

# Amulet Motion Controller

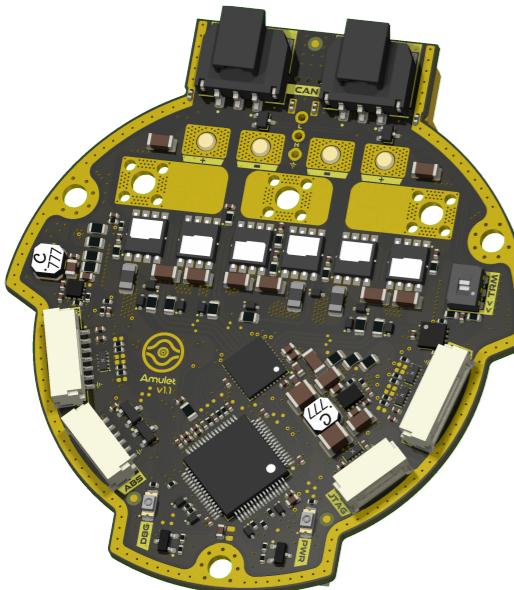
Variant: DRAFT

2024-11-25

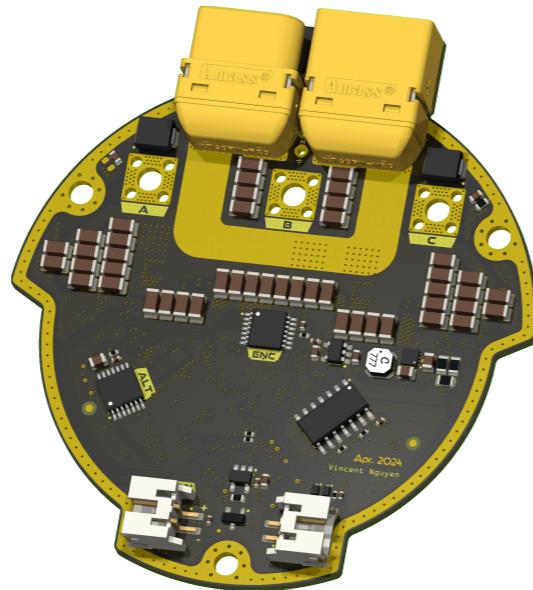
Rev 1.2+ (Unreleased)

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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.

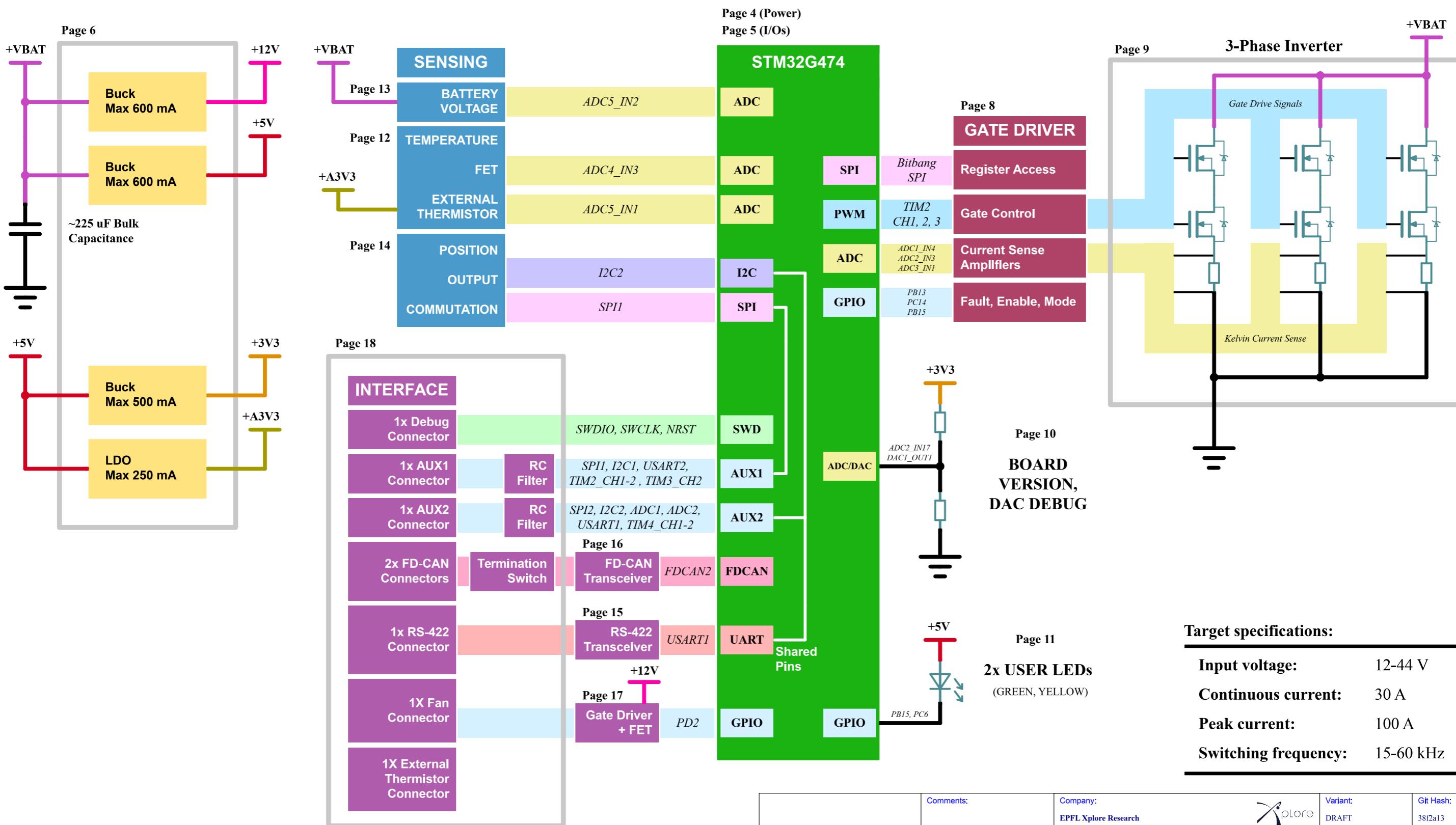
CHECKED - There shouldn't be any mistakes. Contact the engineer if you find any.

