

# Amulet Motion Controller

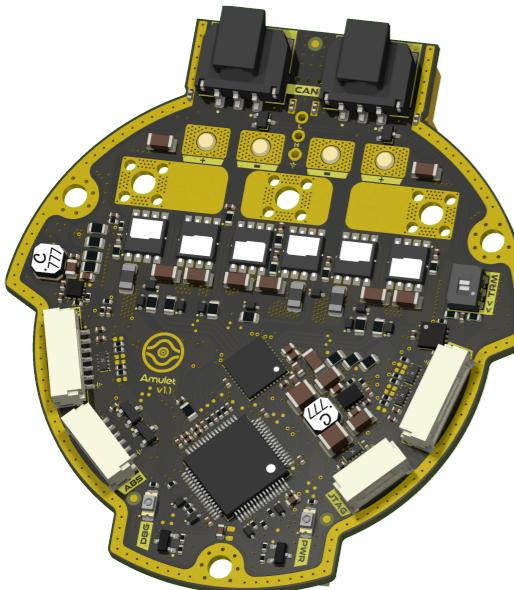
Variant: RELEASED

2024-11-25

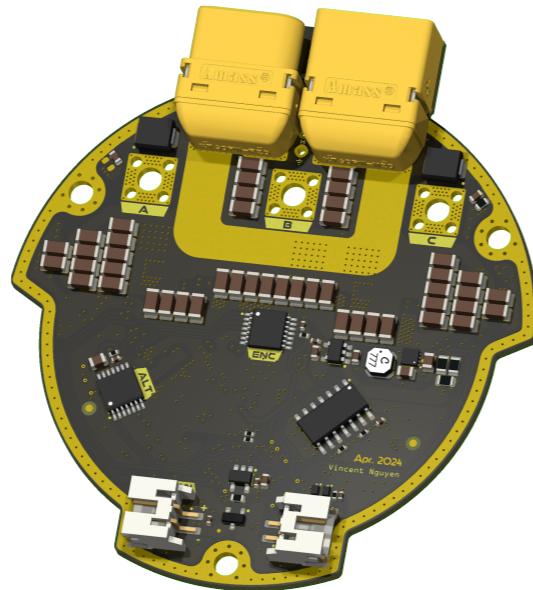
Rev Unreleased

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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.

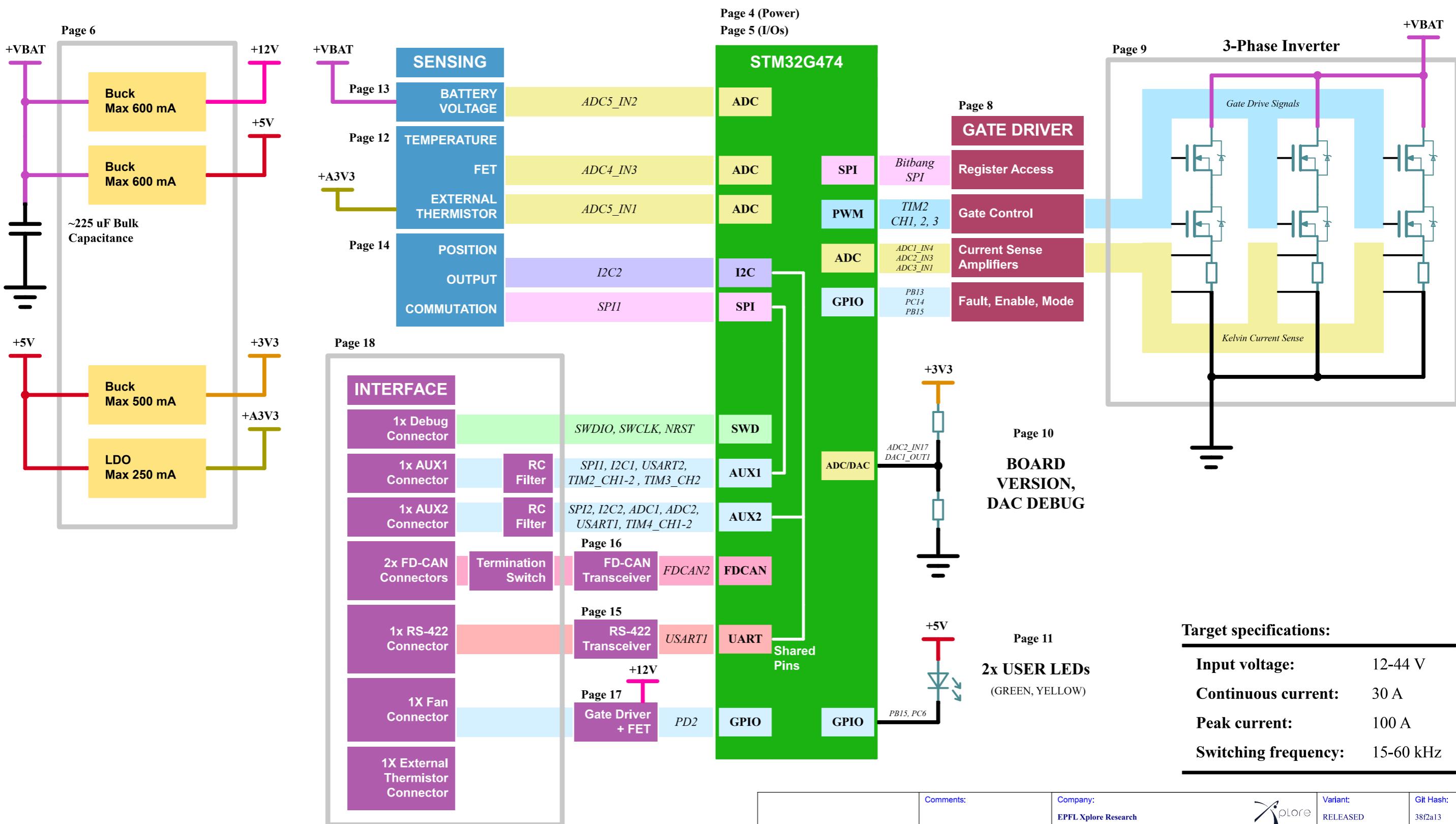
CHECKED - There shouldn't be any mistakes. Contact the engineer if you find any.

