

Amulet Motion Controller

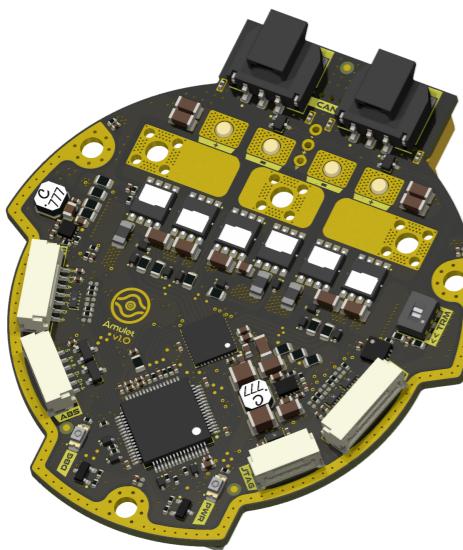
Variant: Preliminary

2023-12-23

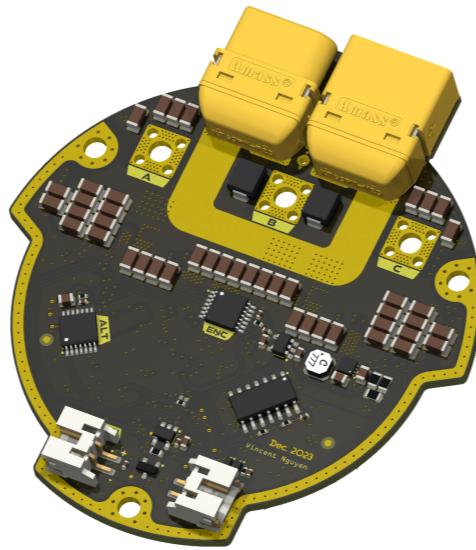
Rev 1.0

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	Misc - Holes, Fiducials	29	39
10	Misc - Board Version, DAC	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 Dec. 23rd 2023

DESIGN CONSIDERATIONS

DESIGN NOTE:
Example text for informational design notes.

DESIGN NOTE:
Example text for debug notes.

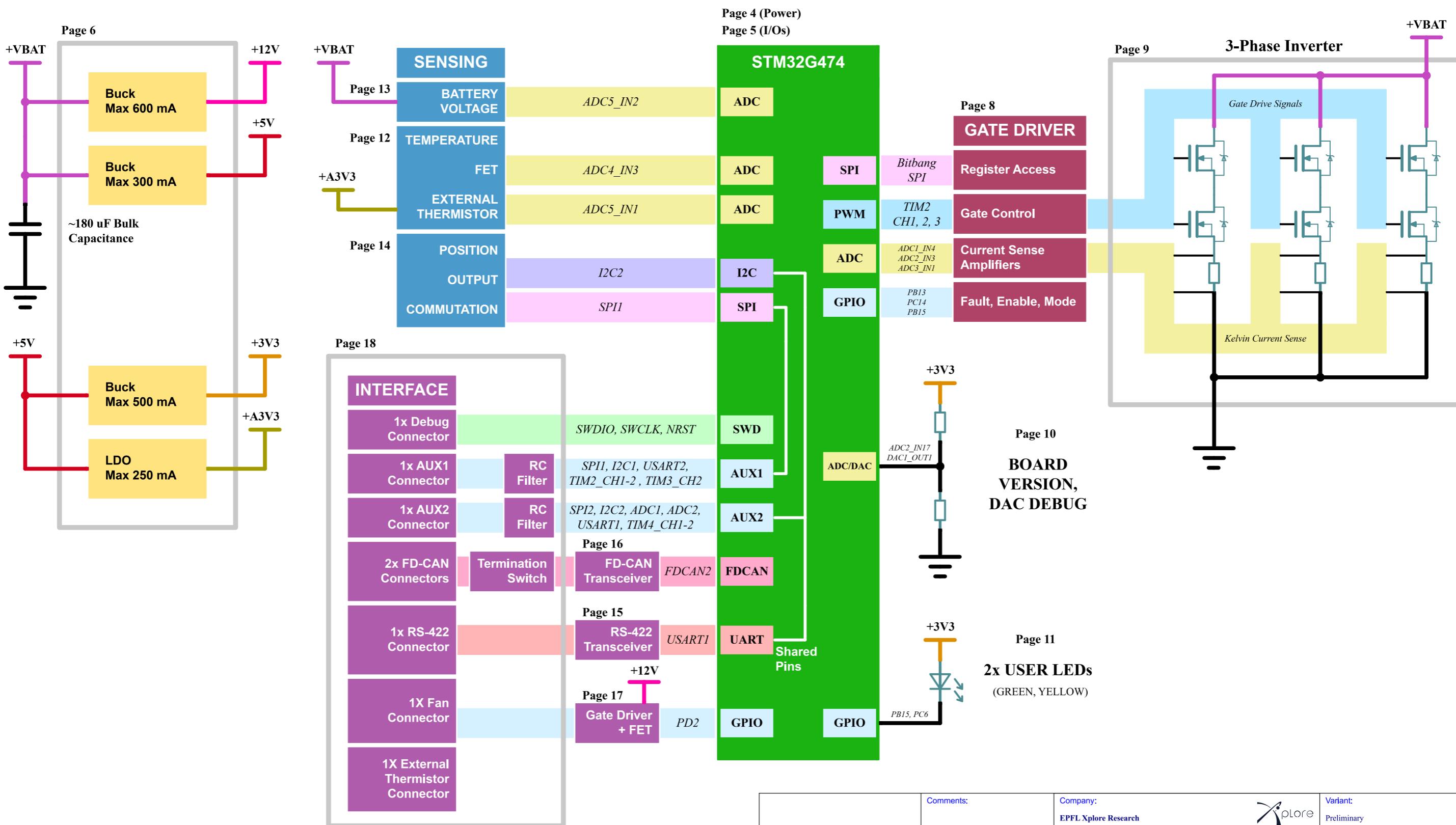
DESIGN NOTE:
Example text for cautionary design notes.

DESIGN NOTE:
Example text for critical design notes.

LAYOUT NOTE:
Example text for critical layout guidelines.

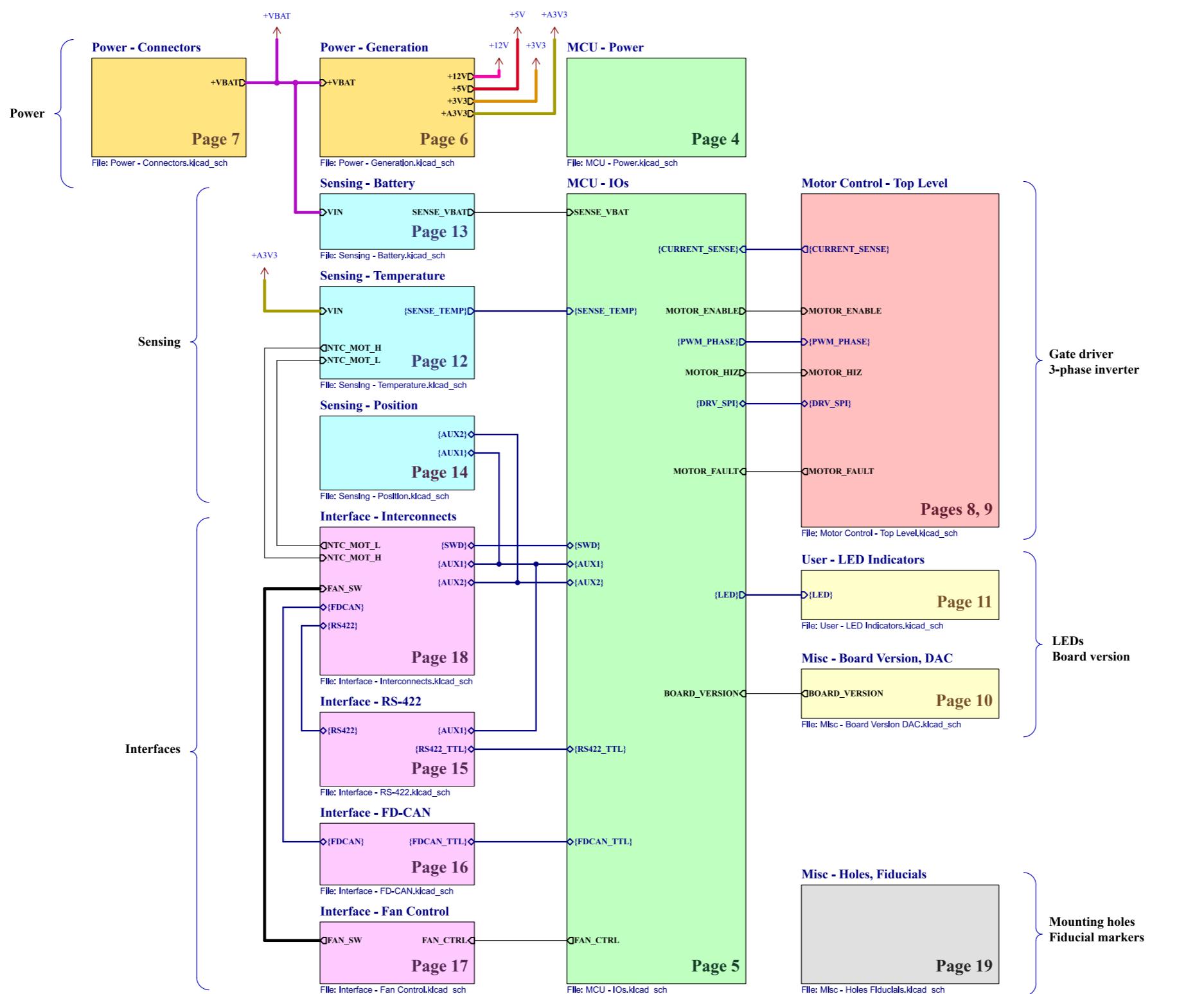
	Comments:	Company: EPFL Xplore Research	Variant: Preliminary
	Board Name: Amulet Motion Controller	Project Name: Chienpanzé	
	Sheet Title: Cover Page	File Name: amulet_controller.kicad_sch	Designer: Vincent Nguyen
	Sheet Path: /	Reviewer:	Date: 2023-12-23 Revision: 1.0
		Size: A3	Sheet: 1 of 21