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

Date: 25-Nov-2024

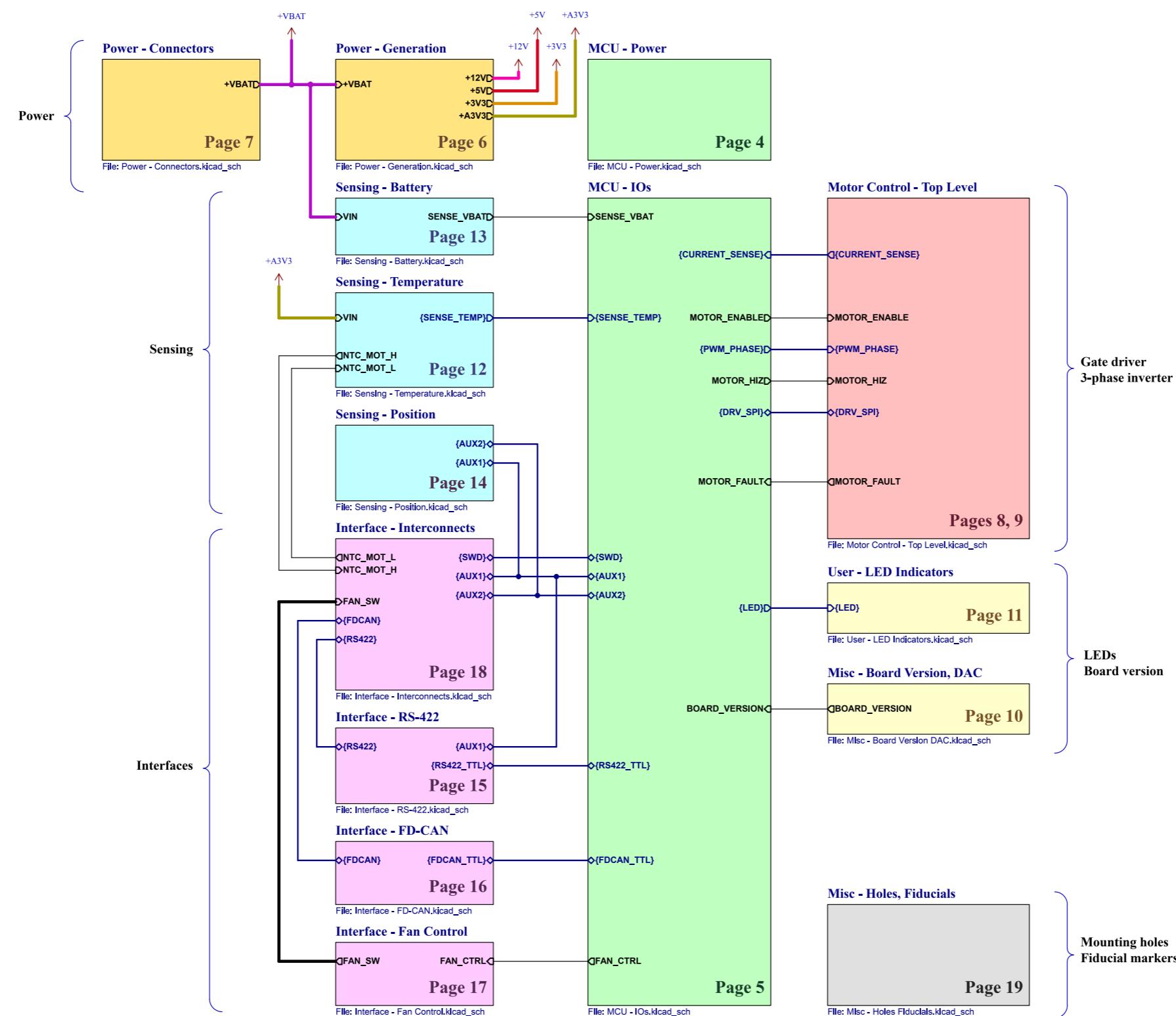
	Comments:	Company:	Xplore	
		EPFL Xplore Research		
	Board Name:	Amulet Motion Controller		Project Name:
		Chienpanzé		Chienpanzé
	Sheet Title:	File Name:	Designer:	Date:
	Cover Page	amulet_controller.kicad_sch	Vincent Nguyen	2024-04-13
	Sheet Path:	Reviewer:		Revision:
	/			1.2+ (Unreleased)
	Size:	Sheet:		
		A3	1 of 21	

# [2] Block Diagram



Comments:	Company: EPFL Xplore Research		Variant: DRAFT	Git Hash: 38f2a13
	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: A3	Revision: 1.2+ (Unreleased)

