

# Amulet Motion Controller

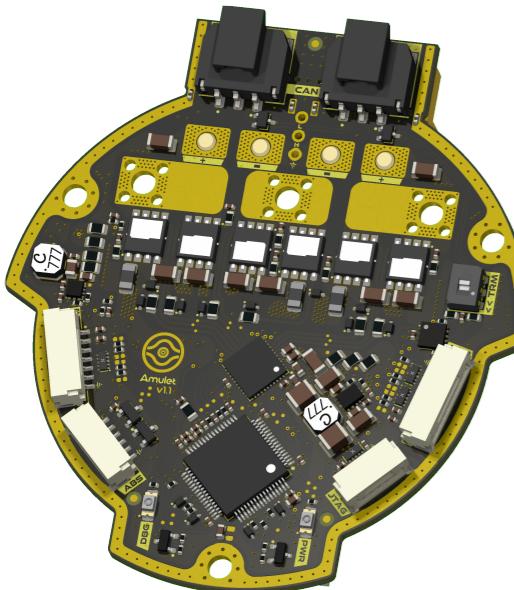
Variant: CHECKED

2024-12-02

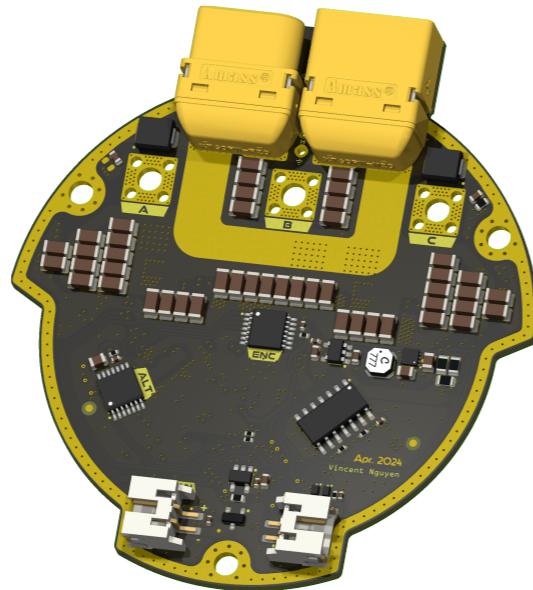
Rev 1.1.1+ (Unreleased)

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## TOP VIEW



## BOTTOM VIEW



## 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.

## NOTES

Schematic based off Josh Pieper's moteus controllers.

Not fitted components are marked as

DRAFT - Very early stage of schematic, ignore details.

PRELIMINARY - Close to final schematic.

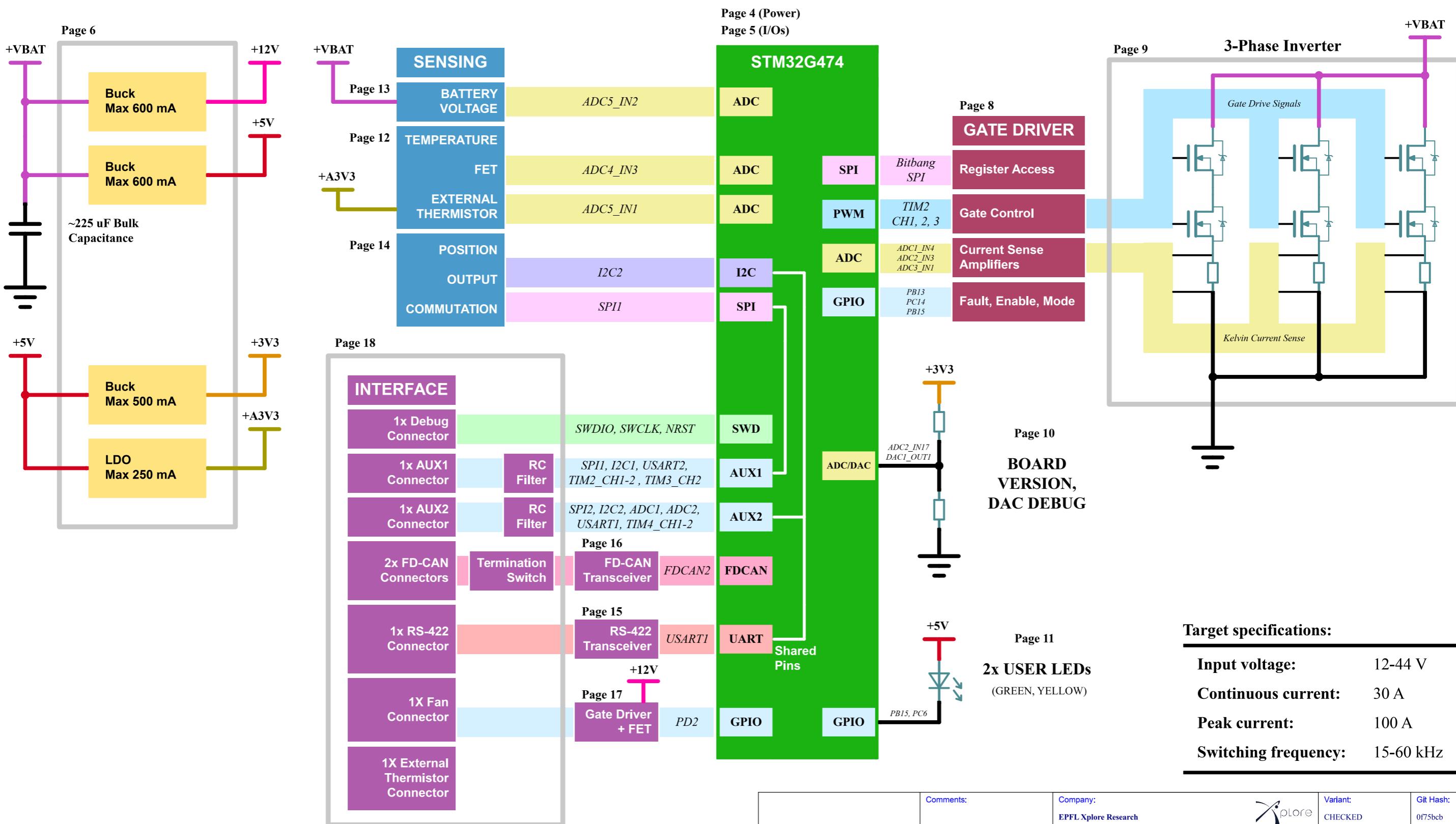
CHECKED - There shouldn't be any mistakes. Contact the engineer if you find any.