[2] Block Diagram



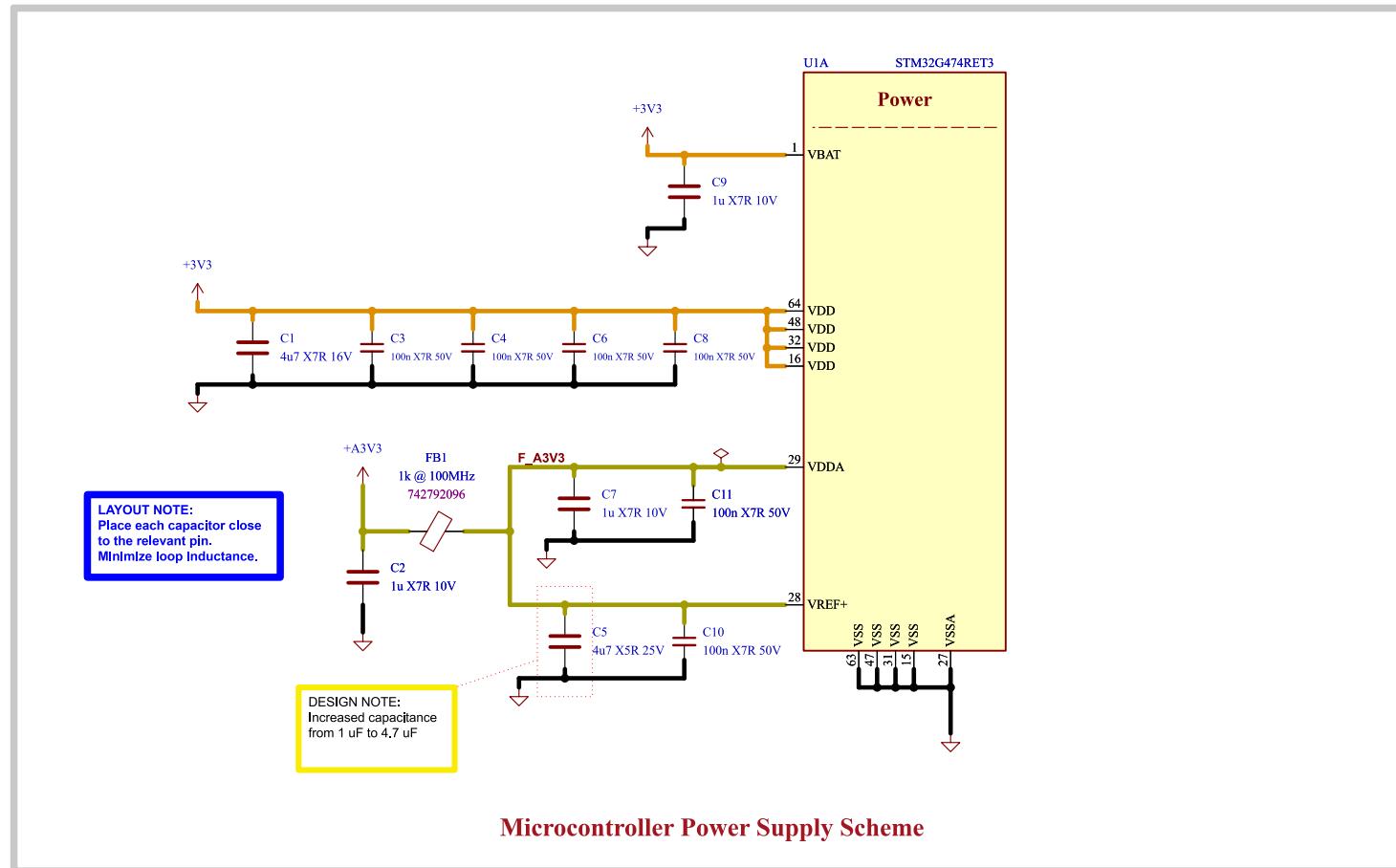
	Comments:	Company: EPFL Xplore Research	Variant: Preliminary
	Board Name: Amulet Motion Controller		
	Project Name: Chienpanzé		
Sheet Title:	File Name:	Designer:	Date: 2023-12-20 Revision: 1.0
Block Diagram	Block Diagram.kicad_sch	Vincent Nguyen	
Sheet Path:	/Block Diagram/	Reviewer:	Size: A3 Sheet: 2 of 21

[3] Project Architecture



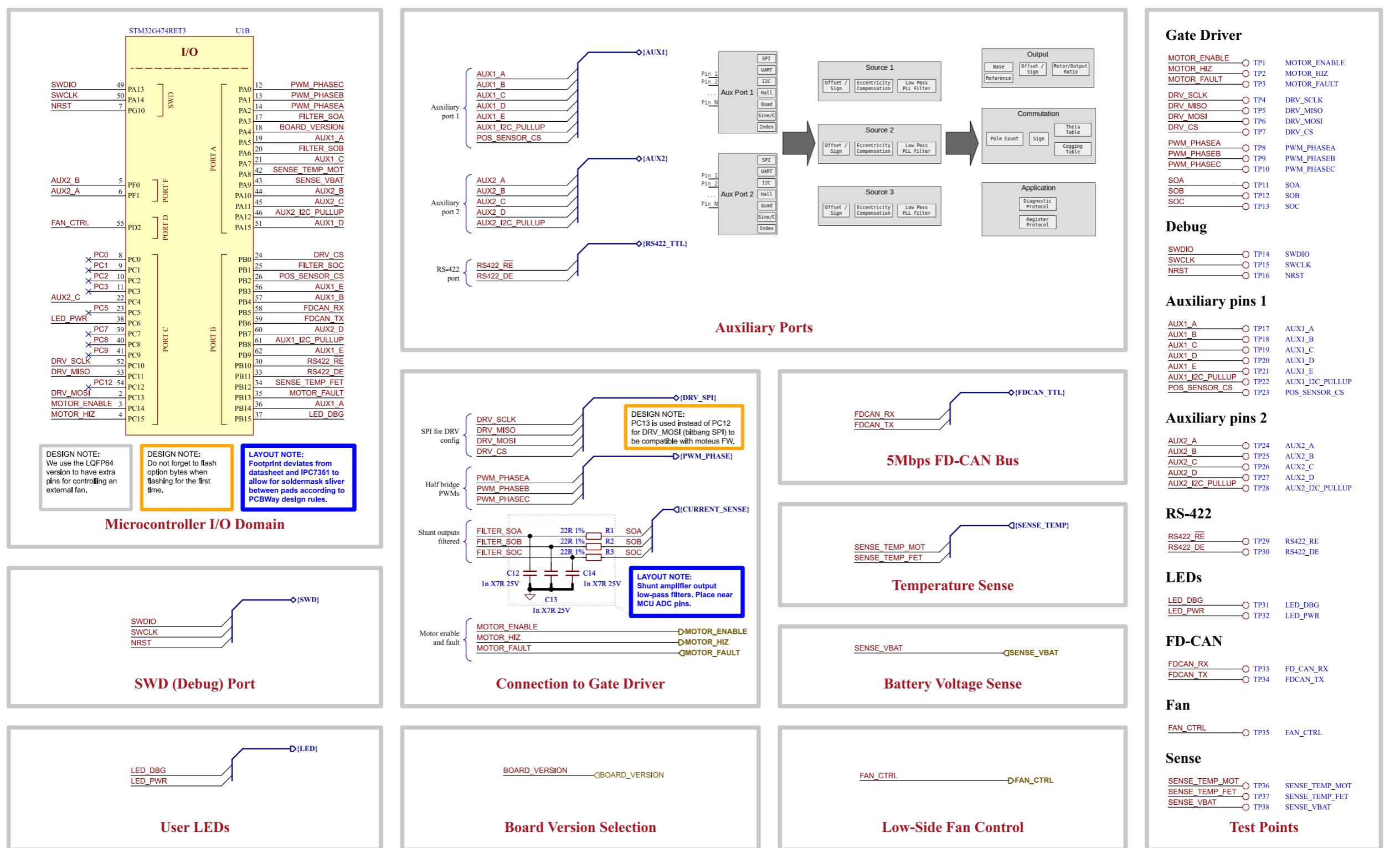
	Comments:	Company:		
		EPFL Xplore Research	Variant:	
	Board Name:	Amulet Motion Controller		Project Name:
	Chienpanzé		Date:	Revision:
	Sheet Title:	File Name:	Designer:	
	Project Architecture	Project Architecture.kicad_sch	Vincent Nguyen	2023-12-22 1.0
	Sheet Path:	Reviewer:		Size: A3 Sheet: 3 of 21
	/Project Architecture/			