# [3] Project Architecture



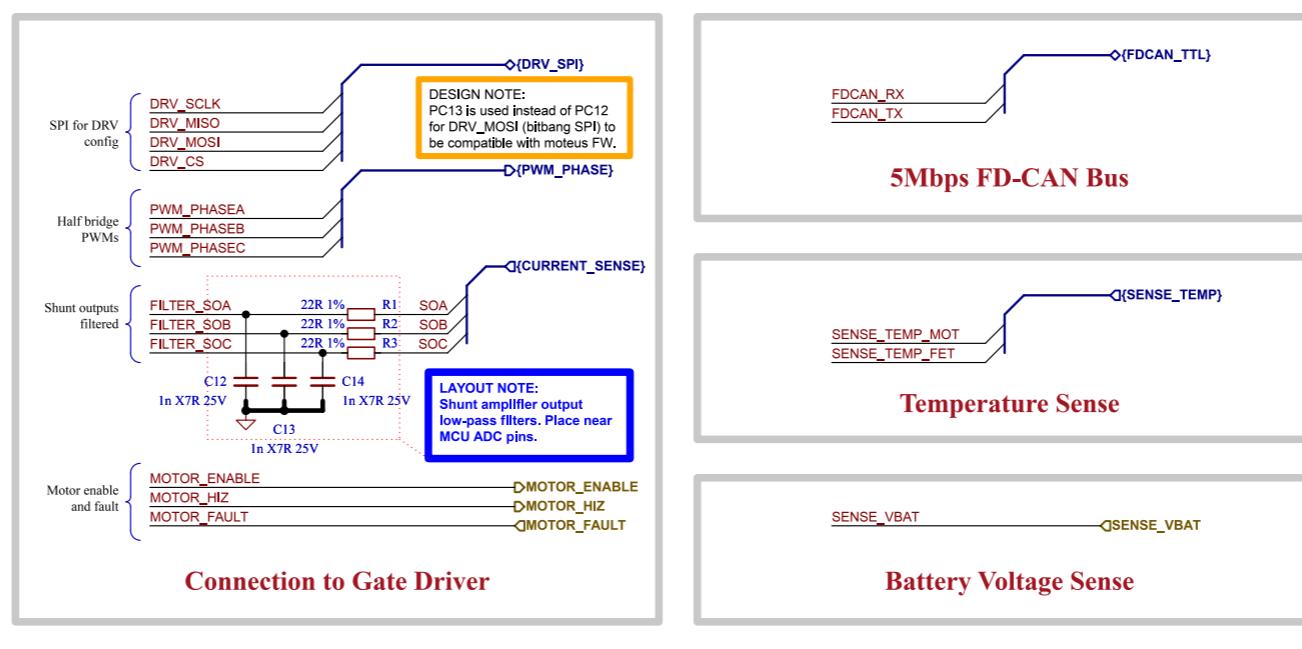
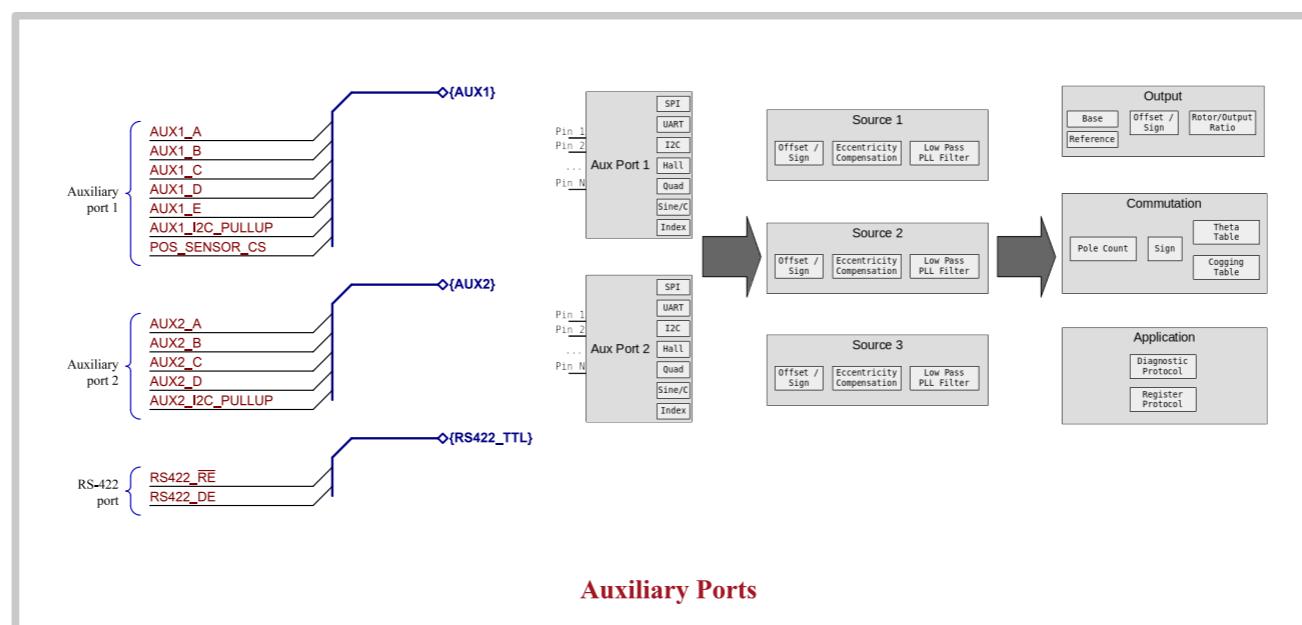
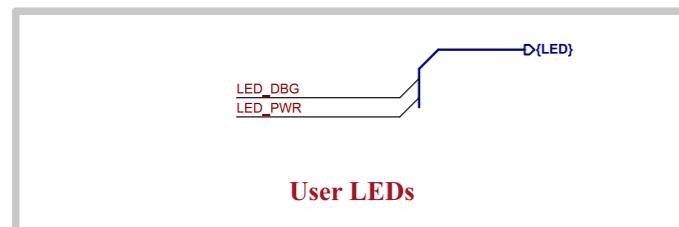
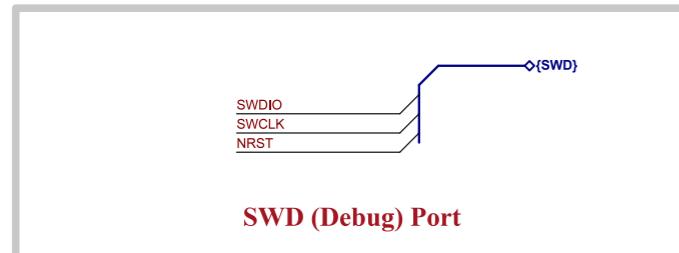
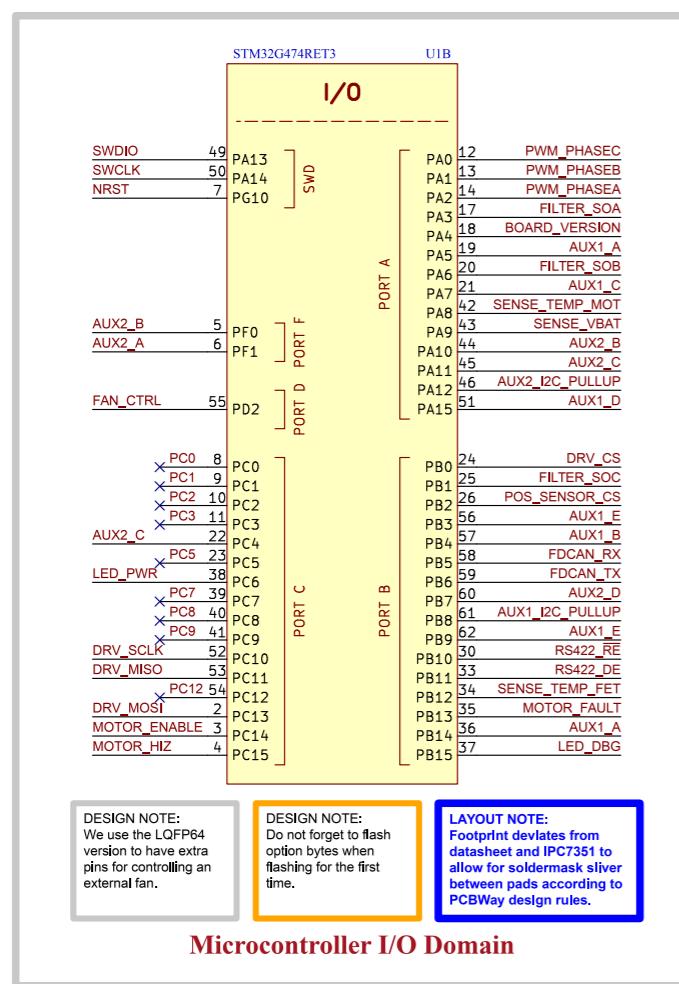
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		Board Name:			
		<b>Amulet Motion Controller</b>			
	Sheet Title:	File Name:	Designer:	Date:	Revision:
	Project Architecture	Project Architecture.kicad_sch	Vincent Nguyen	2023-12-22	1.2+ (Unreleased)
	Sheet Path:	/Project Architecture/	Reviewer:	Size:	Sheet:
				A3	3 of 21

# [4] MCU - Power



	Comments: AN5346 STM32G474 Datasheet p.81 J. Pieper ADC investigation	Company: EPFL Xplore Research 	Variant: DRAFT	Git Hash: 38f2a13
	<b>Board Name:</b> <b>Amulet 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> 1.2+ (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>