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

Date: 02-Dec-2024

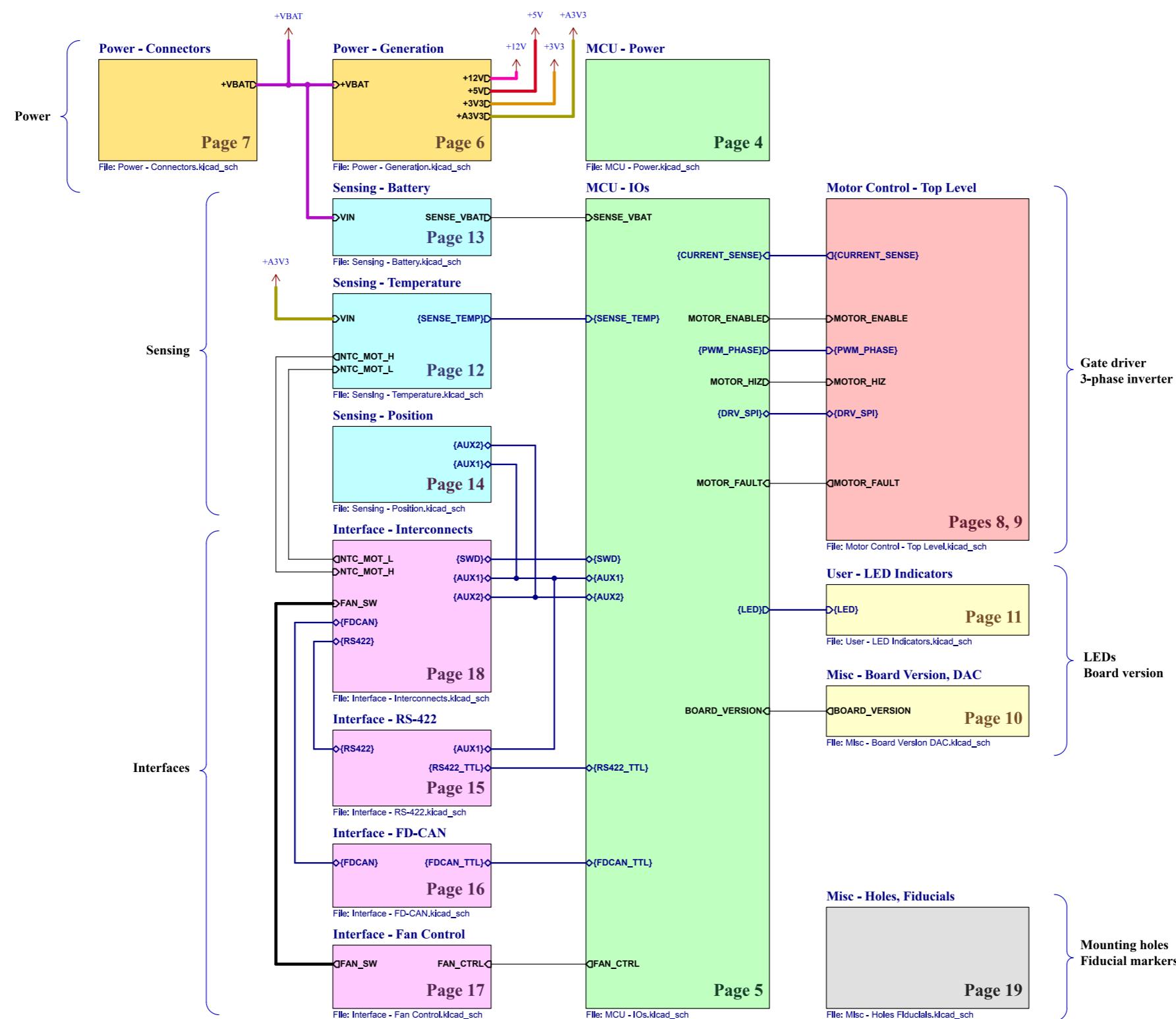
	Comments:	Company:	xplore	Variant: CHECKED	Git Hash: 0f75bcb
		Board Name:			
	Sheet Title:	File Name:	Cover Page	Designer:	Project Name: <b>Chienpanzé</b>
		amulet_controller.kicad_sch		Vincent Nguyen	
	Sheet Path:	Reviewer:	/	Date:	Revision: 1.1.1+ (Unreleased)
				2024-04-13	
	Size:	Sheet:	A3	1 of 21	

# [2] Block Diagram



Comments:	Company: EPFL Xplore Research		Variant: CHECKED	Git Hash: 0f75bcb
	Board Name: <b>Amulet Motion Controller</b>		Project Name: <b>Chienpanzé</b>	
Sheet Title: Block Diagram	File Name: Block Diagram.kicad_sch		Designer: Vincent Nguyen	Date: 2024-04-13
Sheet Path: /Block Diagram/	Reviewer:		Size: <b>A3</b>	Sheet: <b>2</b> of <b>21</b>