[4] MCU - Power



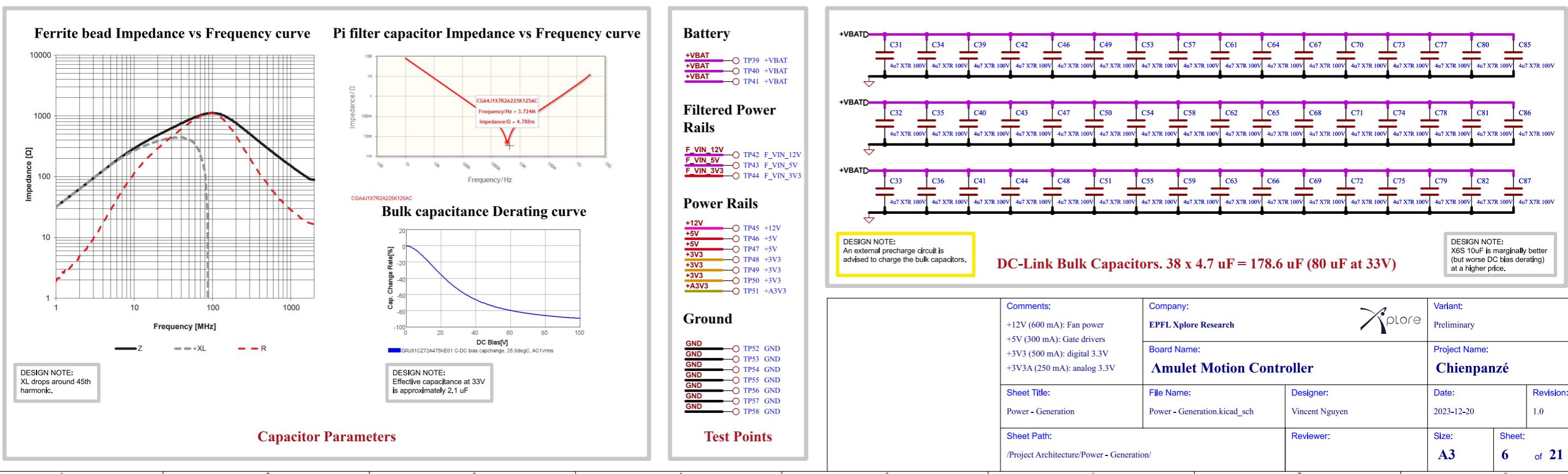
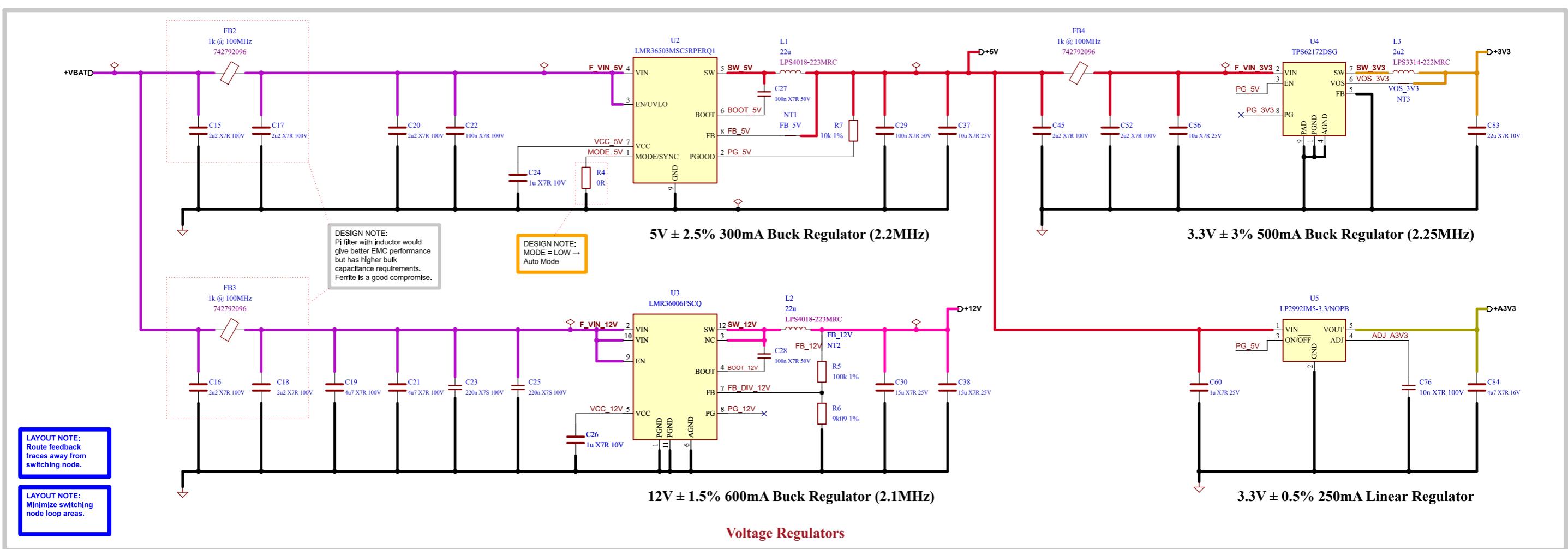
	Comments: AN5346 STM32G474 Datasheet p.81 J. Pieper ADC investigation	Company: EPFL Xplore Research	Variant: Preliminary
	Board Name: Amulet Motion Controller		
	Sheet Title: MCU - Power	File Name: MCU - Power.kicad_sch	Designer: Vincent Nguyen
	Sheet Path: /Project Architecture/MCU - Power/	Reviewer: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

[5] MCU - I/Os

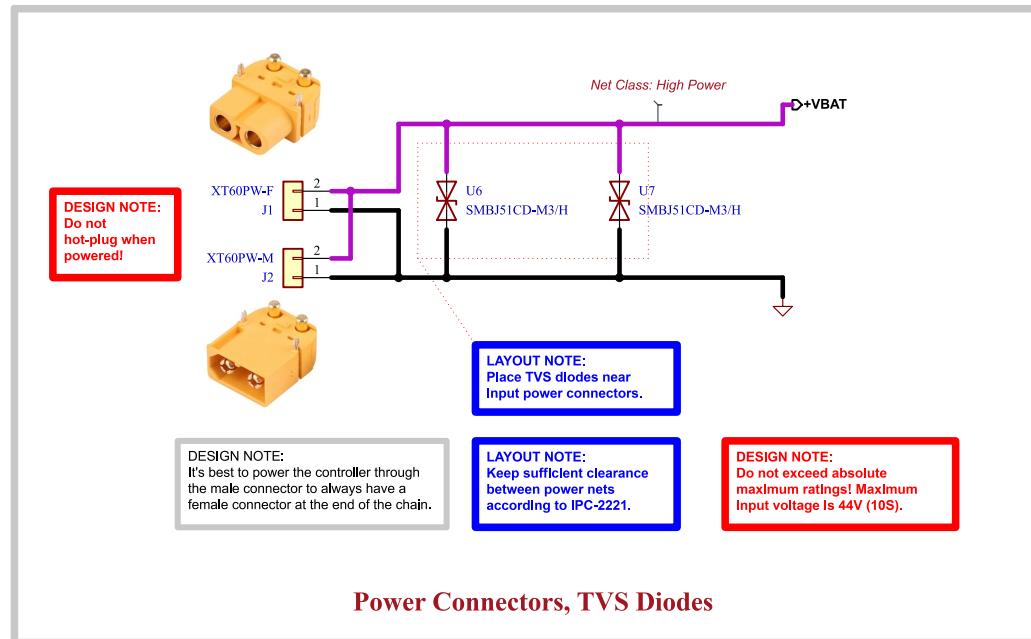


Comments: References: Flexible I/O worked examples Flexible I/O source configuration	Company: EPFL Xplore Research		Variant: Preliminary
	Board Name: Amulet Motion Controller	Project Name: Chienpanzé	
Sheet Title: MCU - I/Os	File Name: MCU - IOs.kicad_sch	Designer: Vincent Nguyen	Date: 2023-12-20
Sheet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