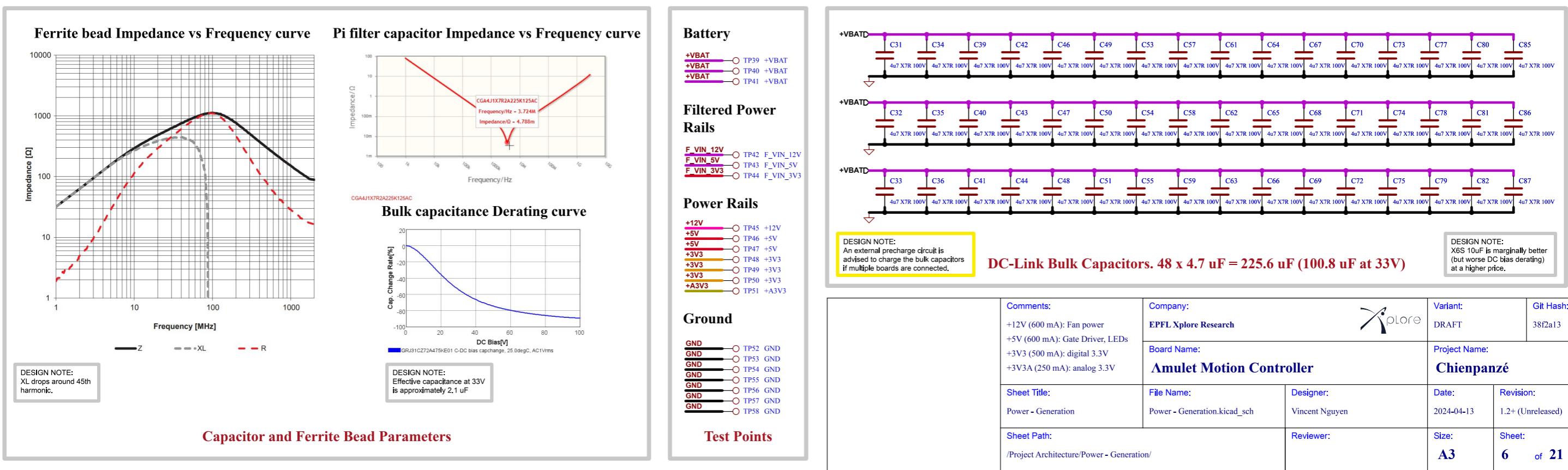
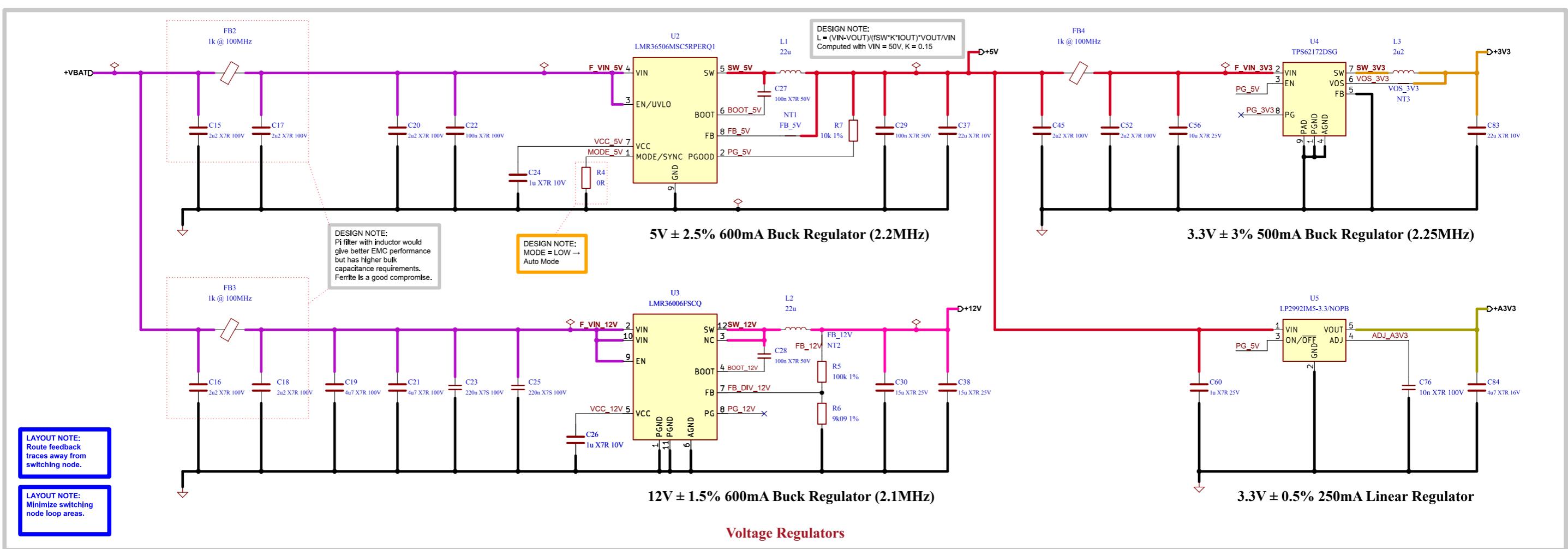
# [5] MCU - I/Os



<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>RS-422</b>	
RS422_RE	TP29
RS422_DE	TP30
<b>LEDs</b>	
LED_DBG	TP31
LED_PWR	TP32
<b>FD-CAN</b>	
FDCAN_RX	TP33
FDCAN_TX	TP34
<b>Fan</b>	
FAN_CTRL	TP35
<b>Sense</b>	
SENSE_TEMP_MOT	TP36
SENSE_TEMP_FET	TP37
SENSE_VBAT	TP38
<b>Test Points</b>	

Comments: References: Flexible I/O worked examples Flexible I/O source configuration	Company: EPFL Xplore Research		Variant: DRAFT	Git Hash: 38f2a13
	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: /Project Architecture/MCU - IOs/		Revision: 1.2+ (Unreleased)
Size: <b>A3</b>		Sheet: <b>5</b> of <b>21</b>		