# [3] Project Architecture



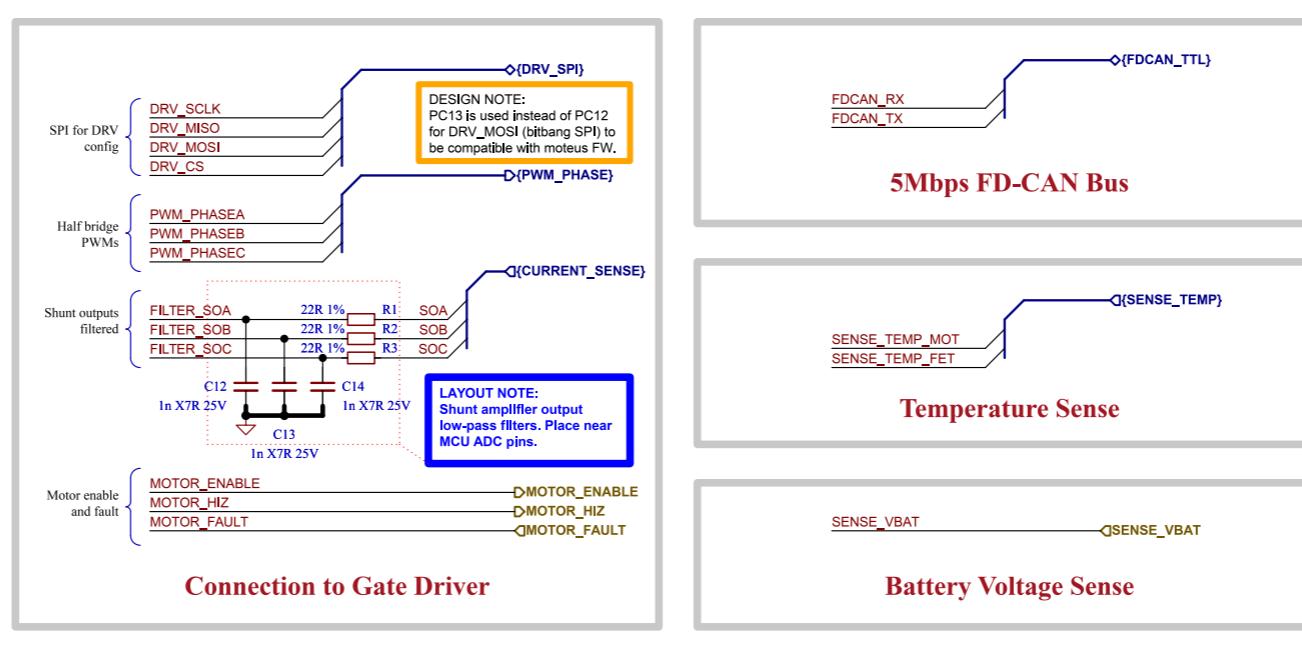
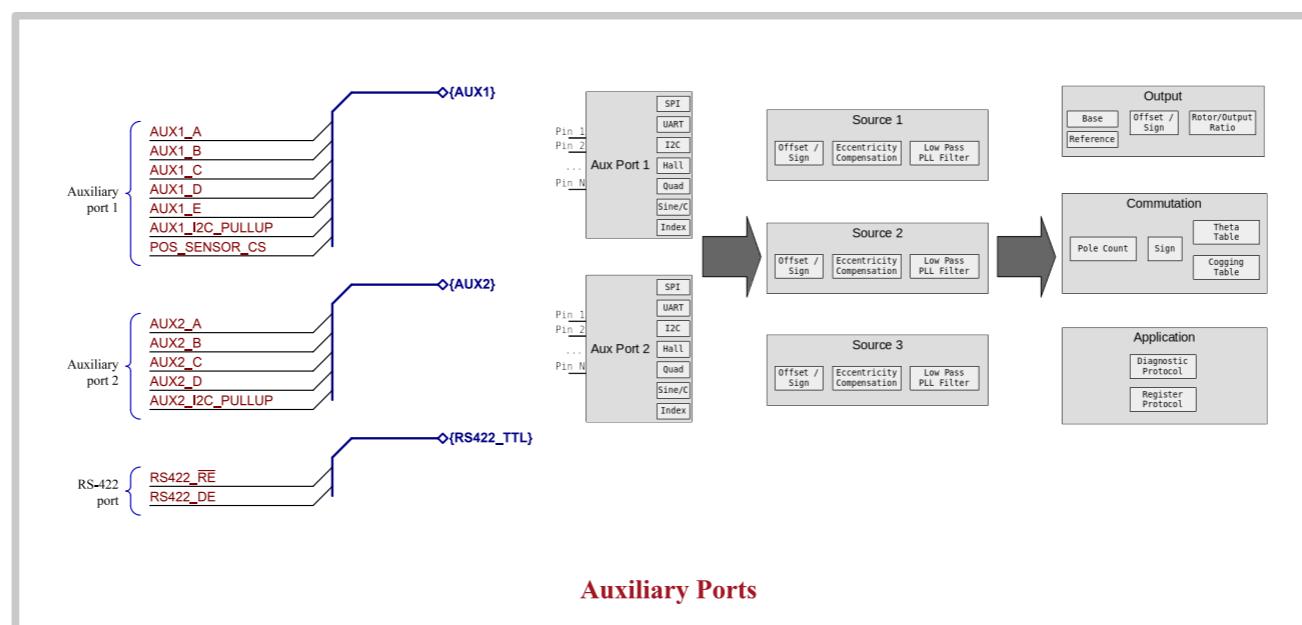
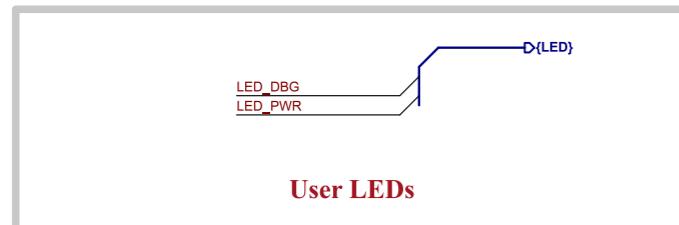
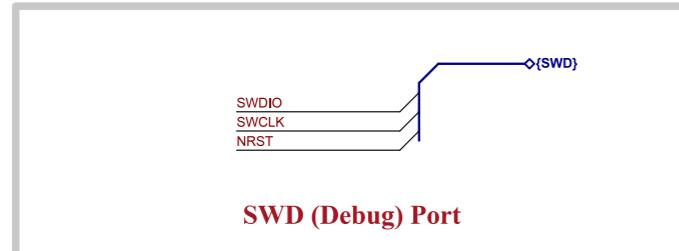
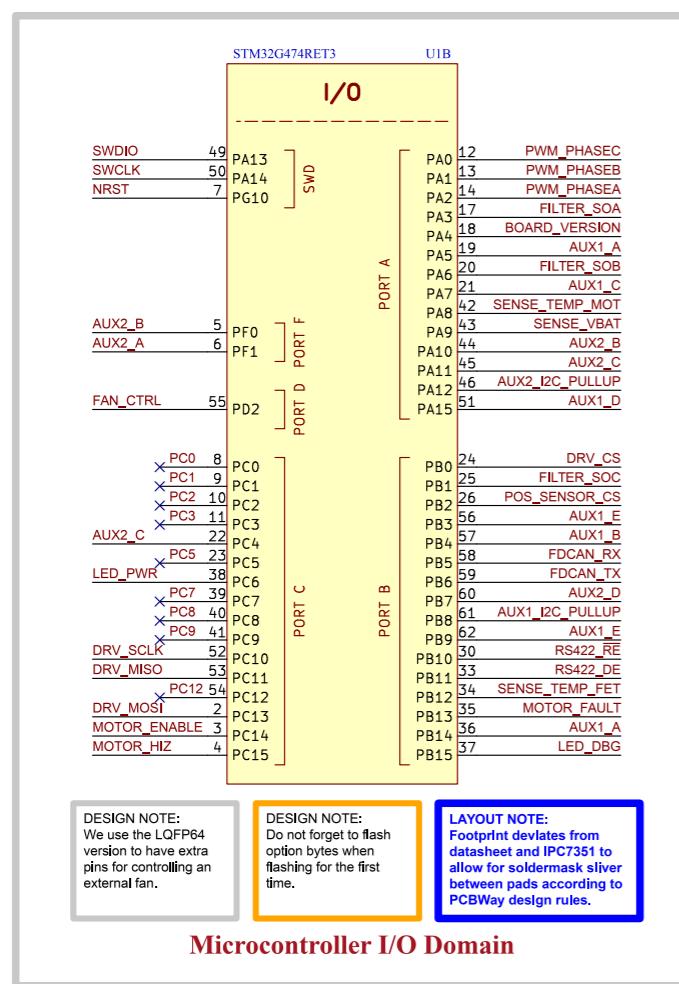
	Comments:	Company: EPFL Xplore Research	Variant: CHECKED	Git Hash: 0f75bcb
	Board Name: <b>Amulet Motion Controller</b>	Project Name: <b>Chienpanzé</b>		
	Sheet Title: Project Architecture	File Name: Project Architecture.kicad_sch	Designer: Vincent Nguyen	Date: 2023-12-22
	Sheet Path: /Project Architecture/		Reviewer:	Revision: 1.1.1+ (Unreleased)

# [4] MCU - Power



	Comments: AN5346 STM32G474 Datasheet p.81 J. Pieper ADC investigation	Company: EPFL Xplore Research	Variant: CHECKED	Git Hash: 0f75bcb
	<b>Board Name:</b> <b>Amulette Motion Controller</b>			<b>Project Name:</b> <b>Chienpanzé</b>
	<b>Sheet Title:</b> MCU - Power	<b>File Name:</b> MCU - Power.kicad_sch	<b>Designer:</b> Vincent Nguyen	<b>Date:</b> 2023-12-18 <b>Revision:</b> 1.1.1+ (Unreleased)
	<b>Sheet Path:</b> /Project Architecture/MCU - Power/		<b>Reviewer:</b>	<b>Size:</b> <b>A4</b> <b>Sheet:</b> <b>4</b> of <b>21</b>