[6] Power - Generation

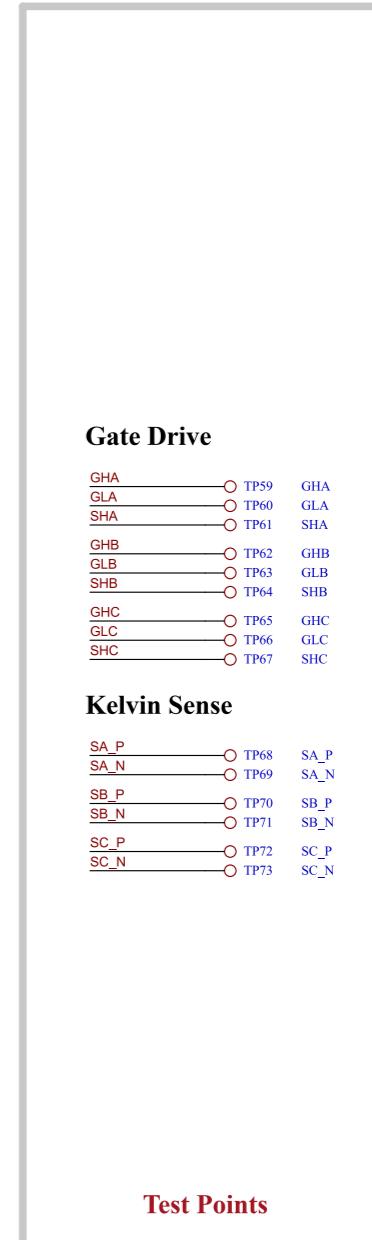
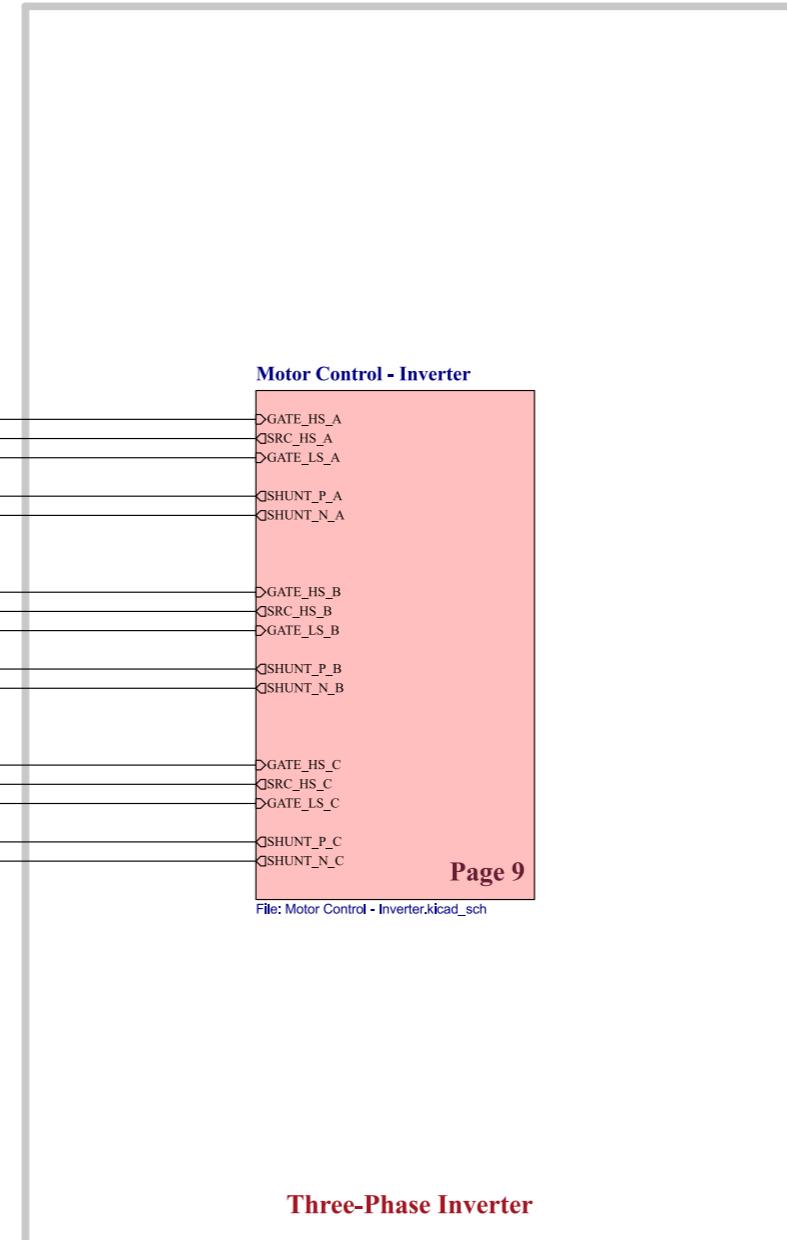
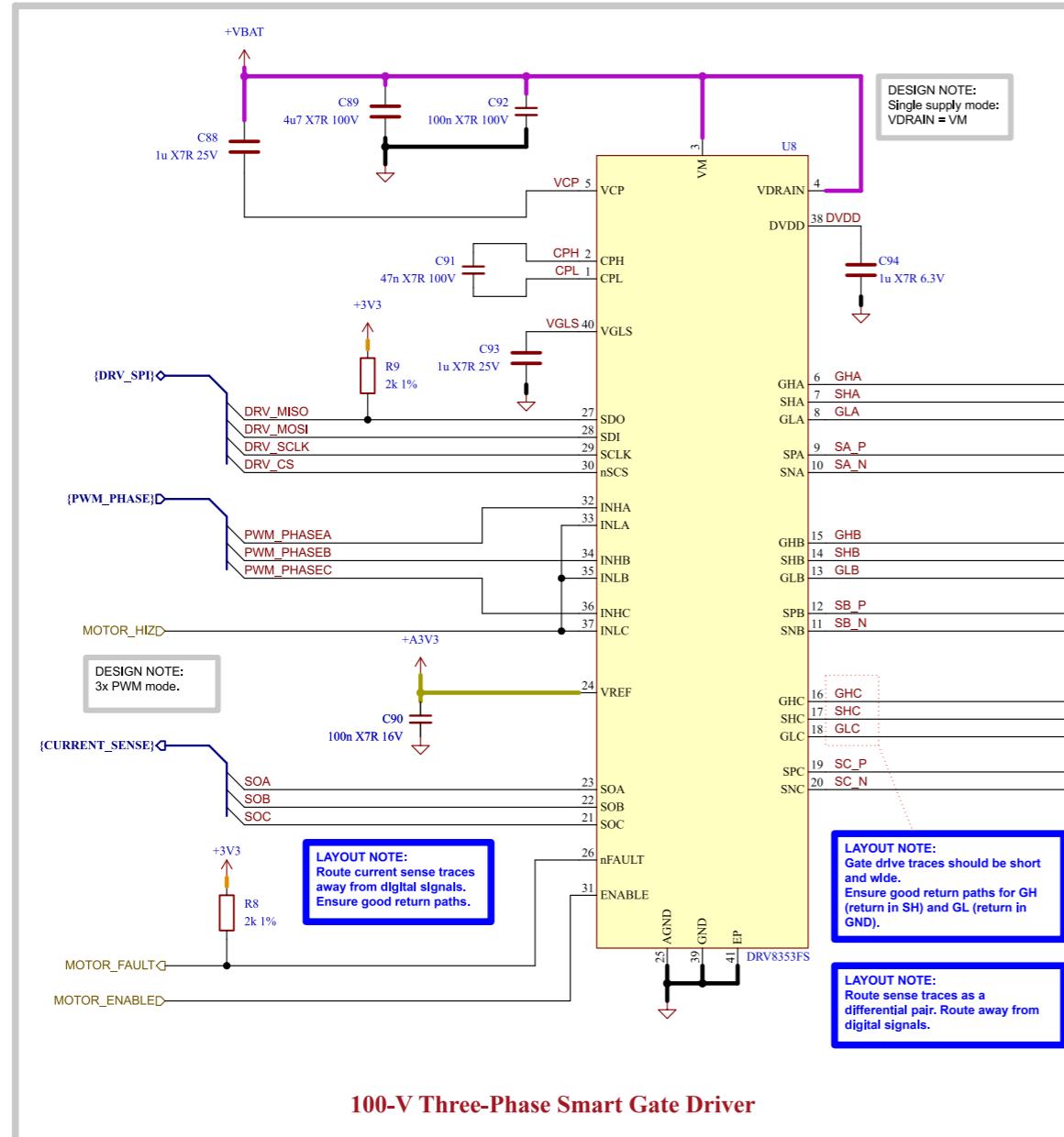