# [6] Power - Generation

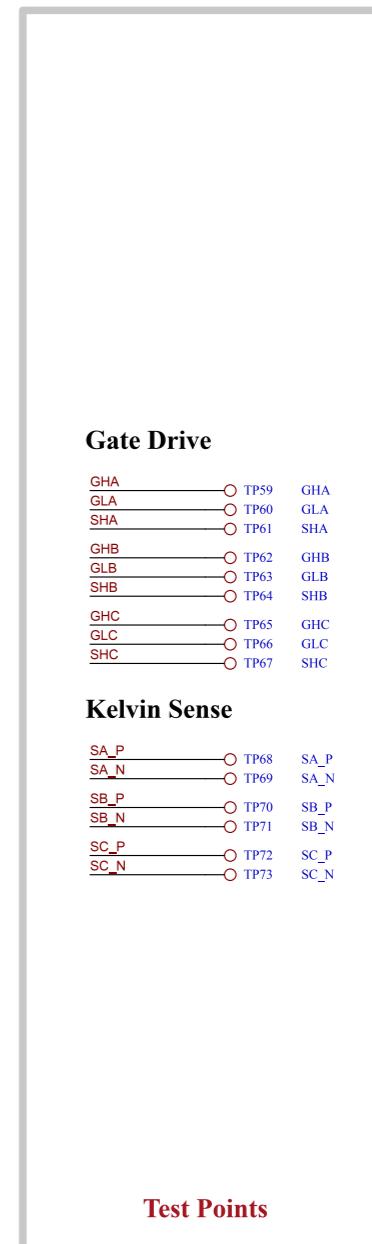
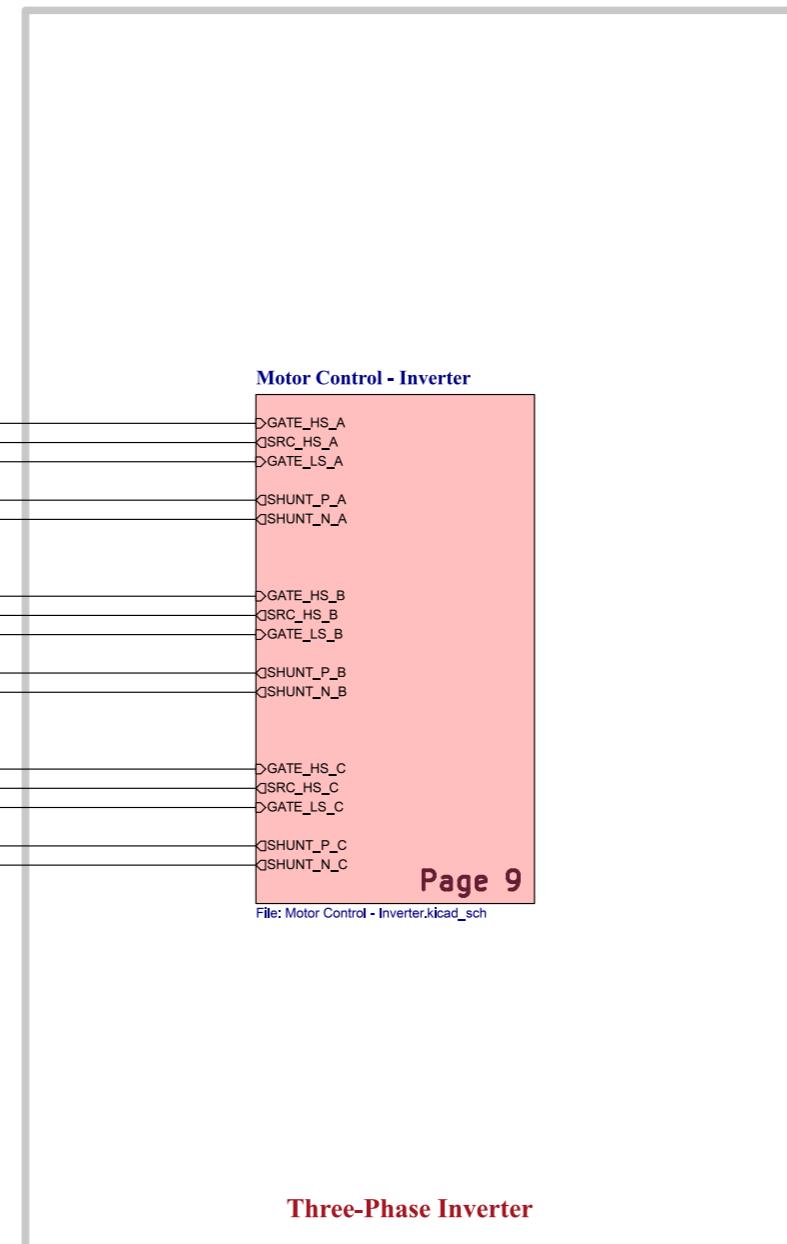
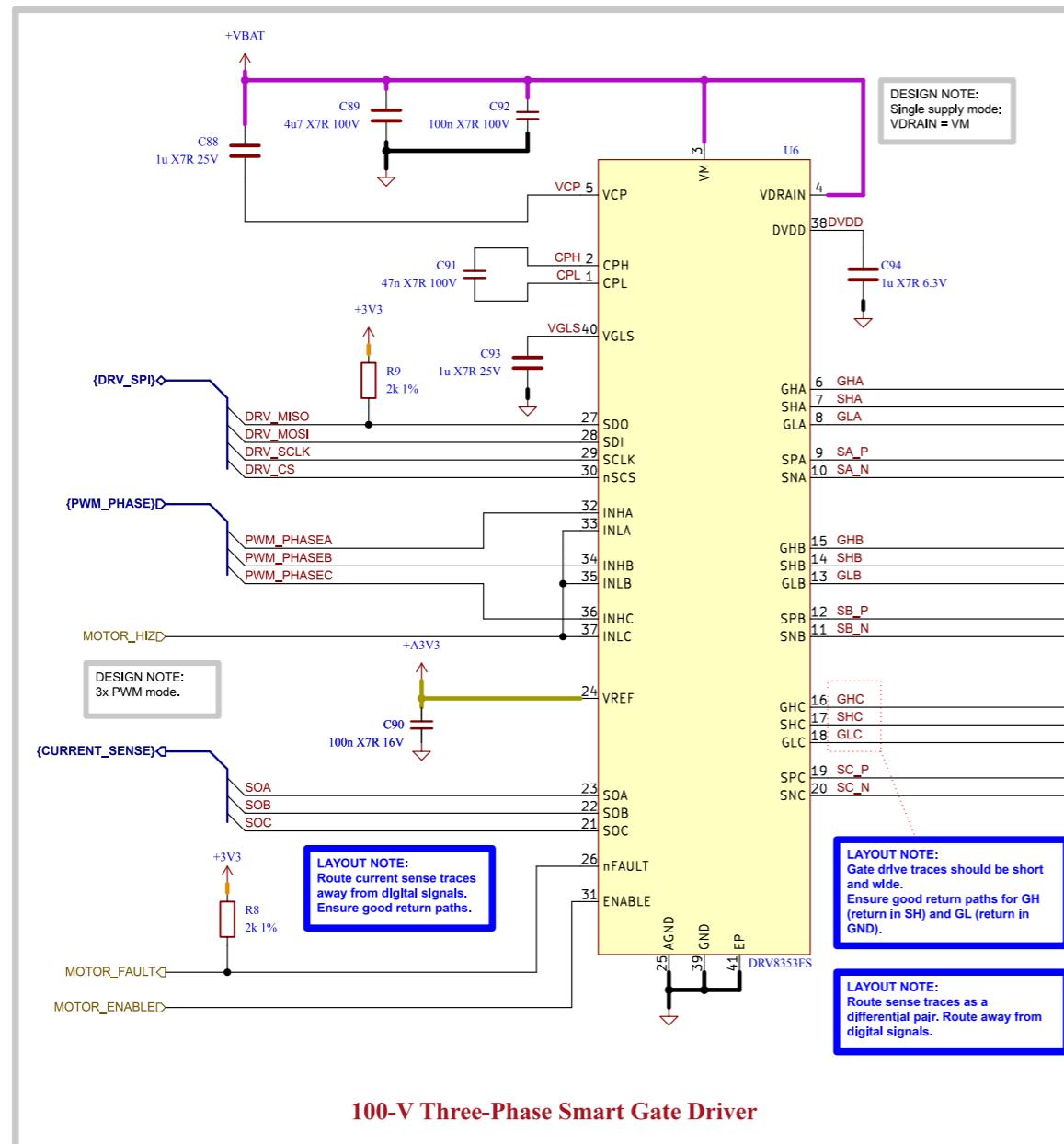