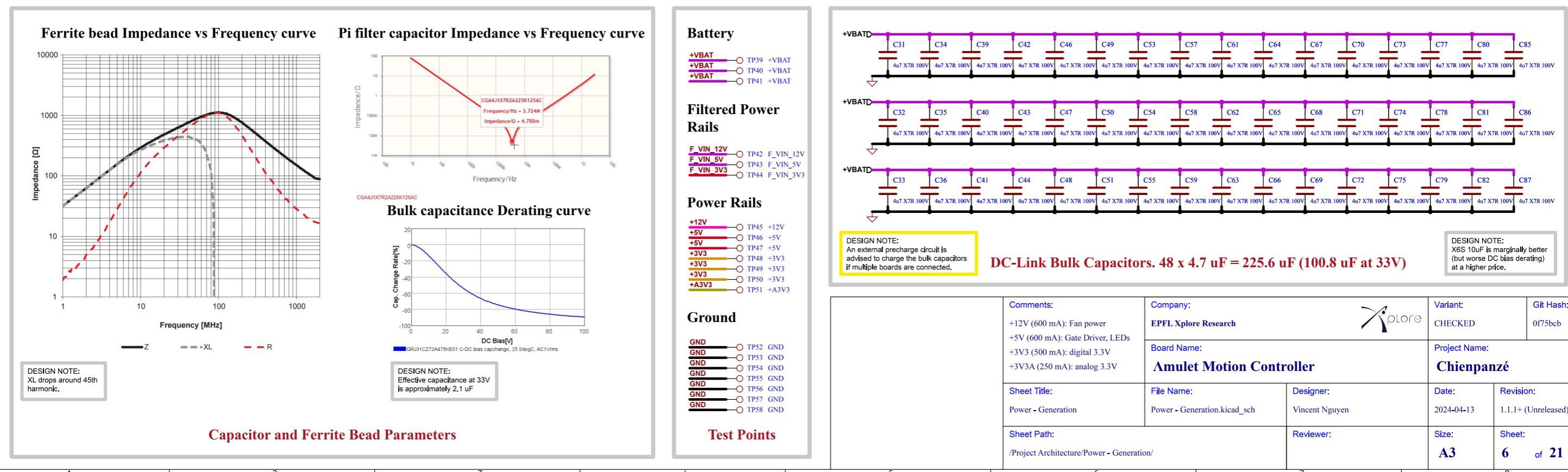
# [5] MCU - I/Os



<b>Gate Driver</b>	
MOTOR_ENABLE	TP1
MOTOR_HIZ	TP2
MOTOR_FAULT	TP3
DRV_SCLK	TP4
DRV_MISO	TP5
DRV_MOSI	TP6
DRV_CS	TP7
PWM_PHASEA	TP8
PWM_PHASEB	TP9
PWM_PHASEC	TP10
SOA	TP11
SOB	TP12
SOC	TP13
<b>Debug</b>	
SWDIO	TP14
SWCLK	TP15
NRST	TP16
<b>Auxiliary pins 1</b>	
AUX1_A	TP17
AUX1_B	TP18
AUX1_C	TP19
AUX1_D	TP20
AUX1_E	TP21
AUX1_I2C_PULLUP	TP22
POS_SENSOR_CS	TP23
<b>Auxiliary pins 2</b>	
AUX2_A	TP24
AUX2_B	TP25
AUX2_C	TP26
AUX2_D	TP27
AUX2_I2C_PULLUP	TP28
<b>Temperature Sense</b>	
SENSE_TEMP_MOT	TP29
SENSE_TEMP_FET	TP30
<b>Battery Voltage Sense</b>	
SENSE_VBAT	TP31
<b>Test Points</b>	
TP32	LED_PWR
TP33	FD_CAN_RX
TP34	FD_CAN_TX
TP35	FAN_CTRL
TP36	SENSE_TEMP_MOT
TP37	SENSE_TEMP_FET
TP38	SENSE_VBAT

Comments: References: Flexible I/O worked examples Flexible I/O source configuration	Company: EPFL Xplore Research		Variant: CHECKED	Git Hash: 0f75bcb
	Board Name: <b>Amulet Motion Controller</b>			
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:		Revision: 1.1.1+ (Unreleased)
Size: <b>A3</b>		Sheet: <b>5 of 21</b>		

# [6] Power - Generation



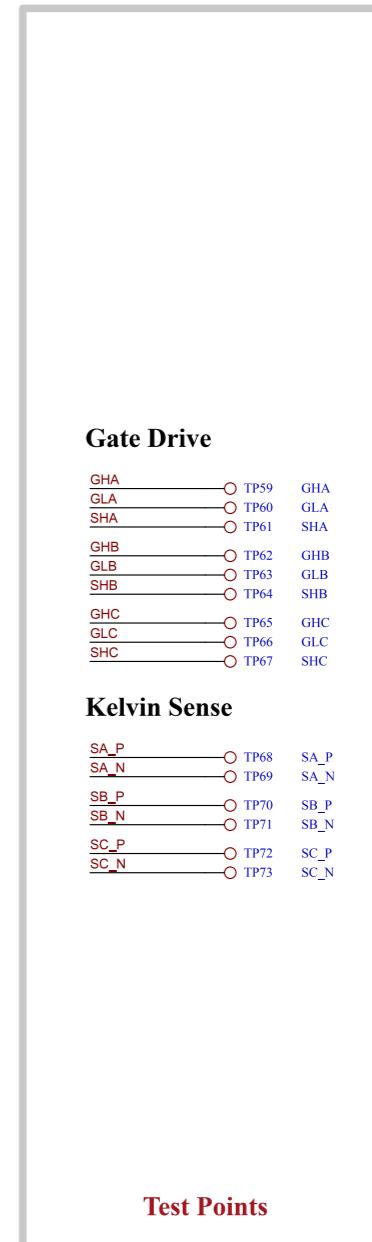
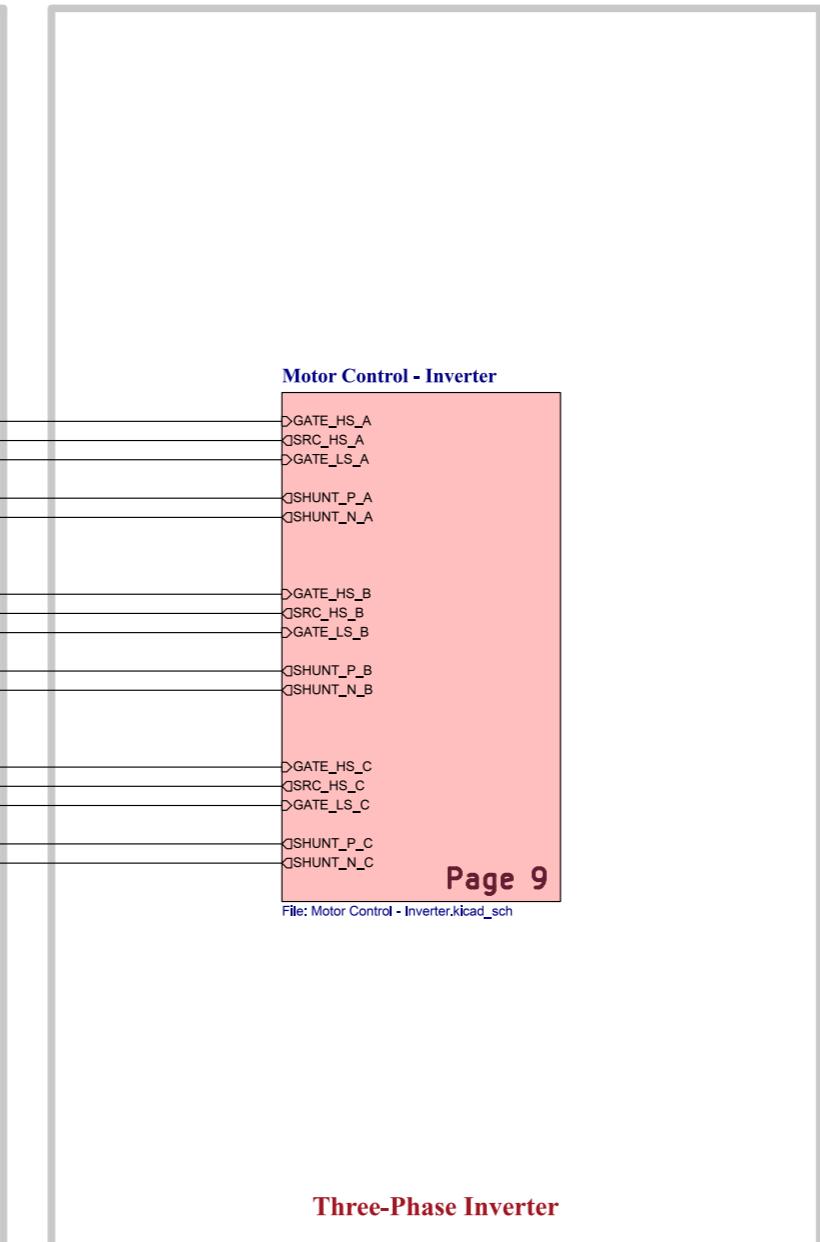
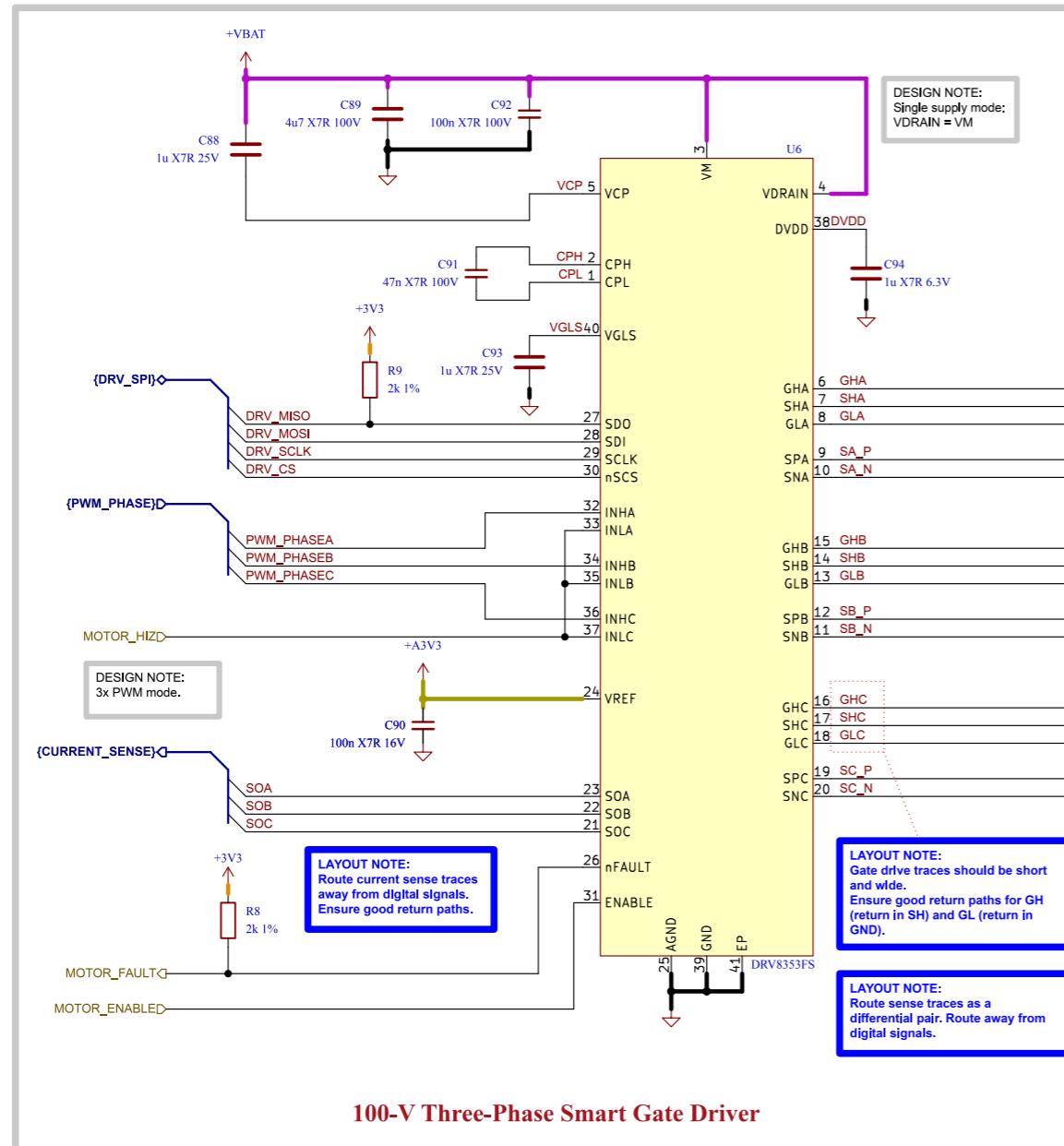
# [7] Power - Connectors