[7] Power - Connectors



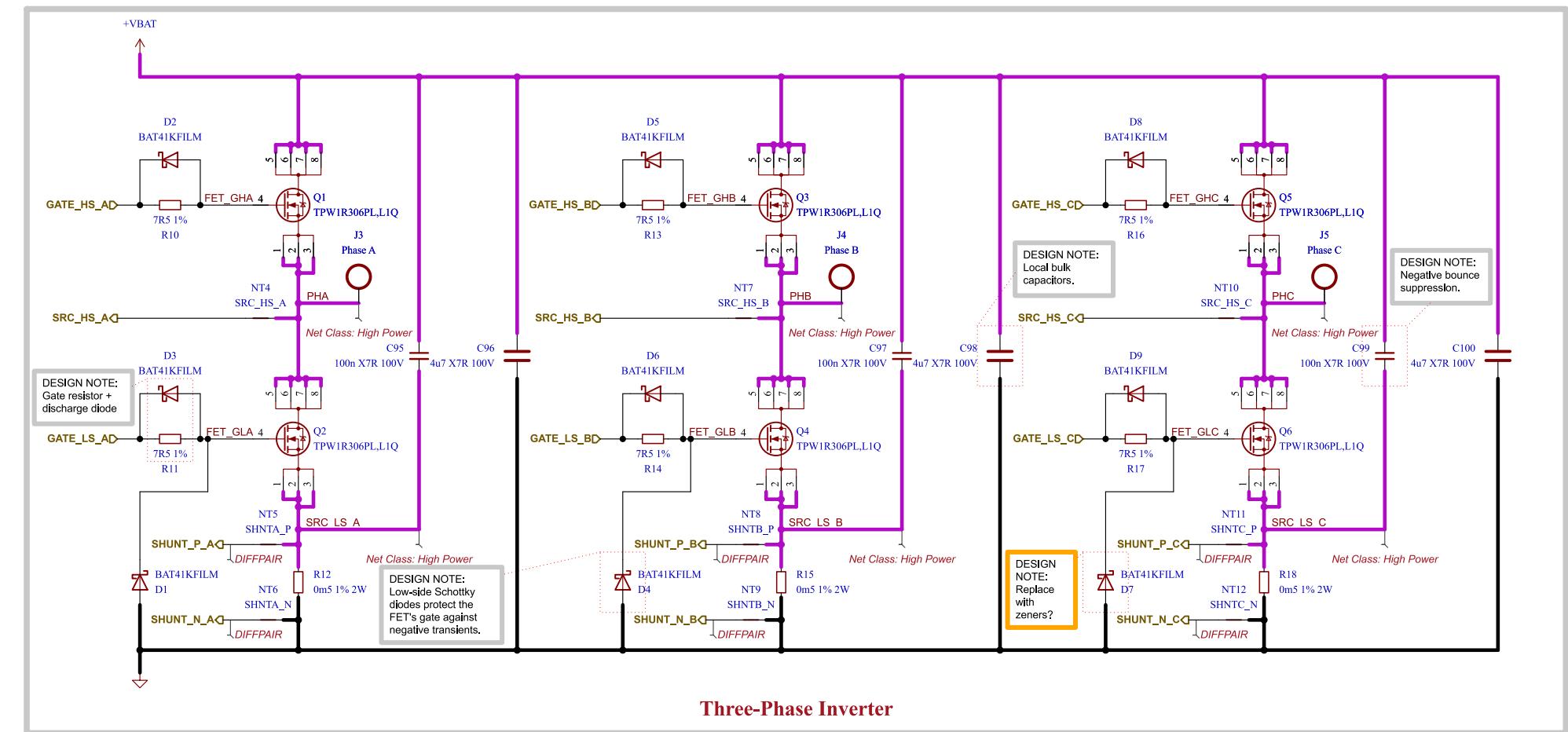
	Comments:	Company: EPFL Xplore Research	Variant: Preliminary
	Board Name: Amulet Motion Controller		
	Sheet Title: Power - Connectors	File Name: Power - Connectors.kicad_sch	Designer: Vincent Nguyen
	Sheet Path: /Project Architecture/Power - Connectors/	Reviewer:	Date: 2023-10-14 Revision: 1.0

[8] Motor Control - Top Level



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

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

Reviewer:

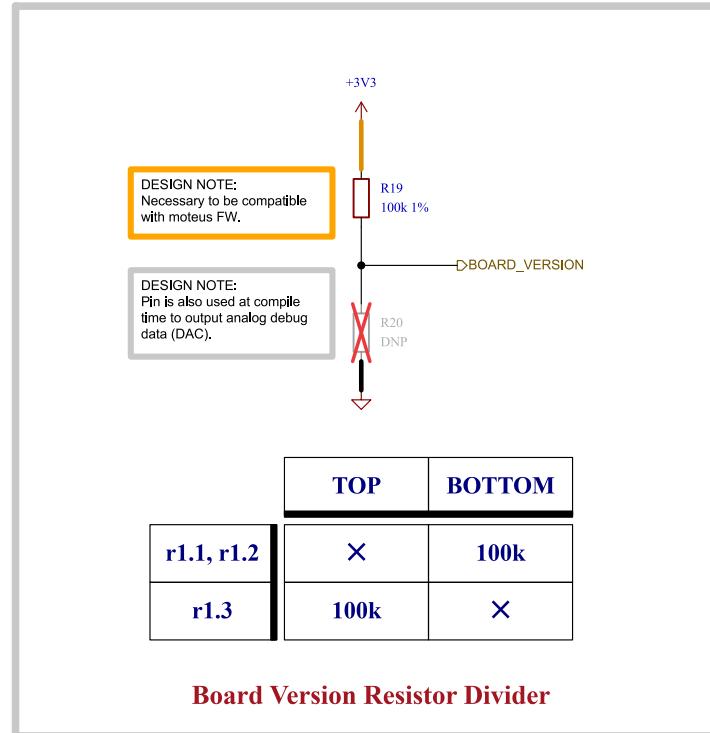
Size:

A4

Sheet:

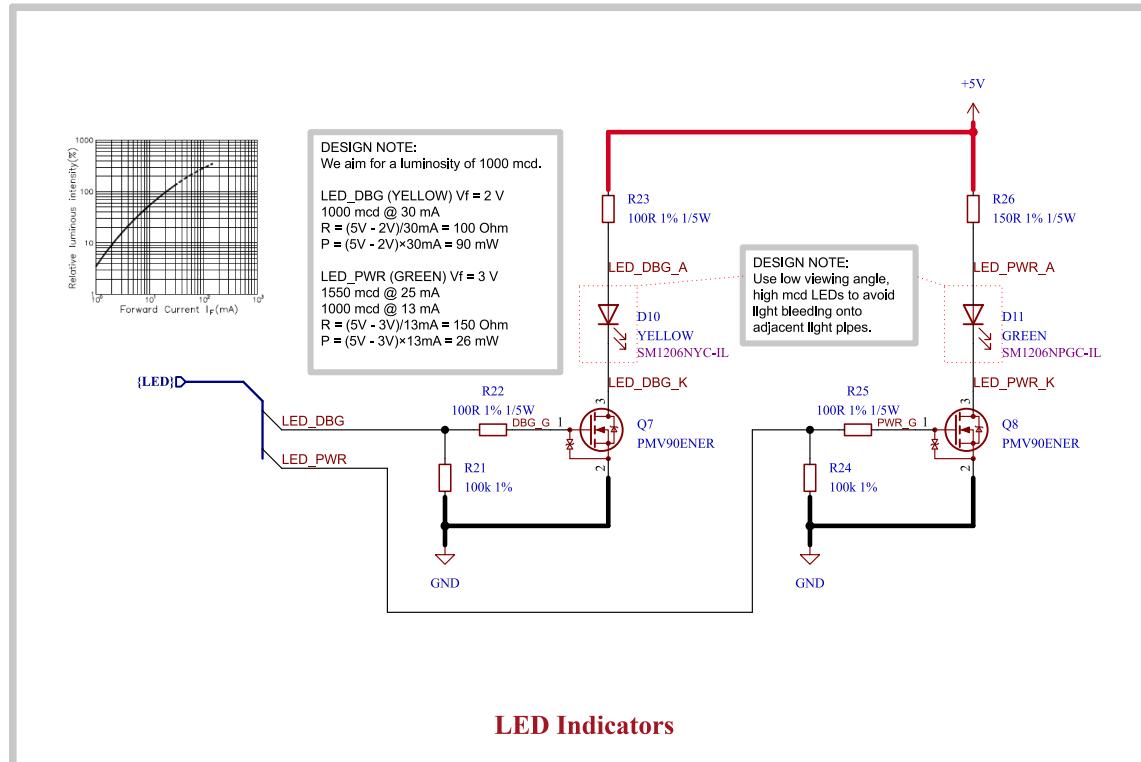
9 of 21

[10] Misc - Board Version, DAC



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

[11] User - LED Indicators



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

[12] Sensing - Temperature

A

B

C

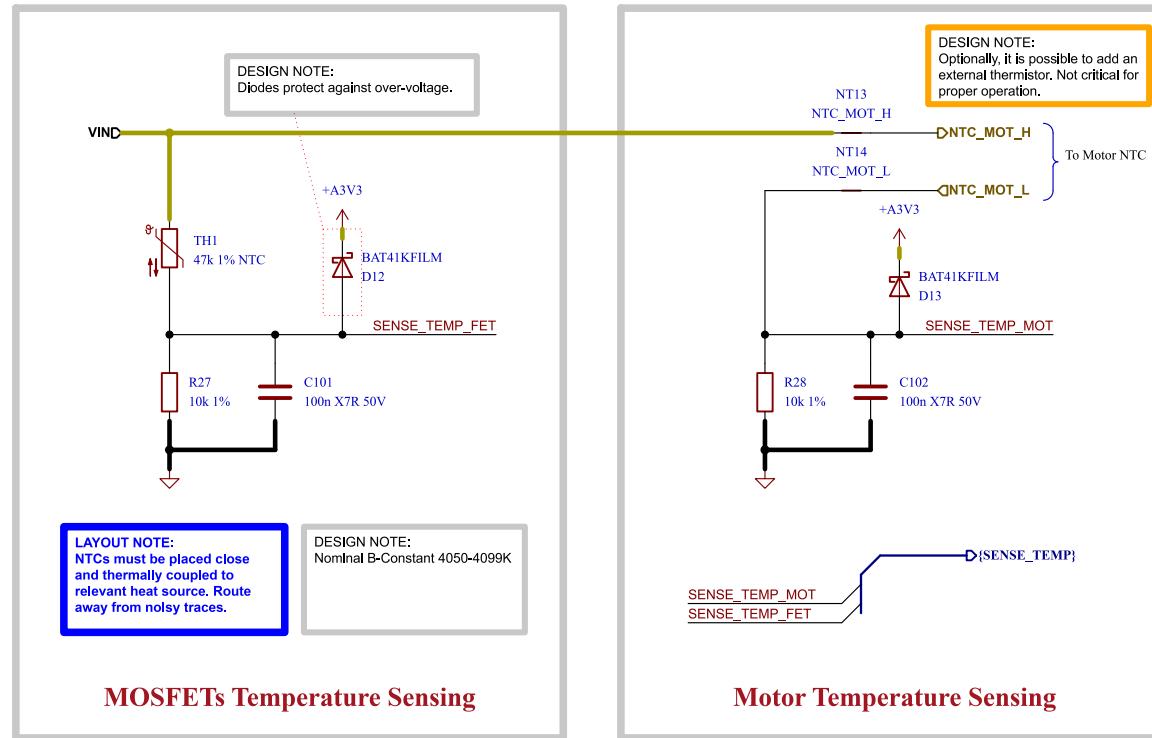
D

A

B

C

D



	Comments:	Company: EPFL Xplore Research	Variant: Preliminary
	Board Name: Amulet Motion Controller	Project Name: Chienpanzé	
	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

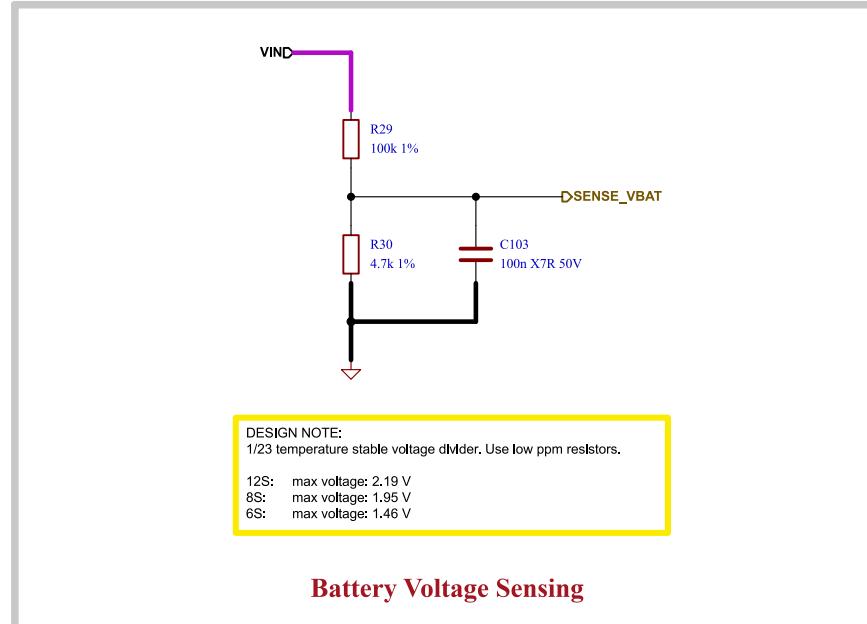
D

A

B

C

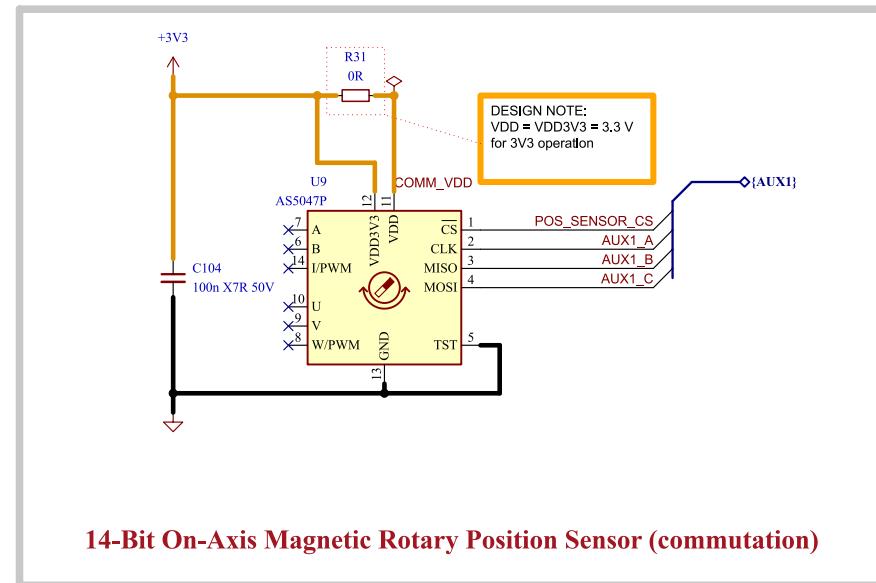
D



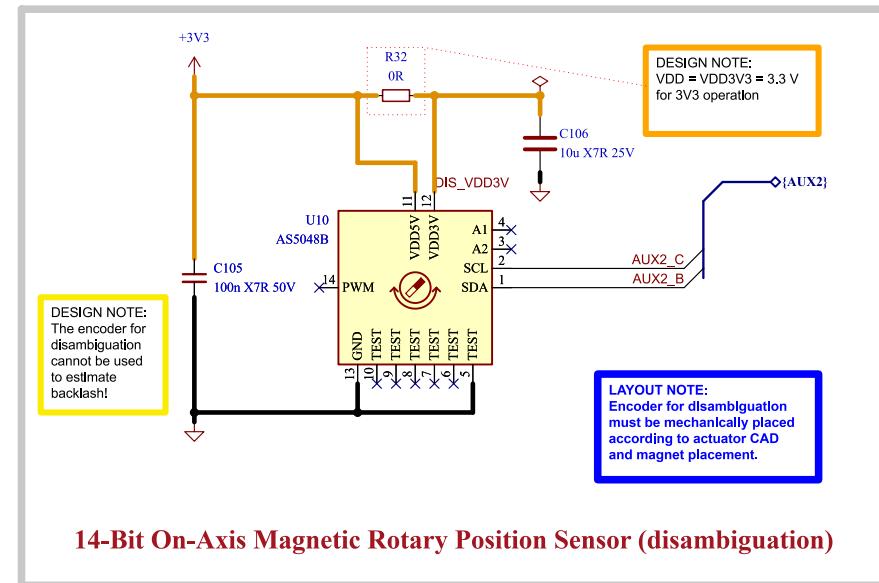
	Comments:	Company: EPFL Xplore Research	Variant: Preliminary
	Board Name: Amulet Motion Controller		
	Sheet Title: Sensing - Battery	File Name: Sensing - Battery.kicad_sch	Designer: Vincent Nguyen
	Sheet Path: /Project Architecture/Sensing - Battery/	Reviewer:	Date: 2023-10-14 Revision: 1.0
		Size: A4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