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

Date: 24-Nov-2024

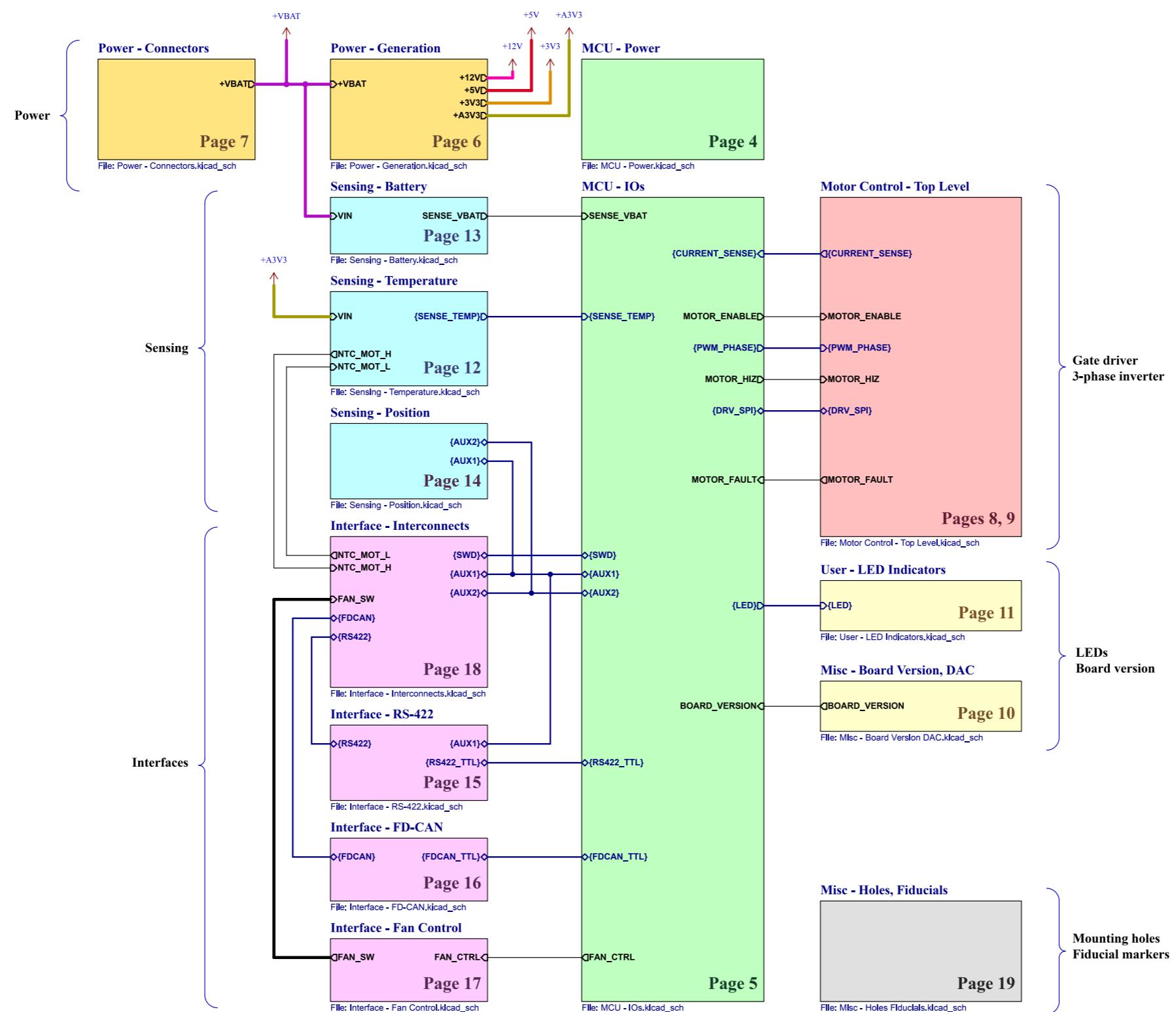
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	Board Name: <b>Amulet Motion Controller</b>	Project Name: <b>Chienpanzé</b>		
	Sheet Title: Cover Page	File Name: amulet_controller.kicad_sch	Designer: Vincent Nguyen	Date: 2024-04-13
	Sheet Path: /		Reviewer:	Size: <b>A3</b> Sheet: <b>1</b> of <b>21</b>

# [2] Block Diagram



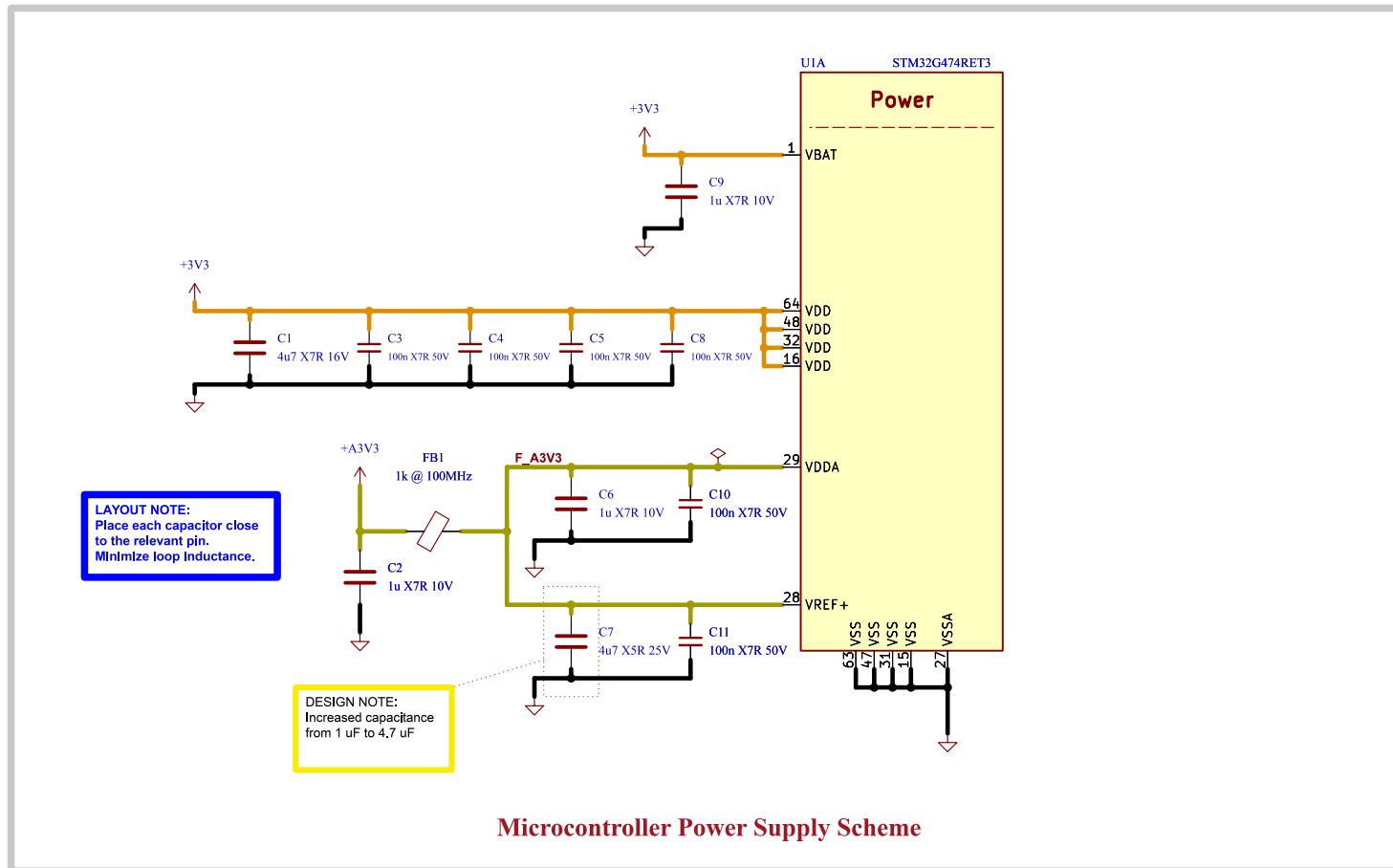
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	Board Name: <b>Amulet Motion Controller</b>		Project Name: <b>Chienpanzé</b>	
Sheet Title: Block Diagram	File Name: Block Diagram.kicad_sch		Designer: Vincent Nguyen	Date: 2024-04-13
Sheet Path: /Block Diagram/	Reviewer:		Size: <b>A3</b>	Sheet: <b>2</b> of <b>21</b>