# [7] Power - Connectors



	Comments:	Company: EPFL Xplore Research	Variant: DRAFT	Git Hash: 38f2a13
	Board Name: <b>Amulet Motion Controller</b>			Project Name: <b>Chienpanzé</b>
	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>
			Sheet: <b>7</b> of 21	

# [8] Motor Control - Top Level



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File: Motor Control - Inverter.kicad\_sch

## Gate Drive

GHA	TP59	GHA
GLA	TP60	GLA
SHA	TP61	SHA
GHB	TP62	GHB
GLB	TP63	GLB
SHB	TP64	SHB
GHC	TP65	GHC
GLC	TP66	GLC
SHC	TP67	SHC

## Kelvin Sense

SA_P	TP68	SA_P
SA_N	TP69	SA_N
SB_P	TP70	SB_P
SB_N	TP71	SB_N
SC_P	TP72	SC_P
SC_N	TP73	SC_N

Comments: Company: EPFL Xplore Research Variant: DRAFT Git Hash: 38f2a13

Board Name: Project Name:

**Amulet Motion Controller** Chienpanzé

Sheet Title: Motor Control - Top Level	File Name: Motor Control - Top Level.kicad_sch	Designer: Vincent Nguyen	Date: 2023-12-20	Revision: 1.2+ (Unreleased)
Sheet Path: /Project Architecture/Motor Control - Top Level/	Reviewer:			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/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:**  
DRAFT

**Git Hash:**  
38f2a13

**Project Name:**  
**Chienpanzé**

**Revision:**  
1.2+ (Unreleased)

**Size:**  
**A4**

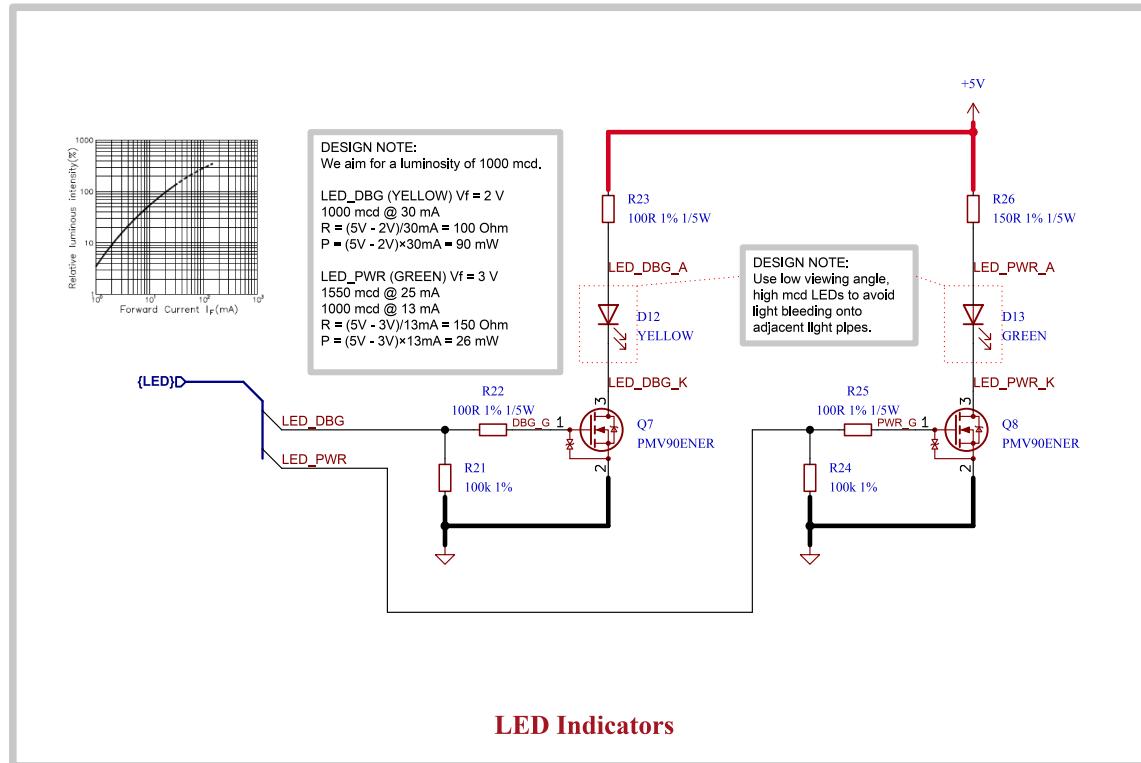
**Sheet:**  
**9** of 21

# [10] Misc - Board Version, DAC



	Comments:	Company: EPFL Xplore Research		Variant: DRAFT	Git Hash: 38f2a13
		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: 1.2+ (Unreleased)
	Sheet Path: <a href="/Project Architecture/Misc - Board Version, DAC/">/Project Architecture/Misc - Board Version, DAC/</a>		Reviewer:	Size: <b>A4</b>	Sheet: <b>10 of 21</b>

# [11] User - LED Indicators



A

A

B

B

C

C

D

D

	Comments:	Company: EPFL Xplore Research	Variant: DRAFT	Git Hash: 38f2a13
	<b>Board Name:</b> <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
	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