A					A
B					B
C					C
D					D
1	2	3	4	5	6

	Comments:  Power - Connectors	Company: EPFL Xplore Research  Board Name: <b>Amulet Motion Controller</b>	Variant: CHECKED	Git Hash: 0f75bcb
	Sheet Title: Power - Connectors	File Name: Power - Connectors.kicad_sch	Designer: Vincent Nguyen	Date: 2023-12-31
	Sheet Path: /Project Architecture/Power - Connectors/	Reviewer:	Size: <b>A4</b>	Revision: 1.1.1+ (Unreleased)
			Sheet: <b>7</b> of 21	

# [8] Motor Control - Top Level



	Comments:	Company: EPFL Xplore Research	Variant: CHECKED	Git Hash: 0f75bcb
	Board Name: <b>Amulet Motion Controller</b>		Project Name: <b>Chienpanzé</b>	
	Sheet Title: Motor Control - Top Level	File Name: Motor Control - Top Level.kicad_sch	Designer: Vincent Nguyen	Date: 2023-12-20
	Sheet Path: /Project Architecture/Motor Control - Top Level/		Reviewer:	Revision: 1.1.1+ (Unreleased)
			Size: <b>A3</b>	Sheet: <b>8 of 21</b>

# [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/IEC60664-1.

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

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

**Sheet Title:**  
Motor Control - Inverter

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

**Company:**  
EPFL Xplore Research

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

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

**Designer:**  
Vincent Nguyen



**Variant:**  
CHECKED

**Git Hash:**  
0f75bcb

**Project Name:**  
**Chienpanzé**

**Date:**  
2024-01-25

**Revision:**  
1.1.1+ (Unreleased)

**Size:**  
**A4**

**Sheet:**  
**9** of 21

# [10] Misc - Board Version, DAC



	Comments:	Company: EPFL Xplore Research		Variant: CHECKED	Git Hash: 0f75bcb
D		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	Date: 2024-04-13	Revision: 1.1.1+ (Unreleased)
	Sheet Path: <a href="#">/Project Architecture/Misc - Board Version, DAC/</a>		Reviewer:	Size: <b>A4</b>	Sheet: <b>10 of 21</b>

# [11] User - LED Indicators



	Comments:	Company: EPFL Xplore Research	Variant: CHECKED	Git Hash: 0f75bcb
	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	Date: 2023-12-19    Revision: 1.1.1+ (Unreleased)
	Sheet Path: <a href="#">/Project Architecture/User - LED Indicators/</a>		Reviewer:	Size: <b>A4</b> Sheet: <b>11</b> of <b>21</b>