# [3] Project Architecture



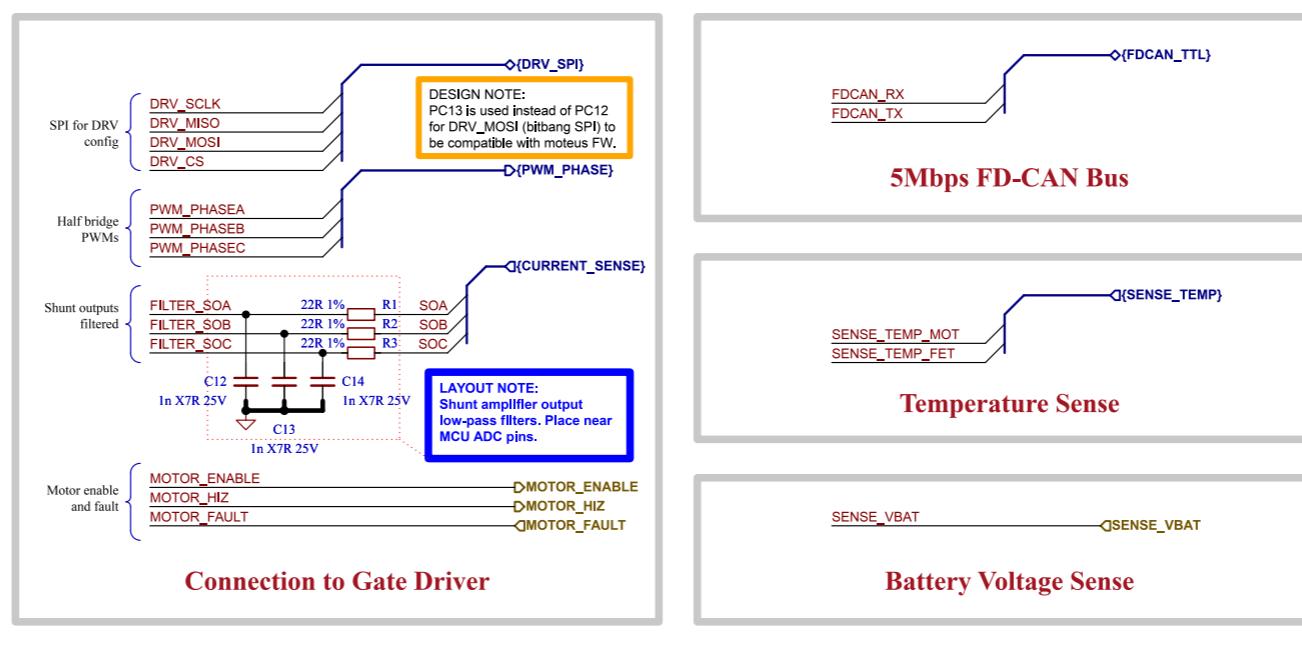
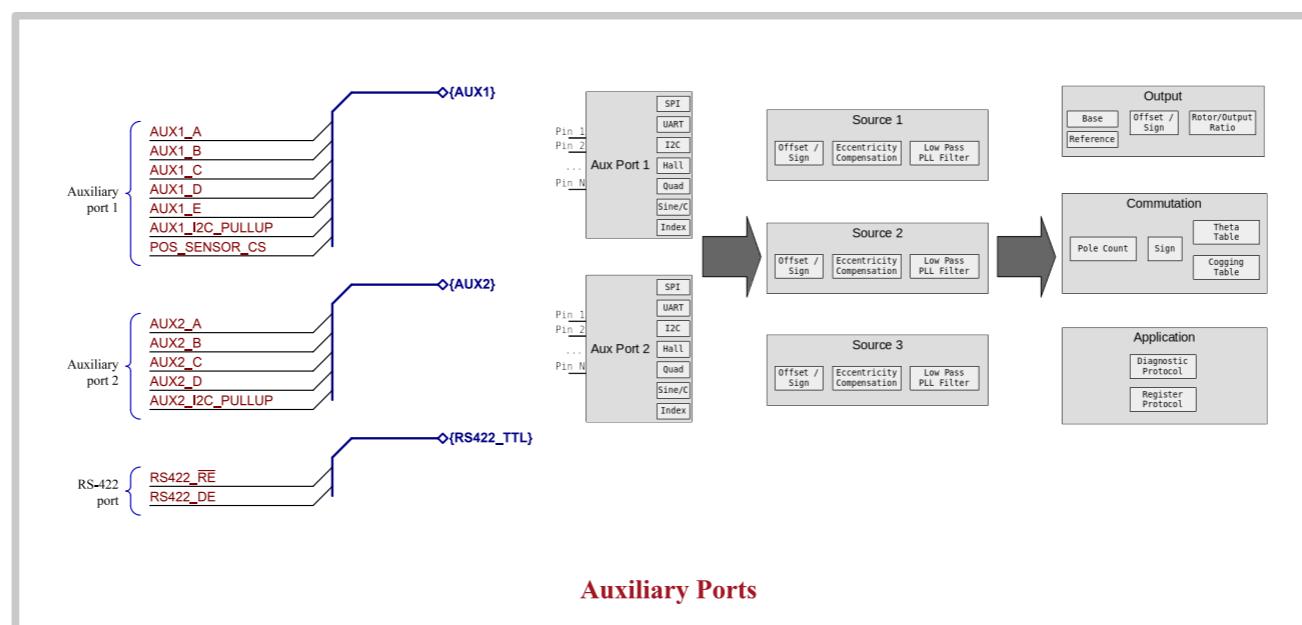
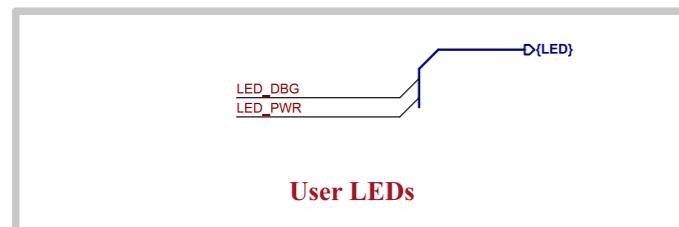
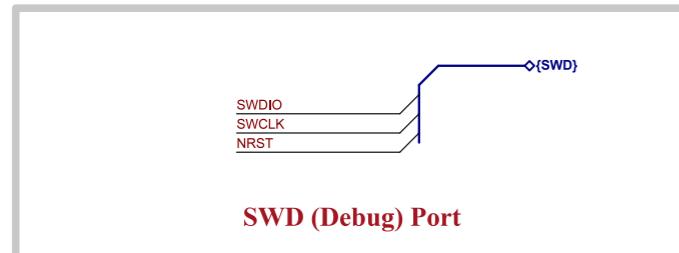
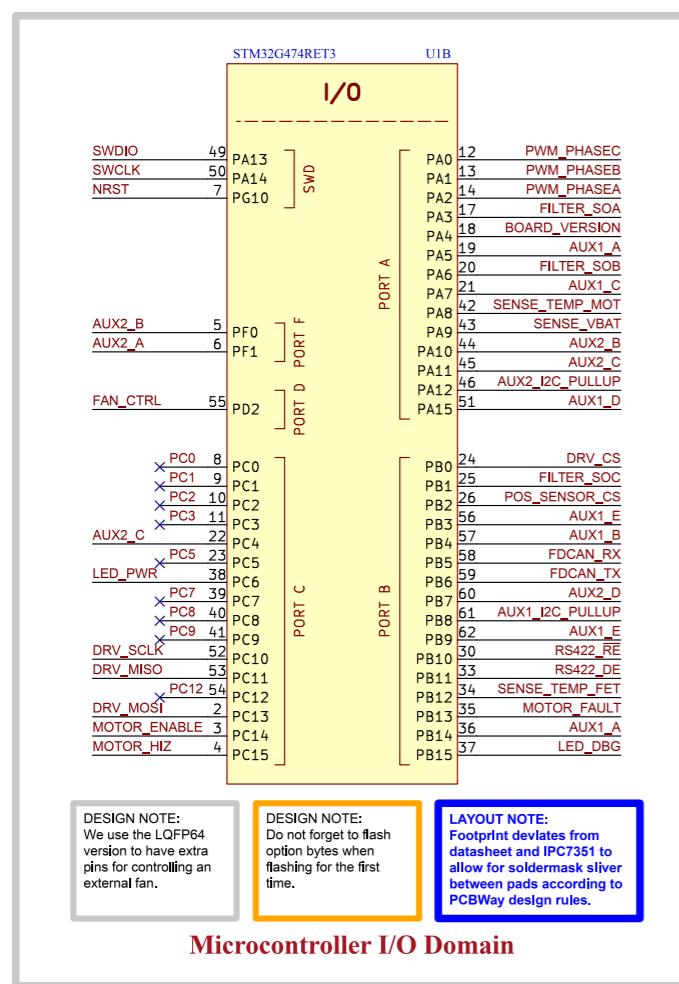
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	Sheet Title:	File Name:	Designer:	Date: 2023-12-22 Revision: Unreleased
	Project Architecture	Project Architecture.kicad_sch	Vincent Nguyen	
	Sheet Path:	/Project Architecture/		Reviewer:
				Size: <b>A3</b> Sheet: <b>3 of 21</b>