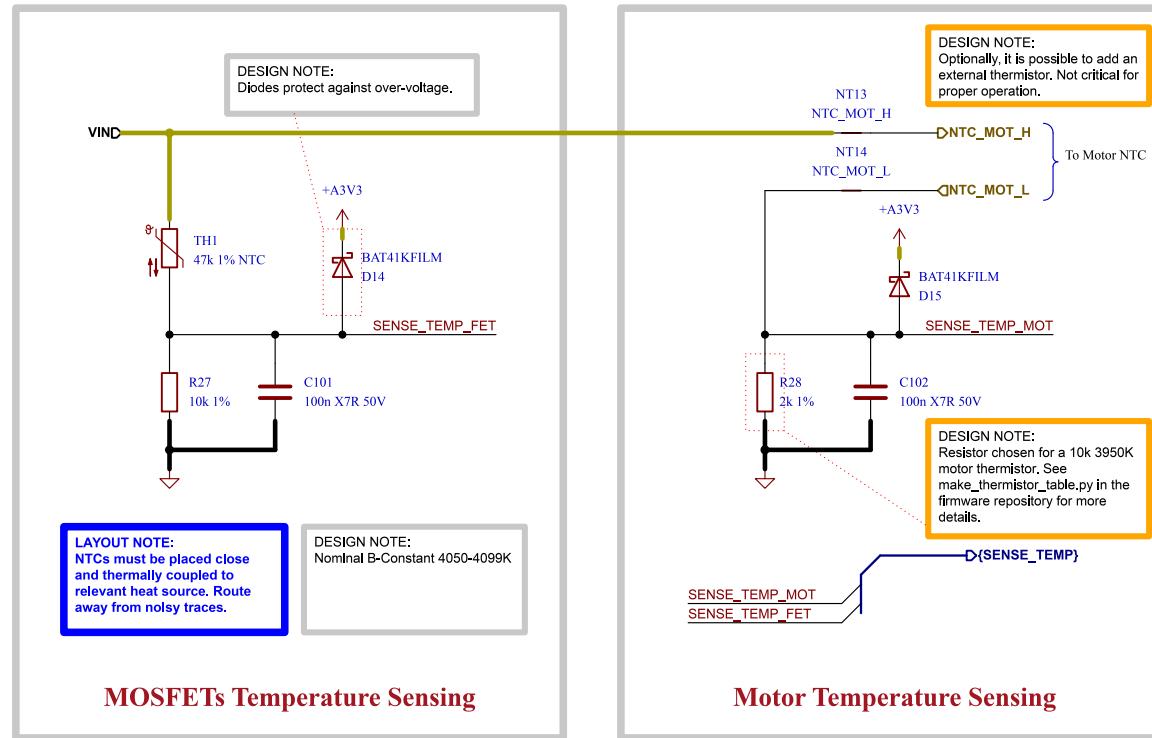
D

A

B

C

D



	Comments:	Company: EPFL Xplore Research	Variant: DRAFT	Git Hash: 38f2a13
	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    Revision: 1.2+ (Unreleased)
	Sheet Path: /Project Architecture/Sensing - Temperature/		Reviewer:	Size: A4    Sheet: 12 of 21

# [13] Sensing - Battery

A

A

B

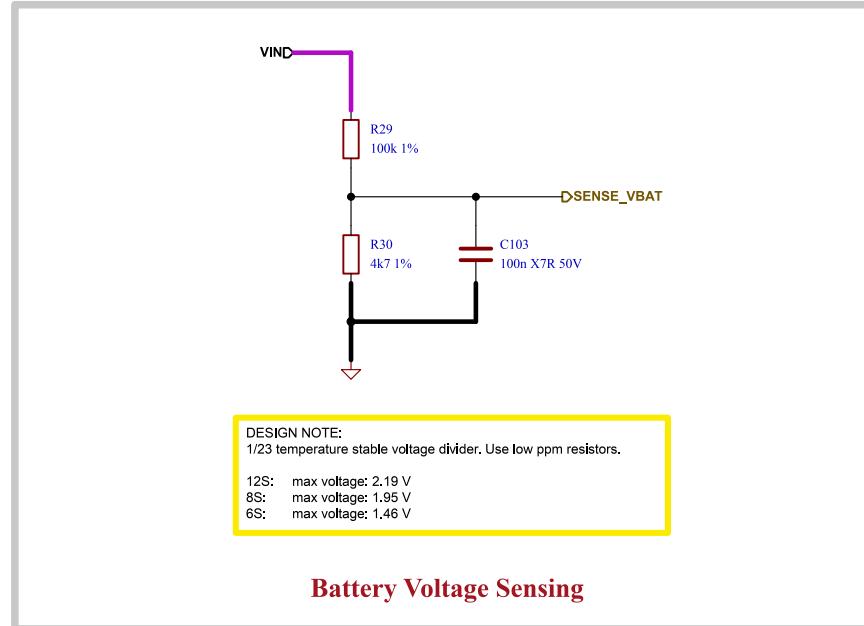
B

C

C

D

D



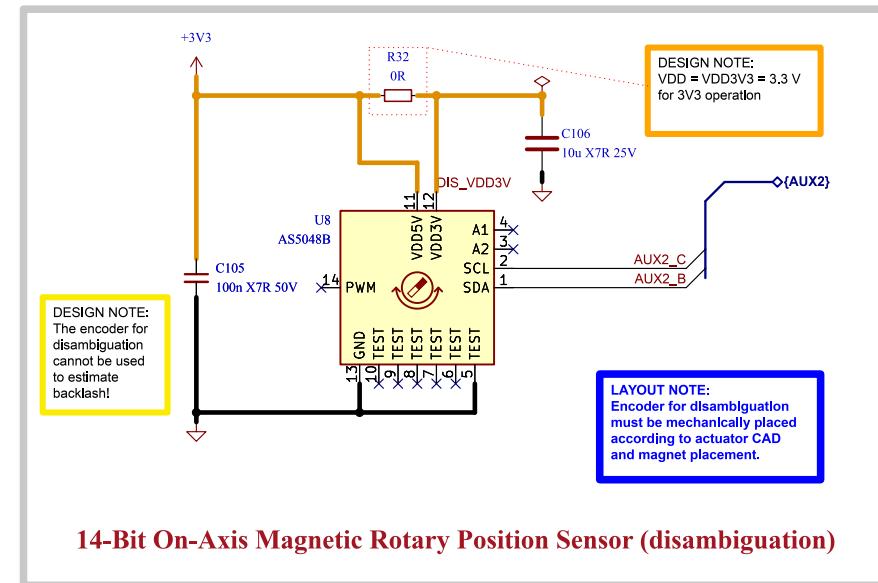
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	Board Name: <b>Amulet Motion Controller</b>			Project Name: <b>Chienpanzé</b>
	Sheet Title: Sensing - Battery	File Name: Sensing - Battery.kicad_sch	Designer: Vincent Nguyen	Date: 2023-10-14
	Sheet Path: /Project Architecture/Sensing - Battery/		Reviewer: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

# [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

Comments:	Company: EPFL Xplore Research	Variant: DRAFT	Git Hash: 38f2a13
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
Sheet Path: /Project Architecture/Sensing - Position/	Reviewer:	Size: <b>A4</b>	Sheet: <b>14 of 21</b>

# [15] Interface - RS-422



	Comments:	Company: EPFL Xplore Research	Variant: DRAFT	Git Hash: 38f2a13
	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
	Sheet Path: /Project Architecture/Interface - RS-422/		Reviewer:	Size: <b>A4</b>
				Sheet: <b>15</b> of <b>21</b>