# [12] Sensing - Temperature

A

B

C

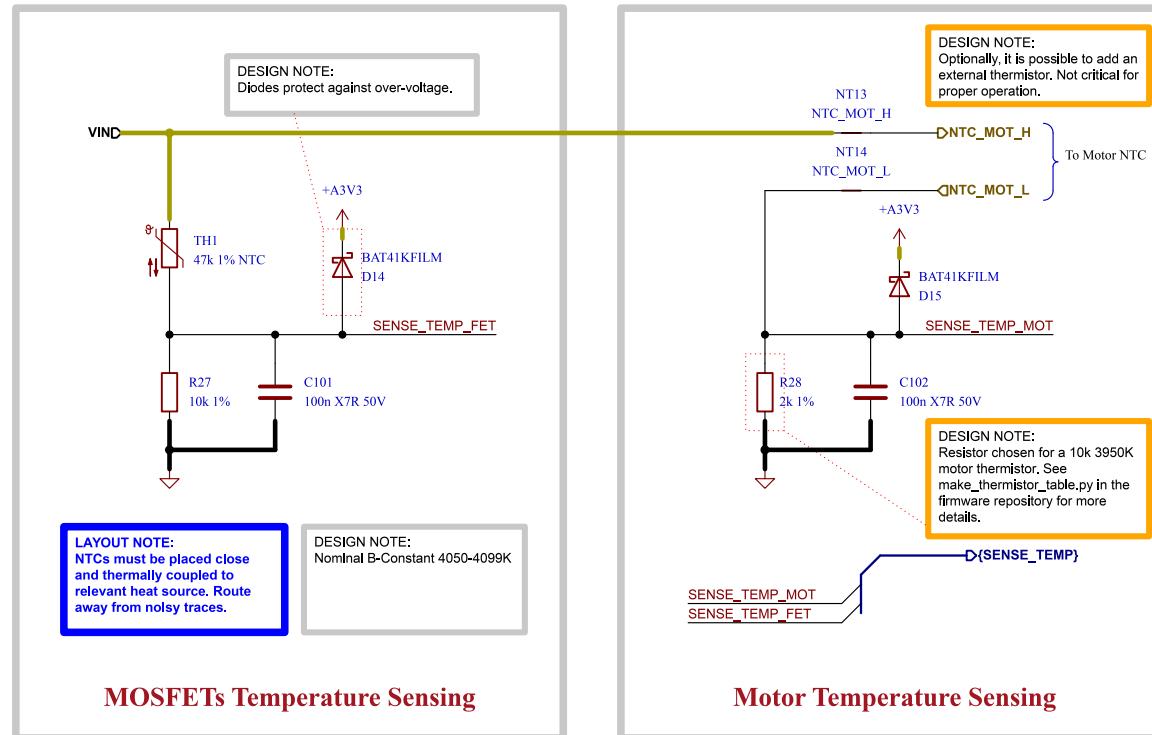
D

A

B

C

D



	Comments:	Company: EPFL Xplore Research	Variant: CHECKED	Git Hash: 0f75bcb
	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	Date: 2024-04-13
	Sheet Path: /Project Architecture/Sensing - Temperature/		Reviewer:	Size: <b>A4</b>
			Sheet: <b>12</b> of <b>21</b>	

# [13] Sensing - Battery

A

B

C

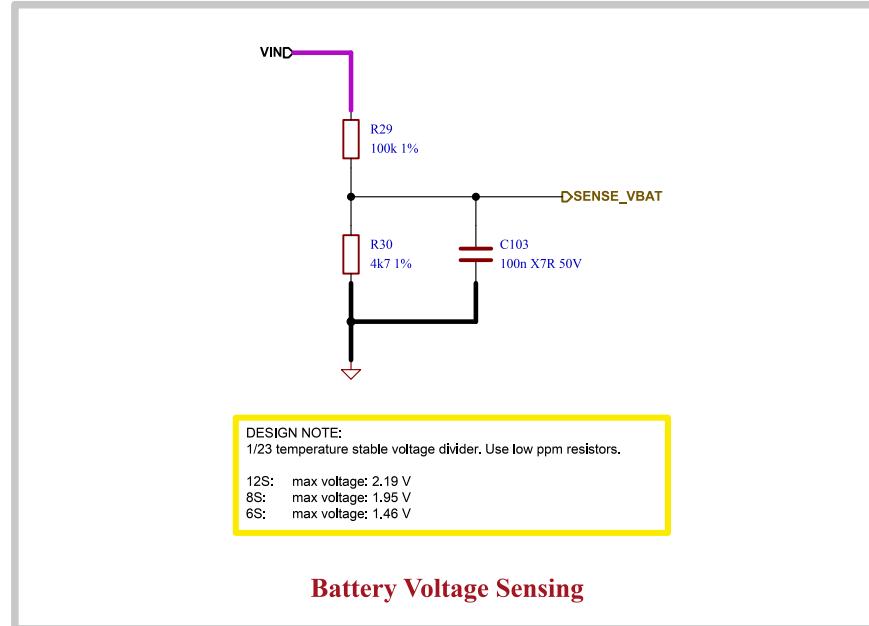
D

A

B

C

D



	Comments:	Company: EPFL Xplore Research	Variant: CHECKED	Git Hash: 0f75bcb
	Board Name: <b>Amulet Motion Controller</b>			Project Name: <b>Chienpanzé</b>
	Sheet Title: Sensing - Battery	File Name: Sensing - Battery.kicad_sch	Designer: Vincent Nguyen	Date: 2023-10-14
	Sheet Path: /Project Architecture/Sensing - Battery/		Reviewer:	Size: <b>A4</b> Sheet: <b>13</b> of <b>21</b>

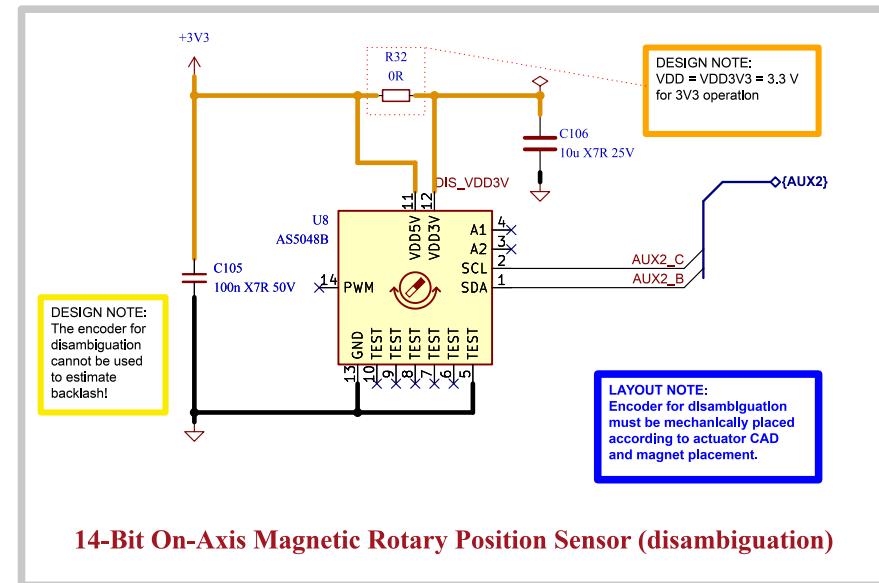
# [14] Sensing - Position

A



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

**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.



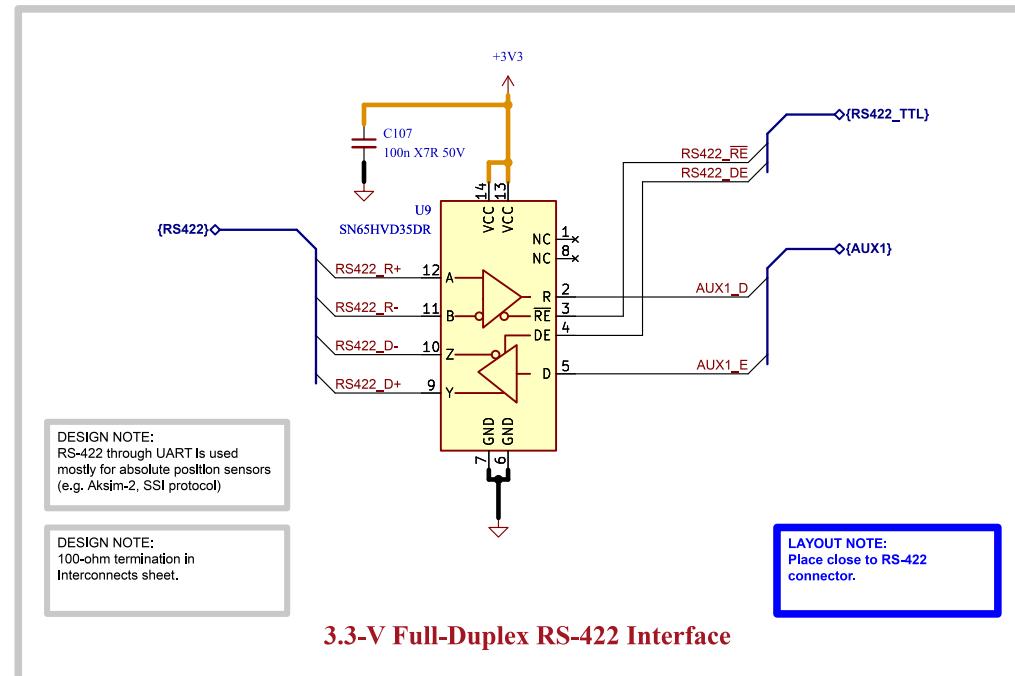
14-Bit On-Axis Magnetic Rotary Position Sensor (disambiguation)