## [4] MCU - Power



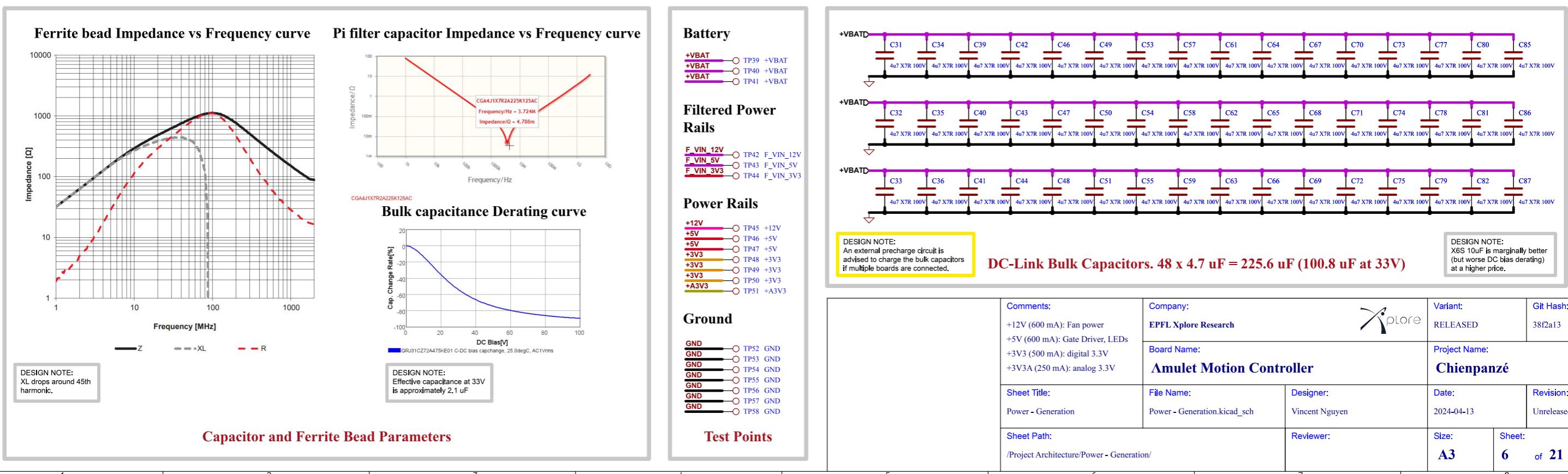
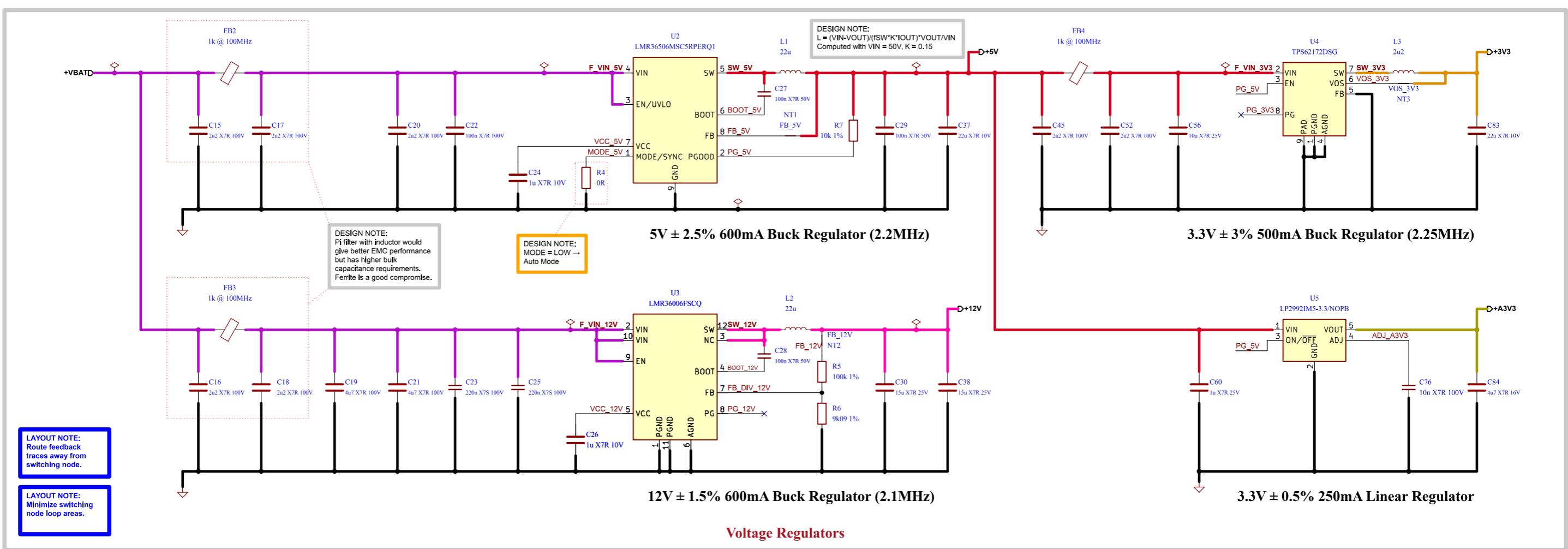
	Comments: AN5346 STM32G474 Datasheet p.81 J. Pieper ADC investigation	Company: EPFL Xplore Research	Variant: RELEASED	Git Hash: 38f2a13
	<b>Board Name:</b> <b>Amulet Motion Controller</b>			<b>Project Name:</b> <b>Chienpanzé</b>
	Sheet Title: MCU - Power	File Name: MCU - Power.kicad_sch	Designer: Vincent Nguyen	Date: 2023-12-18
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# [5] MCU - I/Os