# [16] Interface - FD-CAN



A

A

B

B

C

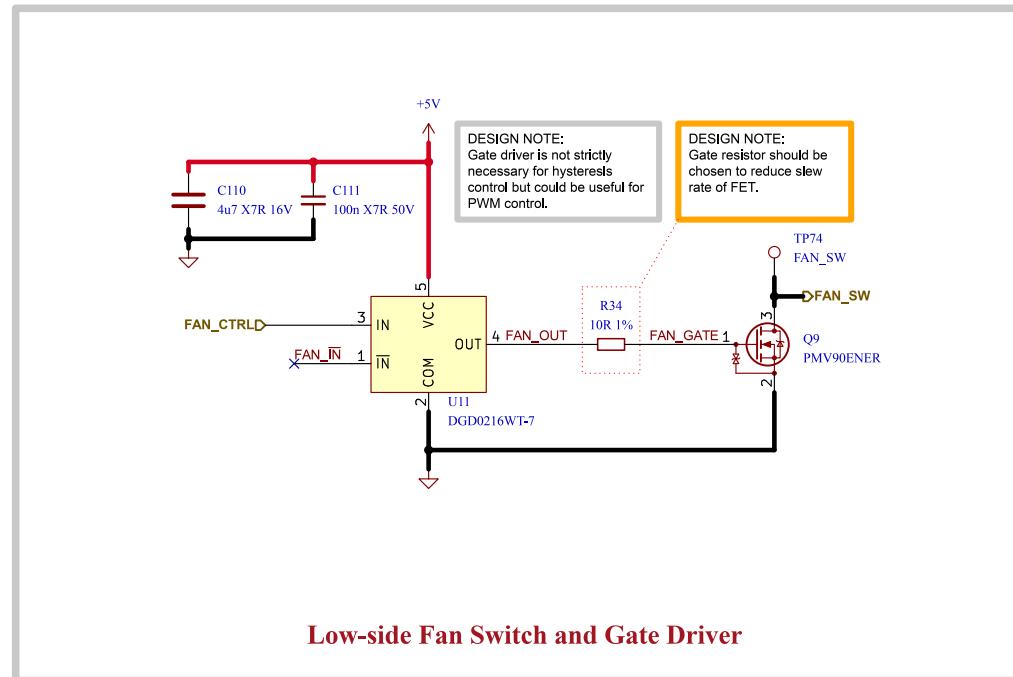
C

D

D

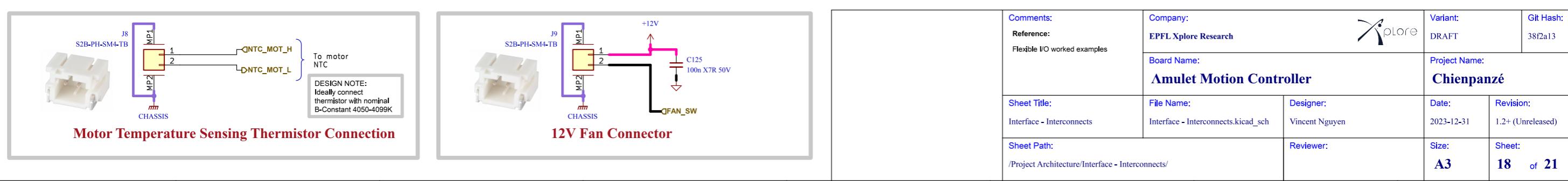
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	Board Name: <b>Amulet Motion Controller</b>			Project Name: <b>Chienpanzé</b>
	Sheet Title: Interface - FD-CAN	File Name: Interface - FD-CAN.kicad_sch	Designer: Vincent Nguyen	Date: 2023-10-15
	Sheet Path: /Project Architecture/Interface - FD-CAN/		Reviewer:	Size: <b>A4</b>
				Sheet: <b>16 of 21</b>

# [17] Interface - Fan Control



	Comments:	Company: EPFL Xplore Research	Variant: DRAFT	Git Hash: 38f2a13
	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: 1.2+ (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

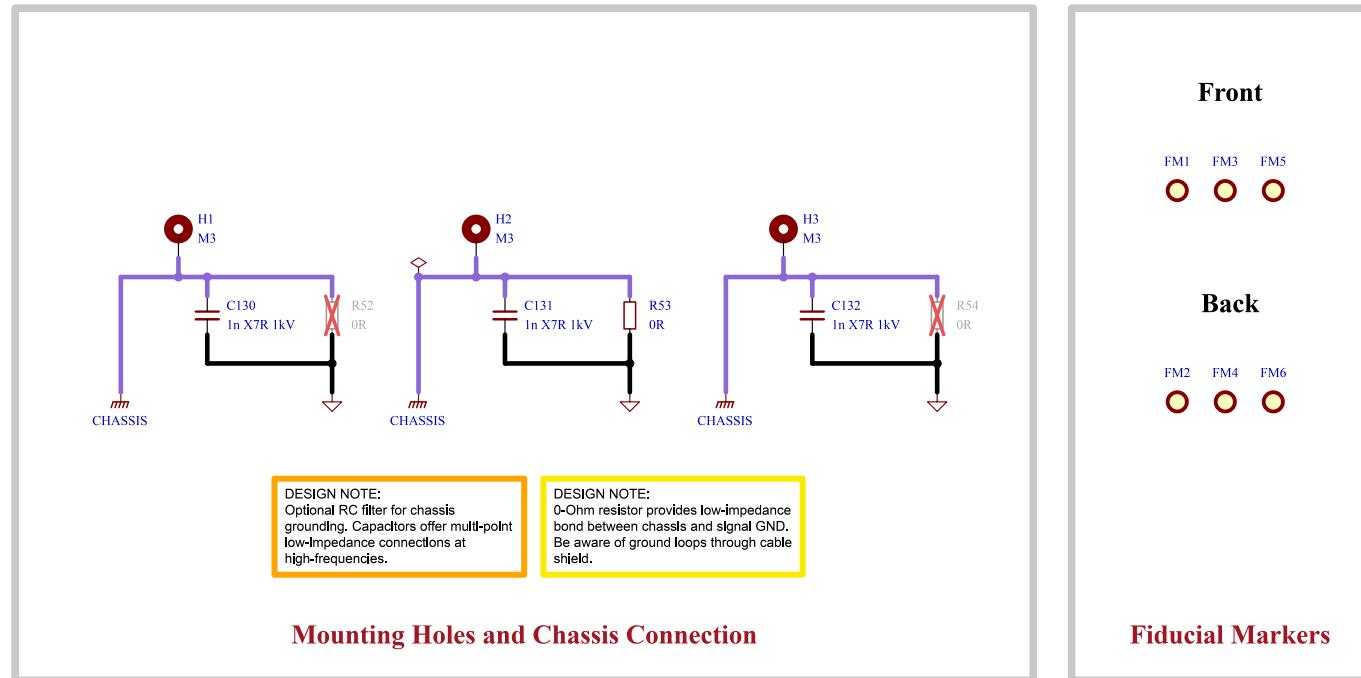
A

B

B

C

C



D

D

		Comments:	Company: EPFL Xplore Research	Variant: DRAFT	Git Hash: 38f2a13
		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: 1.2+ (Unreleased)		Reviewer:	Size: <b>A4</b>
		Sheet Path: /Project Architecture/Misc - Holes, Fiducials/			Sheet: <b>19 of 21</b>

# [20] Power - Sequencing

A



C

	Comments:	Company: EPFL Xplore Research	Variant: DRAFT	Git Hash: 38f2a13
		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
	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>		Variant: DRAFT	Git Hash: 38f2a13
		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> 1.2+ (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>