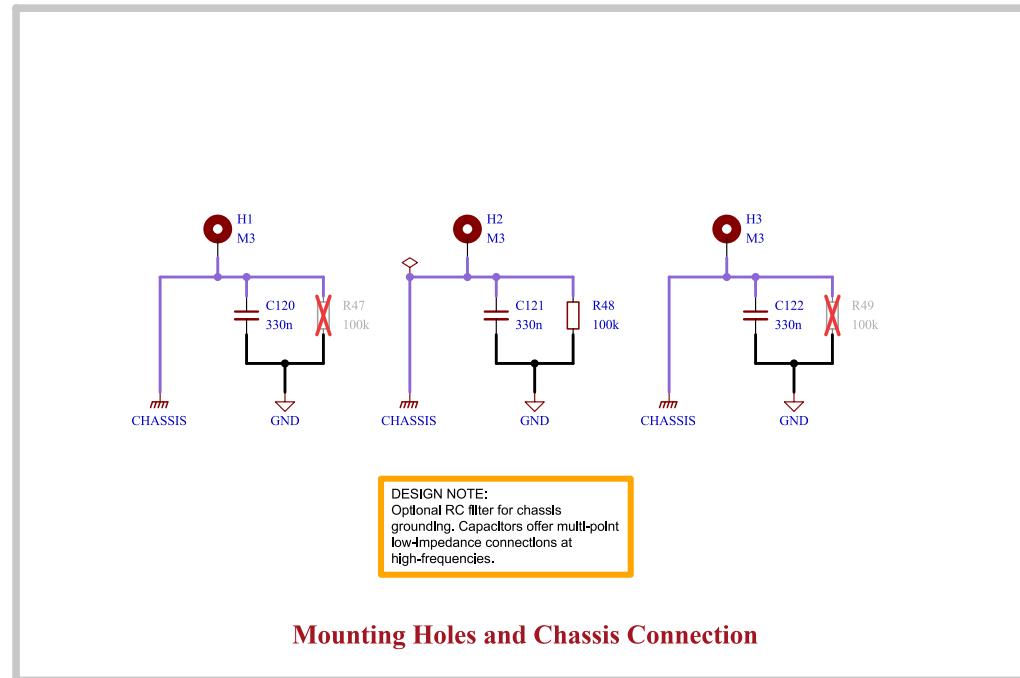
	Comments:	Company: EPFL Xplore Research	Variant: Preliminary
	Project Name: <b>Chienpanzée</b>	Board Name: <b>γ Gamma Controller</b>	
	Sheet Title: Interface - Fan Control	File Name: FanControl.kicad_sch	Designer: Vincent Nguyen
	Sheet Path: <a href="#">/Project Architecture/Interface - Fan Control/</a>	Reviewer:	Date: 2023-11-19
		Size: <b>A4</b>	Revision: 1.0
			Sheet: <b>17</b> of <b>21</b>

# [18] Interface - Interconnects



	Comments:	Company: <b>EPFL Xplore Research</b>	 xplore	Variant: Preliminary
		Project Name: <b>Chienpanzée</b>	Board Name: <b>y Gamma Controller</b>	
	<b>Sheet Title:</b> Interface - Interconnects	<b>File Name:</b> Interconnects.kicad_sch	<b>Designer:</b> Vincent Nguyen	<b>Date:</b> 2023-10-14 <b>Revision:</b> 1.0
<b>Sheet Path:</b> /Project Architecture/Interface - Interconnects/		<b>Reviewer:</b>	<b>Size:</b> <b>A3</b>	<b>Sheet:</b> <b>18</b> of <b>21</b>

# [19] Mechanical - Holes



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

# [20] Power Sequencing

A

A

B

B

C

C

D

D

	Comments:	Company: EPFL Xplore Research	Variant: Preliminary
	Project Name: <b>Chienpanzée</b>		Board Name: <b>γ Gamma Controller</b>
	Sheet Title: Power Sequencing	File Name: PowerSequencing.kicad_sch	Designer: Vincent Nguyen
	Sheet Path: /Power Sequencing/	Reviewer:	Date: 1.0
		Size: <b>A4</b>	Sheet: <b>20 of 21</b>

# [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
- 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

A

B

B

C

C

D

D

	Comments:	Company: EPFL Xplore Research		Variant: Preliminary	
		Project Name: <b>Chienpanzée</b>		Board Name: <b>γ Gamma Controller</b>	
	Sheet Title: Revision History	File Name: RevisionHistory.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>