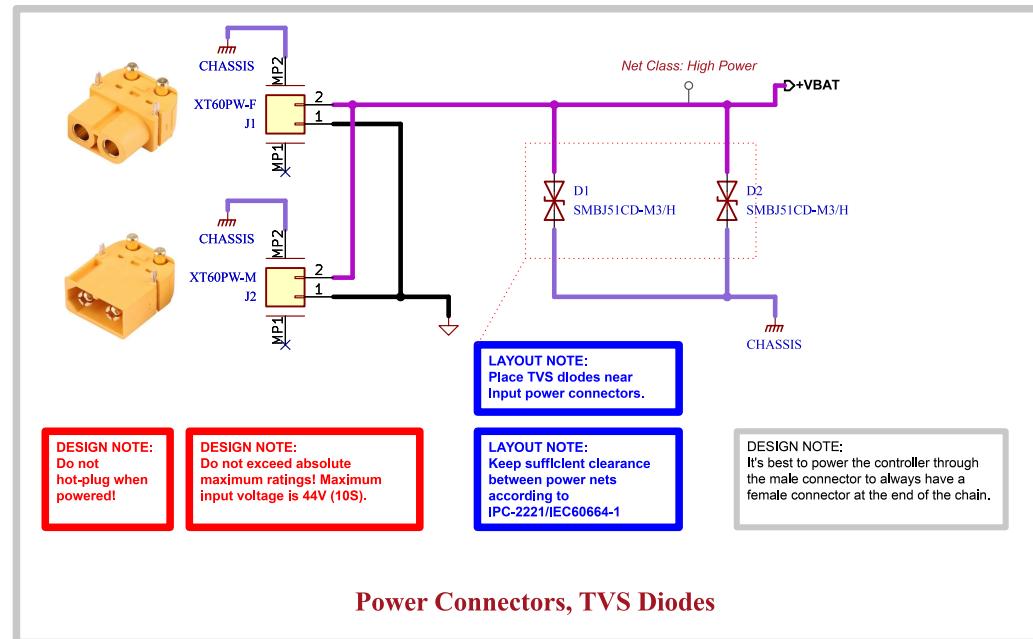


<b>Gate Driver</b>		
MOTOR_ENABLE	TP1	MOTOR_ENABLE
MOTOR_HIZ	TP2	MOTOR_HIZ
MOTOR_FAULT	TP3	MOTOR_FAULT
DRV_SCLK	TP4	DRV_SCLK
DRV_MISO	TP5	DRV_MISO
DRV_MOSI	TP6	DRV_MOSI
DRV_CS	TP7	DRV_CS
PWM_PHASEA	TP8	PWM_PHASEA
PWM_PHASEB	TP9	PWM_PHASEB
PWM_PHASEC	TP10	PWM_PHASEC
SOA	TP11	SOA
SOB	TP12	SOB
SOC	TP13	SOC
<b>Debug</b>		
SWDIO	TP14	SWDIO
SWCLK	TP15	SWCLK
NRST	TP16	NRST
<b>Auxiliary pins 1</b>		
AUX1_A	TP17	AUX1_A
AUX1_B	TP18	AUX1_B
AUX1_C	TP19	AUX1_C
AUX1_D	TP20	AUX1_D
AUX1_E	TP21	AUX1_E
AUX1_I2C_PULLUP	TP22	AUX1_I2C_PULLUP
POS_SENSOR_CS	TP23	POS_SENSOR_CS
<b>Auxiliary pins 2</b>		
AUX2_A	TP24	AUX2_A
AUX2_B	TP25	AUX2_B
AUX2_C	TP26	AUX2_C
AUX2_D	TP27	AUX2_D
AUX2_I2C_PULLUP	TP28	AUX2_I2C_PULLUP
<b>Temperature Sense</b>		
SENSE_TEMP_MOT	TP29	RS422_RE
SENSE_TEMP_FET	TP30	RS422_DE
<b>Battery Voltage Sense</b>		
SENSE_VBAT	TP31	LED_DBG
SENSE_VBAT	TP32	LED_PWR
<b>Comments:</b>		
<b>References:</b>		
Flexible I/O worked examples		
Flexible I/O source configuration		
<b>Company:</b>		
EPFL Xplore Research		
<b>Board Name:</b>		
<b>Amulet Motion Controller</b>		
<b>Sheet Title:</b>	<b>File Name:</b>	<b>Designer:</b>
MCU - I/Os	MCU - IOs.kicad_sch	Vincent Nguyen
<b>Sheet Path:</b>	<b>Reviewer:</b>	
/Project Architecture/MCU - IOs/		
<b>Size:</b>	<b>Sheet:</b>	
A3	5	of 21