[14] Sensing - Position

A



B



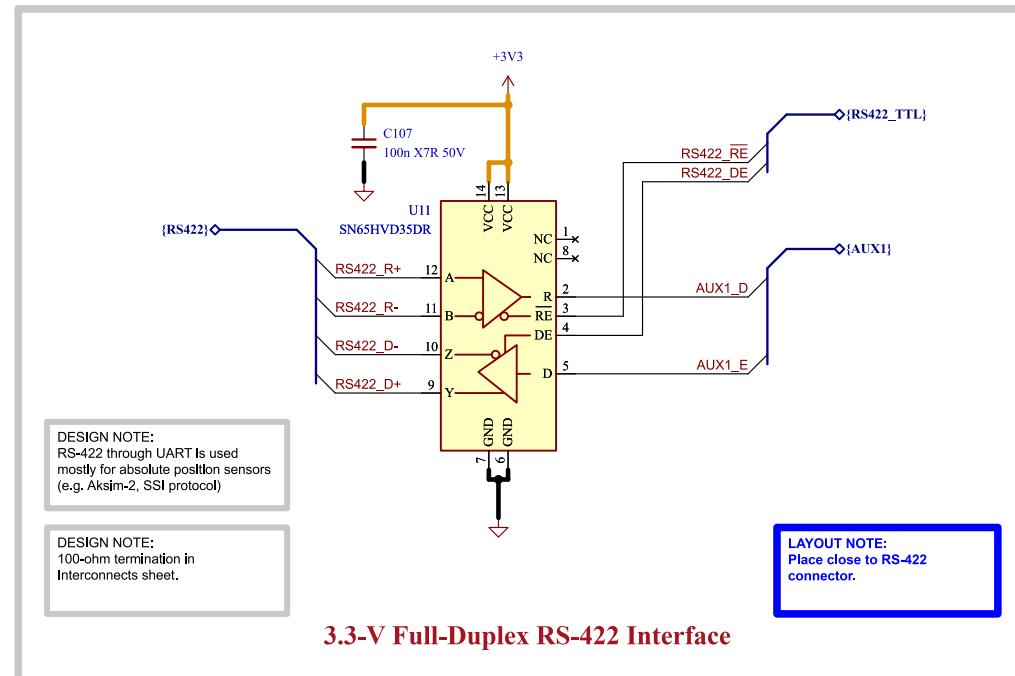
C

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

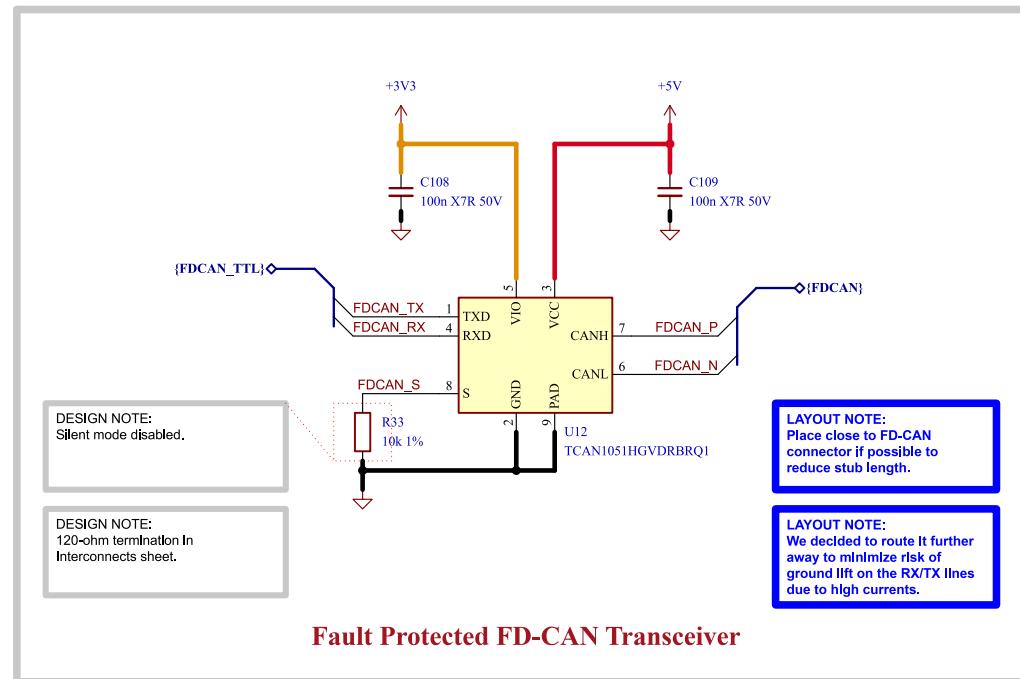
	Comments:	Company: EPFL Xplore Research	Variant: Preliminary
	Board Name: Amulet Motion Controller		
	Sheet Title: Sensing - Position	File Name: Sensing - Position.kicad_sch	Designer: Vincent Nguyen
	Sheet Path: /Project Architecture/Sensing - Position/	Reviewer:	Date: 2023-10-14 Revision: 1.0

[15] Interface - RS-422



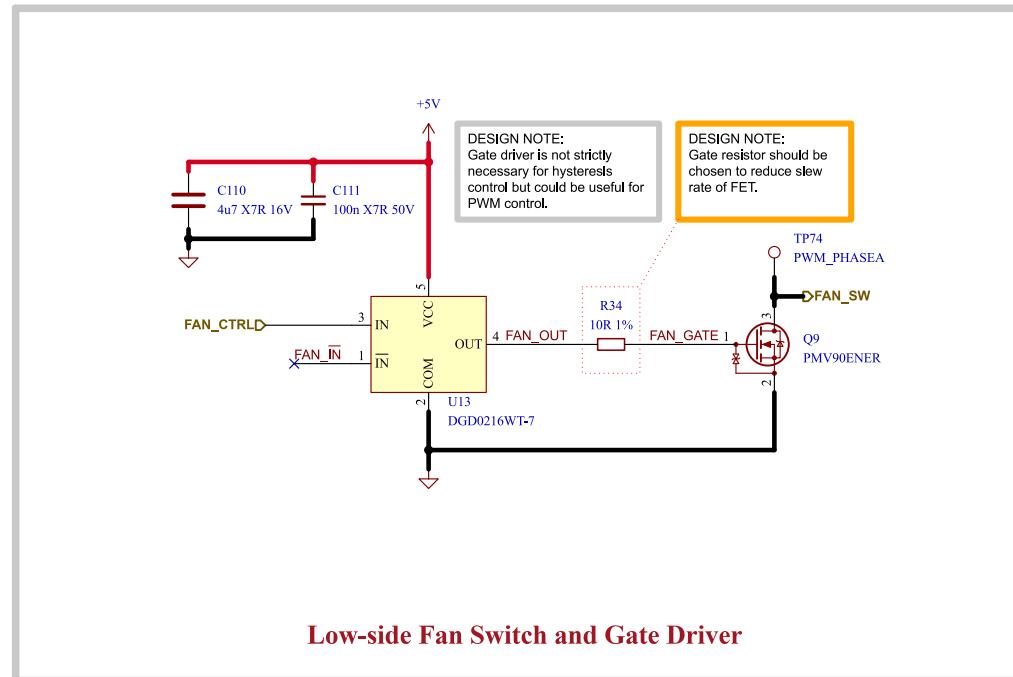
	Comments:	Company: EPFL Xplore Research	Variant: Preliminary
	Board Name: Amulet Motion Controller		
	Sheet Title: Interface - RS-422	File Name: Interface - RS-422.kicad_sch	Designer: Vincent Nguyen
	Sheet Path: /Project Architecture/Interface - RS-422/	Reviewer:	Date: 2023-10-15 Revision: 1.0