C

D

	Comments:	Company: EPFL Xplore Research	Variant: CHECKED	Git Hash: 0f75bcb
	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	Date: 2023-10-14
	Revision: 1.1.1+ (Unreleased)		Reviewer:	Size: <b>A4</b>
	Sheet Path: /Project Architecture/Sensing - Position/		Sheet: <b>14 of 21</b>	

# [15] Interface - RS-422



	Comments:	Company: EPFL Xplore Research 	Variant: CHECKED	Git Hash: 0f75bcb
	Board Name: <b>Amulette Motion Controller</b>			Project Name: <b>Chienpanzé</b>
	Sheet Title: Interface - RS-422	File Name: Interface - RS-422.kicad_sch	Designer: Vincent Nguyen	Date: 2023-10-15    Revision: 1.1.1+ (Unreleased)
	Sheet Path: /Project Architecture/Interface - RS-422/		Reviewer:	Size: <b>A4</b> Sheet: <b>15</b> of <b>21</b>

# [16] Interface - FD-CAN



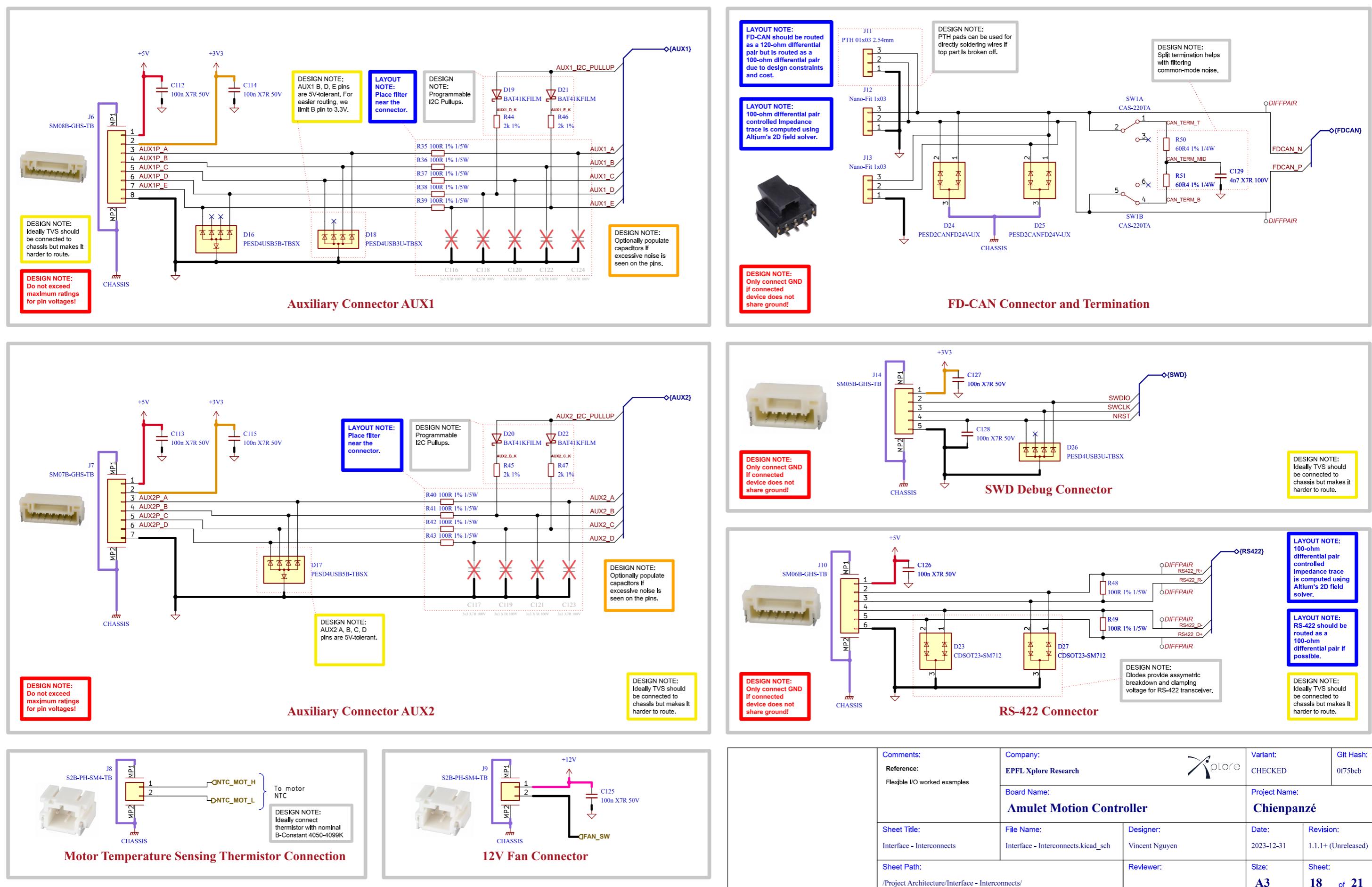
	Comments:	Company: EPFL Xplore Research 	Variant: CHECKED	Git Hash: 0f75bcb
	Board Name: <b>Amulet Motion Controller</b>			Project Name: <b>Chienpanzé</b>
	Sheet Title: Interface - FD-CAN	File Name: Interface - FD-CAN.kicad_sch	Designer: Vincent Nguyen	Date: 2023-10-15    Revision: 1.1.1+ (Unreleased)
	Sheet Path: /Project Architecture/Interface - FD-CAN/		Reviewer:	Size: <b>A4</b> Sheet: <b>16</b> of <b>21</b>

# [17] Interface - Fan Control



	Comments:	Company: EPFL Xplore Research	Variant: CHECKED	Git Hash: 0f75bcb
	Board Name: <b>Amulet Motion Controller</b>			Project Name: <b>Chienpanzé</b>
	Sheet Title: Interface - Fan Control	File Name: Interface - Fan Control.kicad_sch	Designer: Vincent Nguyen	Date: 2023-11-19    Revision: 1.1.1+ (Unreleased)
	Sheet Path: <a href="#">/Project Architecture/Interface - Fan Control/</a>		Reviewer:	Size: <b>A4</b> Sheet: <b>17</b> of <b>21</b>