# [6] Power - Generation

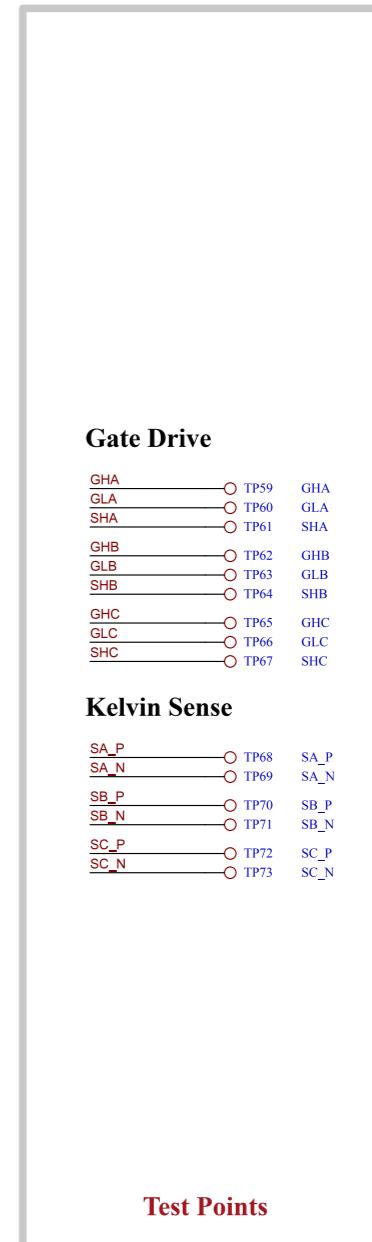
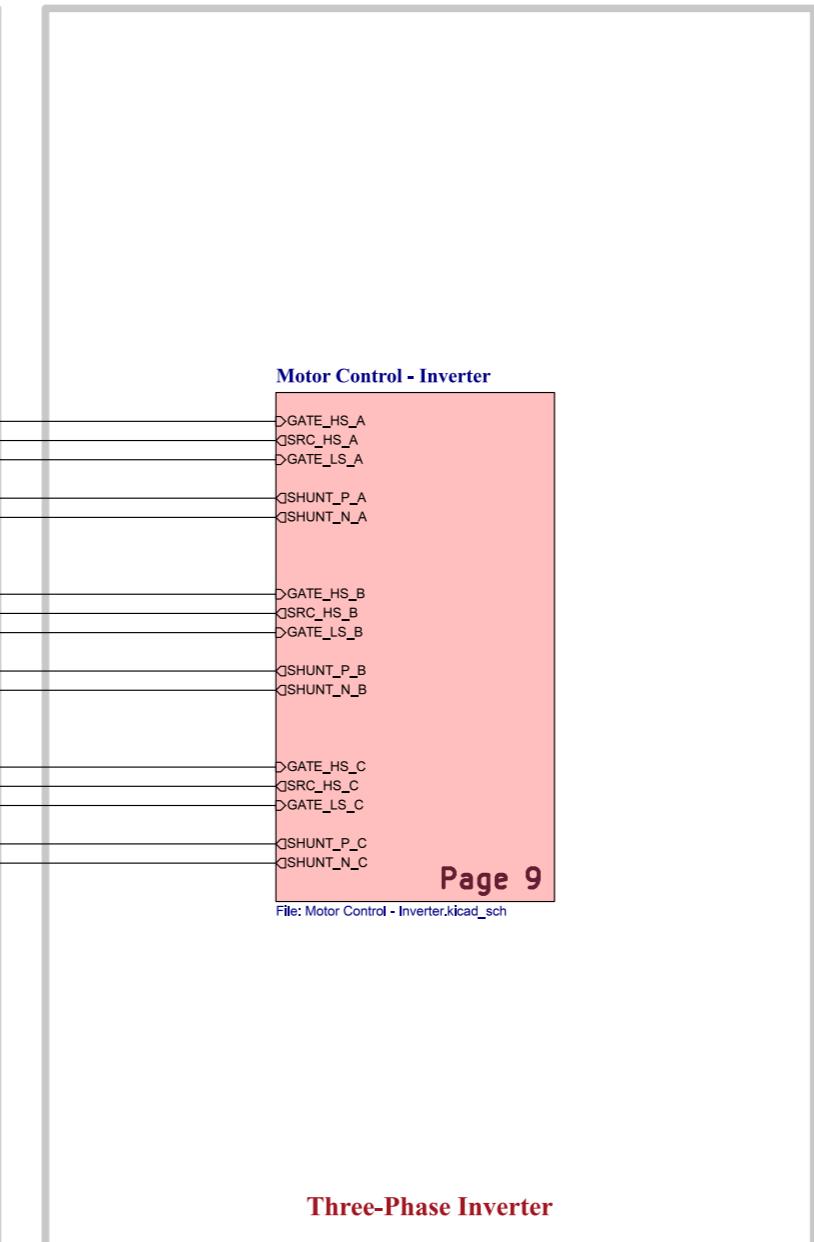
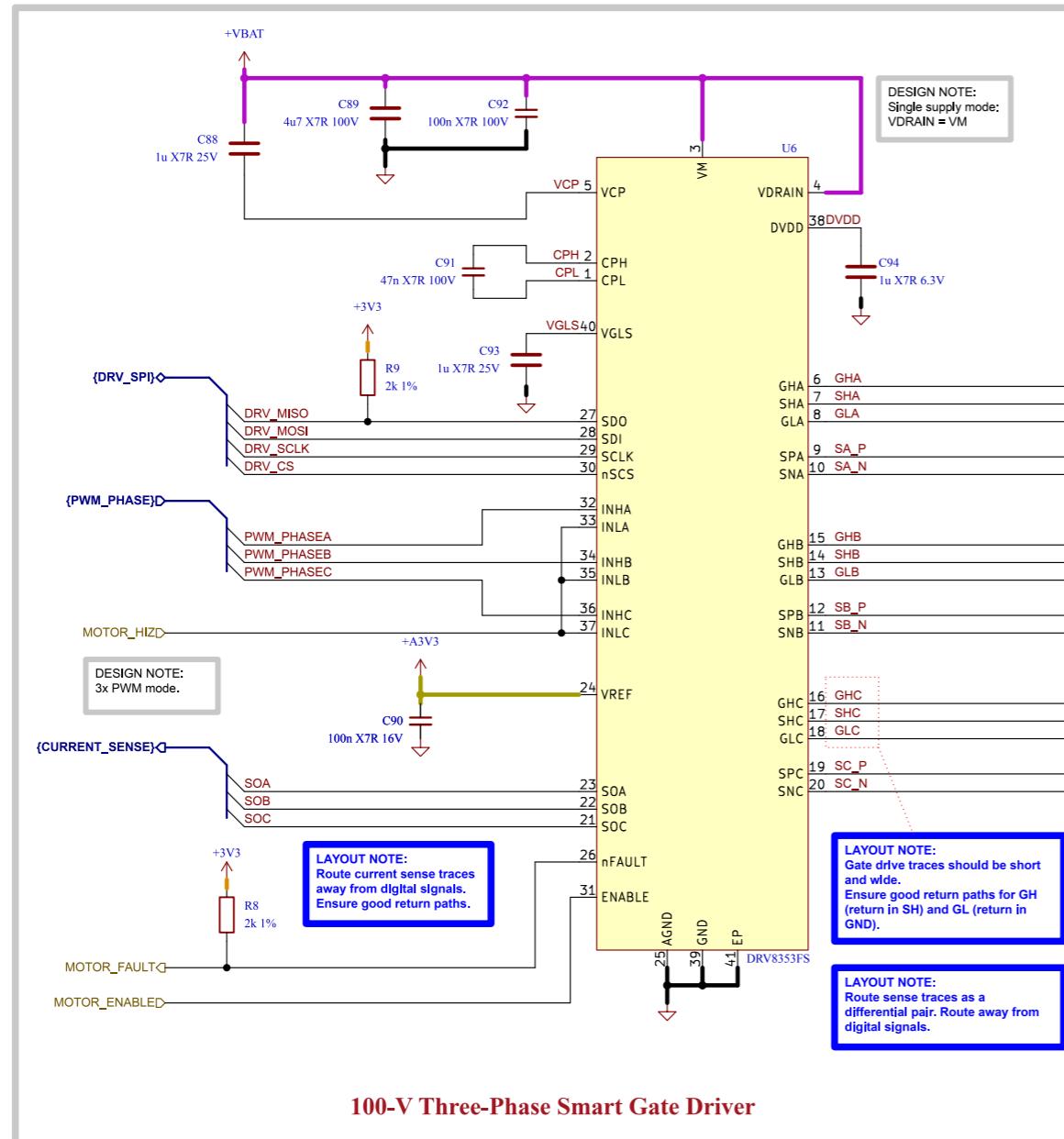