[16] Interface - FD-CAN



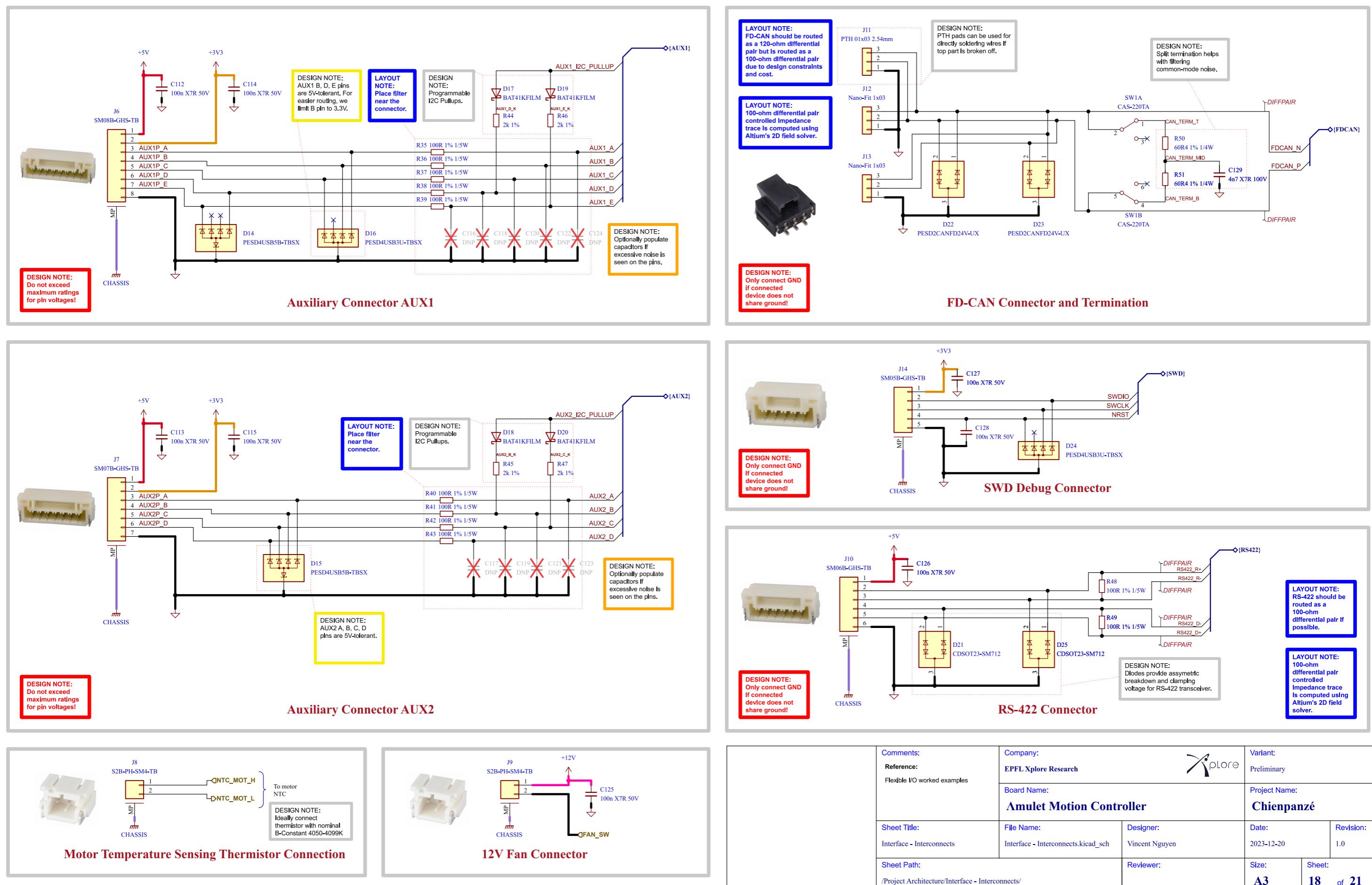
	Comments:	Company: EPFL Xplore Research	Variant: Preliminary
	Board Name: Amulet Motion Controller		
	Sheet Title: Interface - FD-CAN	File Name: Interface - FD-CAN.kicad_sch	Designer: Vincent Nguyen
	Sheet Path: /Project Architecture/Interface - FD-CAN/	Reviewer:	Date: 2023-10-15 Revision: 1.0
		Size: A4	Sheet: 16 of 21

[17] Interface - Fan Control



	Comments:	Company: EPFL Xplore Research	Variant: Preliminary
	Board Name: Amulet Motion Controller		
	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



[19] Misc - Holes, Fiducials

A

A

B

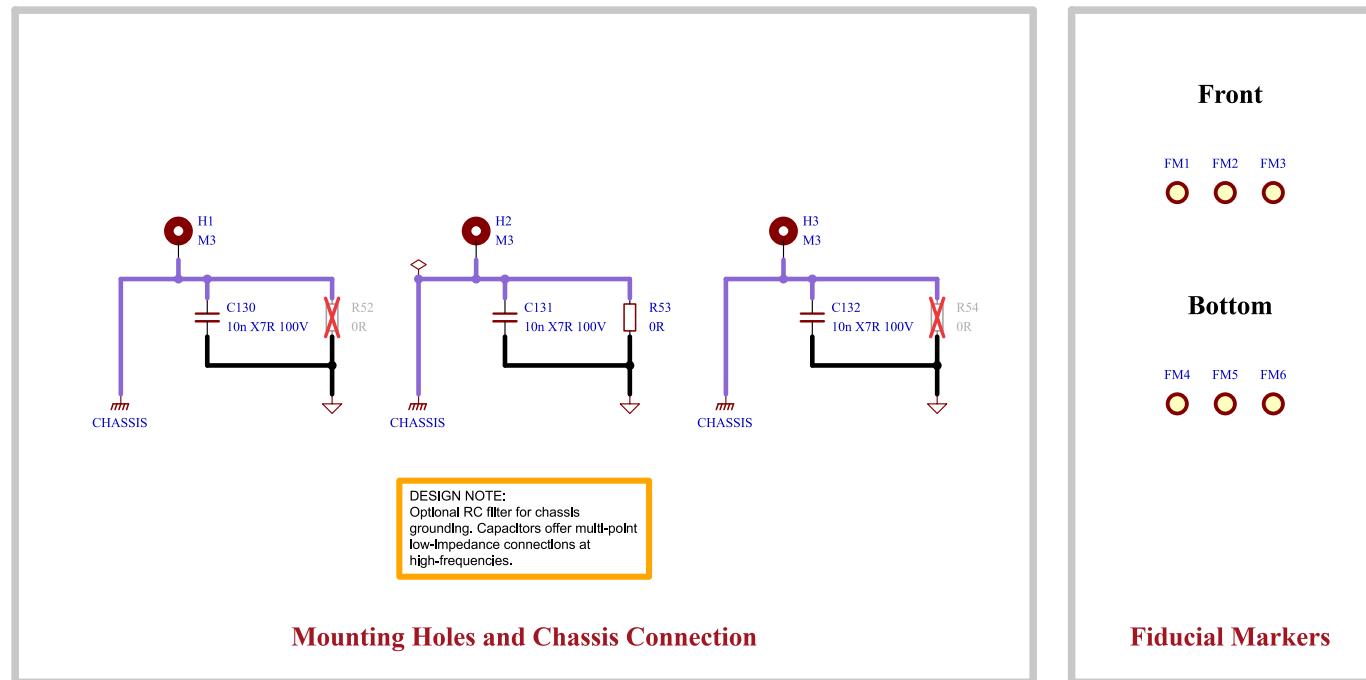
B

C

C

D

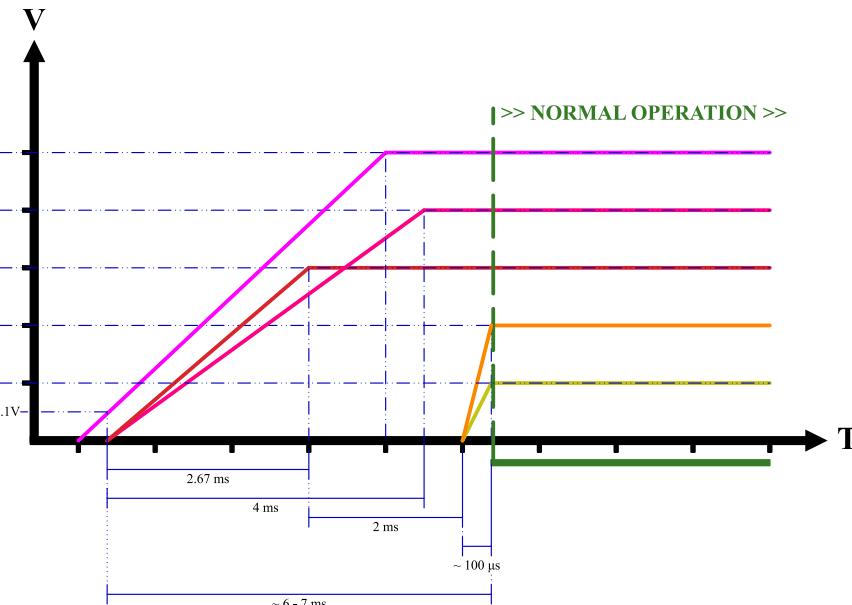
D



		Comments: Company: EPFL Xplore Research	Variant:  Preliminary	
		Board Name: Amulet Motion Controller	Project Name: Chienpanzé	
		Sheet Title: Misc - Holes, Fiducials	File Name: Misc - Holes Fiducials.kicad_sch	Designer: Vincent Nguyen
		Sheet Path: /Project Architecture/Misc - Holes, Fiducials/		Date: 2023-10-22
		Reviewer:		Size: A4
		Sheet: 19 of 21		

[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: Preliminary		
		Board Name: Amulet Motion Controller				Project Name: Chienpanzé
		Sheet Title: Power - Sequencing	File Name: Power - Sequencing.kicad_sch	Designer: Vincent Nguyen	Date: 2023-12-17	Revision: 1.0
	Sheet Path: /Power - Sequencing/	Reviewer:		Size: A4	Sheet: 20 of 21	

[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.

xx.xx.xx - XXX

xx.xx.xx - XXX

B

A

B

C

C

D

D

	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
	Sheet Path: /Revision History/	Reviewer:	Date: 2023-12-20
			Revision: 1.0
		Size: A4	Sheet: 21 of 21