# [18] Interface - Interconnects



# [19] Misc - Holes, Fiducials

A

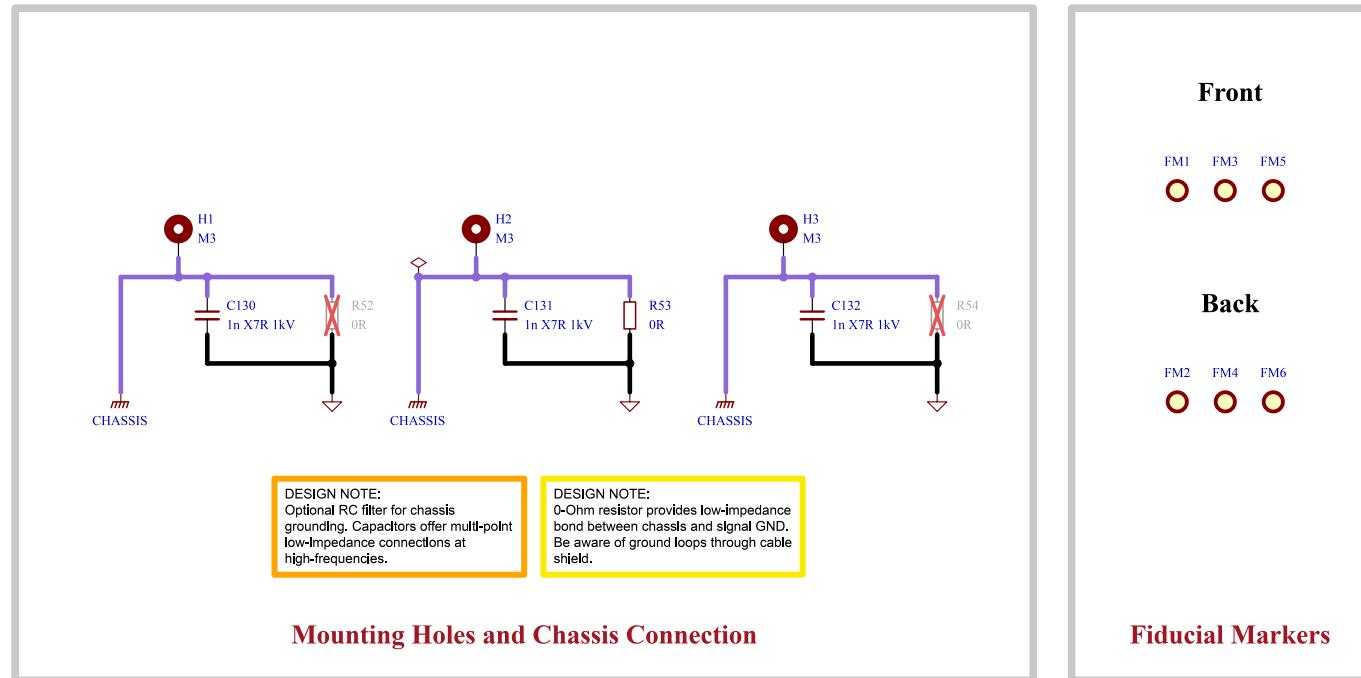
A

B

B

C

C



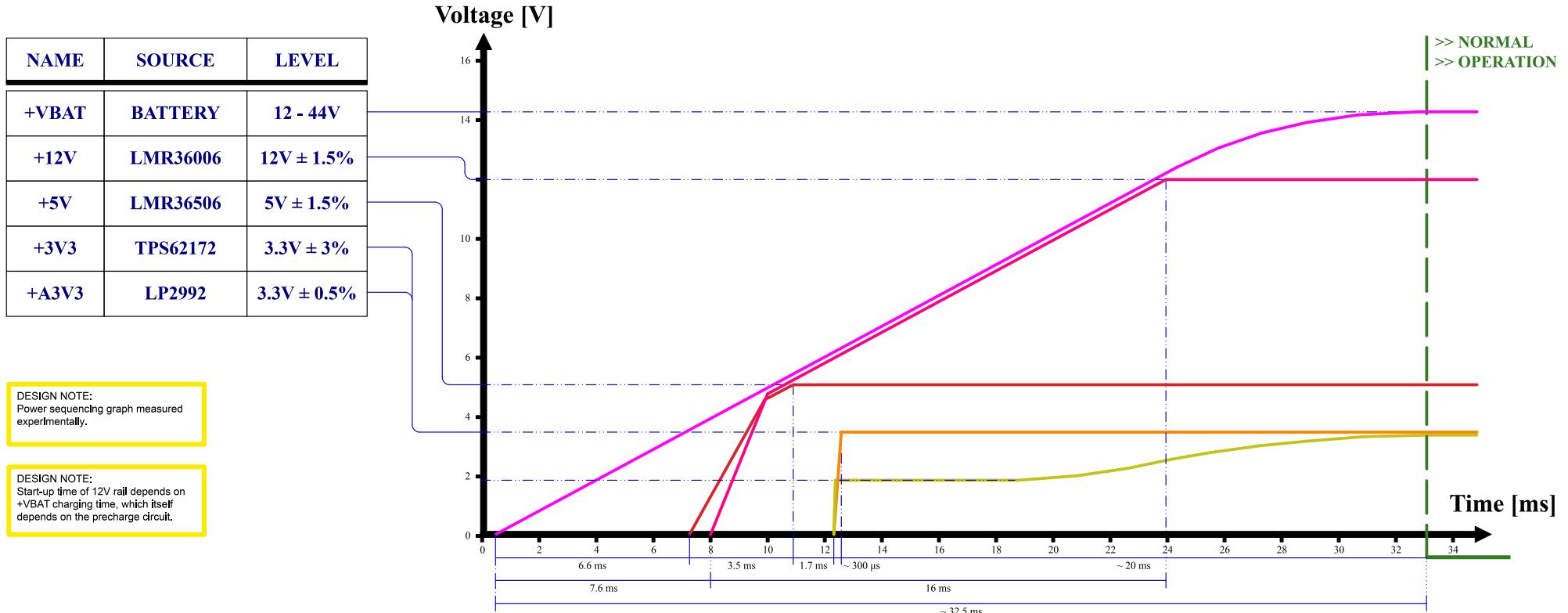
D

D

		Comments:	Company: EPFL Xplore Research	Variant: CHECKED	Git Hash: 0f75bcb
		Board Name: <b>Amulet Motion Controller</b>	Project Name: <b>Chienpanzé</b>		
		Sheet Title: Misc - Holes, Fiducials	File Name: Misc - Holes Fiducials.kicad_sch	Designer: Vincent Nguyen	Date: 2023-10-22
		Revision: 1.1.1+ (Unreleased)		Reviewer:	Size: <b>A4</b>
		Sheet Path: /Project Architecture/Misc - Holes, Fiducials/			Sheet: <b>19 of 21</b>

# [20] Power - Sequencing

A



B

C

D

	Comments:	Company: EPFL Xplore Research	Variant: CHECKED	Git Hash: 0f75bcb
	Board Name: <b>Amulet Motion Controller</b>			Project Name: <b>Chienpanzé</b>
	Sheet Title: Power - Sequencing	File Name: Power - Sequencing.kicad_sch	Designer: Vincent Nguyen	Date: 2024-03-12    Revision: 1.1.1+ (Unreleased)
	Sheet Path: <a href="#">/Power - Sequencing/</a>		Reviewer:	Size: <b>A4</b> Sheet: <b>20</b> of <b>21</b>

## [21] Revision History

	Comments:	Company: <b>EPFL Xplore Research</b>	 xplore	Variant: CHECKED	Git Hash: 0f75bcb
		Board Name: <b>Amulet Motion Controller</b>		Project Name: <b>Chienpanzé</b>	
	<b>Sheet Title:</b> Revision History	<b>File Name:</b> Revision History.kicad_sch	<b>Designer:</b> Vincent Nguyen	<b>Date:</b> 2024-01-03	<b>Revision:</b> 1.1.1+(Unreleased)
<b>Sheet Path:</b> /Revision History/		<b>Reviewer:</b>		<b>Size:</b> <b>A4</b>	<b>Sheet:</b> <b>21</b> of <b>21</b>