# [7] Power - Connectors



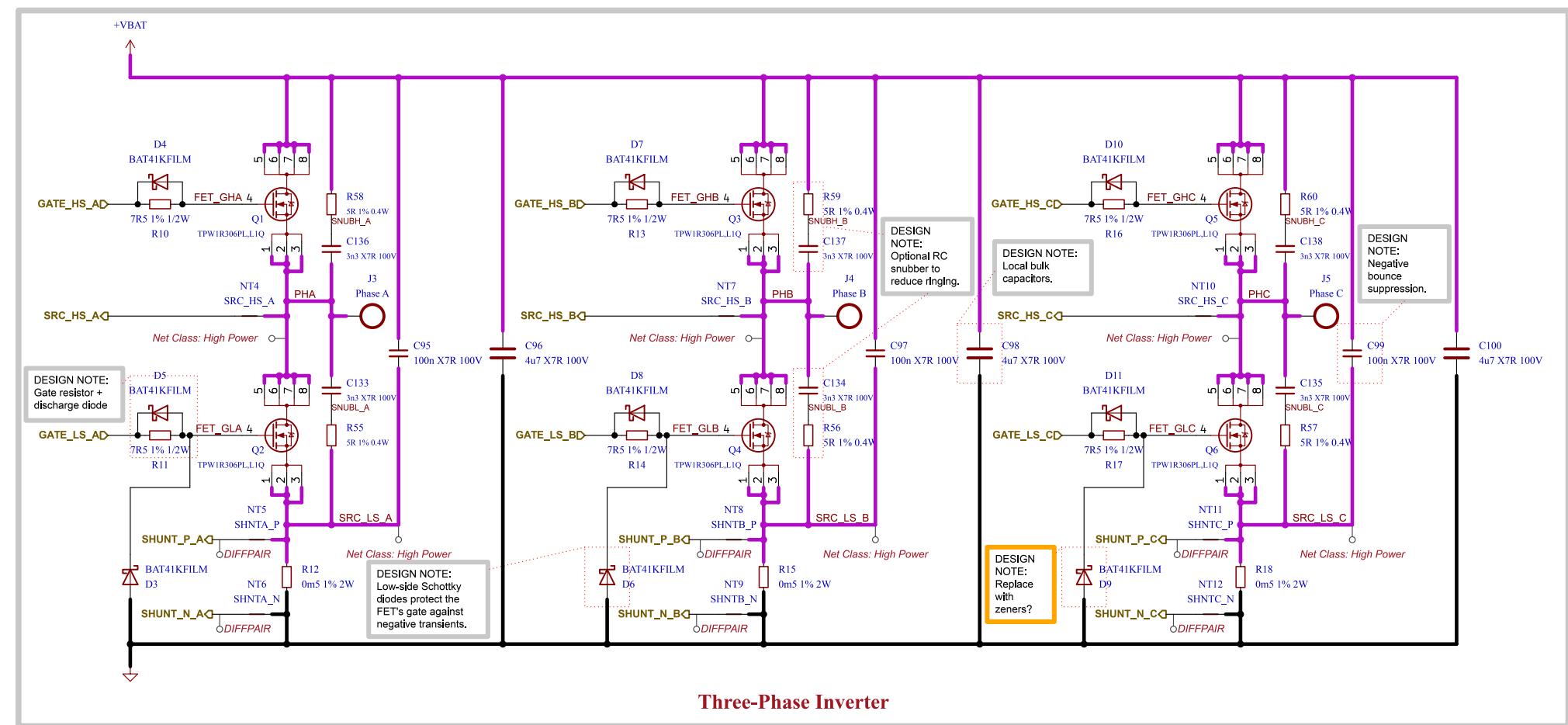
	Comments:  Power - Connectors	Company: EPFL Xplore Research  Board Name: <b>Amulet Motion Controller</b>	Variant: RELEASED	Git Hash: 38f2a13
	Sheet Title: Power - Connectors	File Name: Power - Connectors.kicad_sch Designer: Vincent Nguyen	Date: 2023-12-31	Revision: Unreleased
	Sheet Path: /Project Architecture/Power - Connectors/	Reviewer:	Size: <b>A4</b>	Sheet: <b>7</b> of <b>21</b>

# [8] Motor Control - Top Level



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

**Board Name:** Amulet Motion Controller

Sheet Title:

Motor Control - Inverter

**ANSWER**

/Project Architecture/Motor Control - Top Level/Motor Control - Inverter



Variant:	Git Hash:
RELEASED	38f2a13

Project Name:  
**Chienpanzé**

Date:	Revision:
2024-01-25	Unreleased

$\mathbf{C}_i$        $\mathbf{C}_{i+1}$

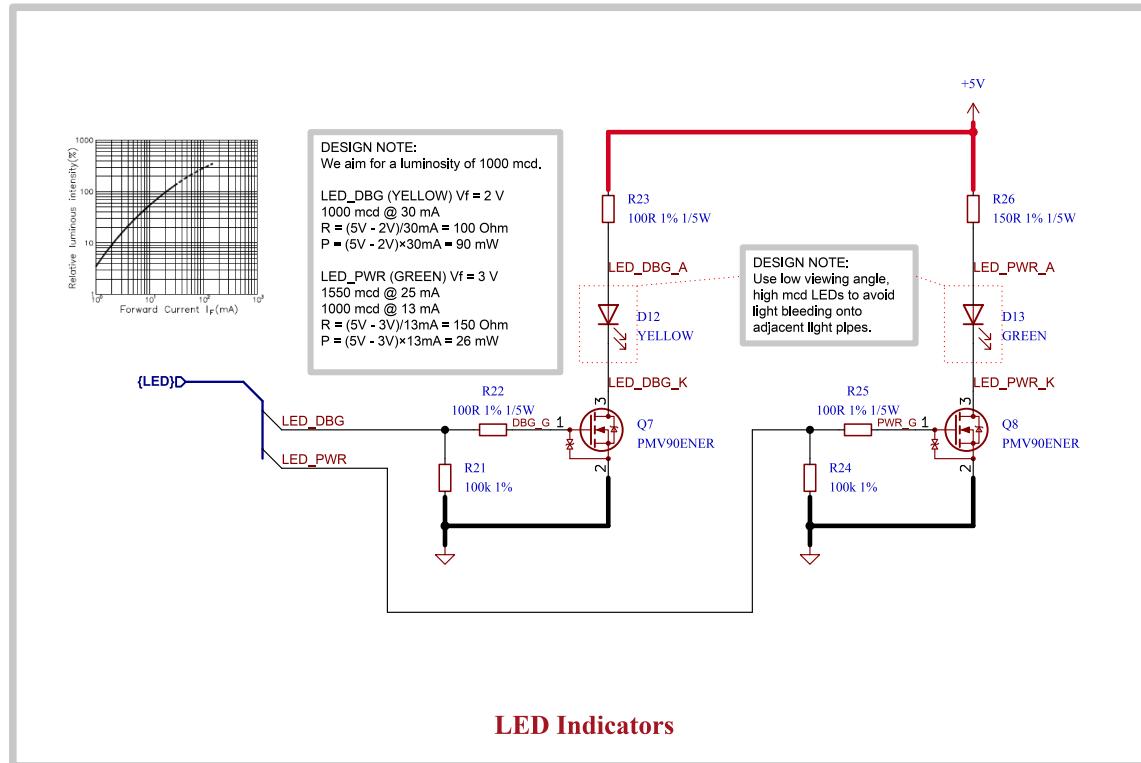
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# [10] Misc - Board Version, DAC



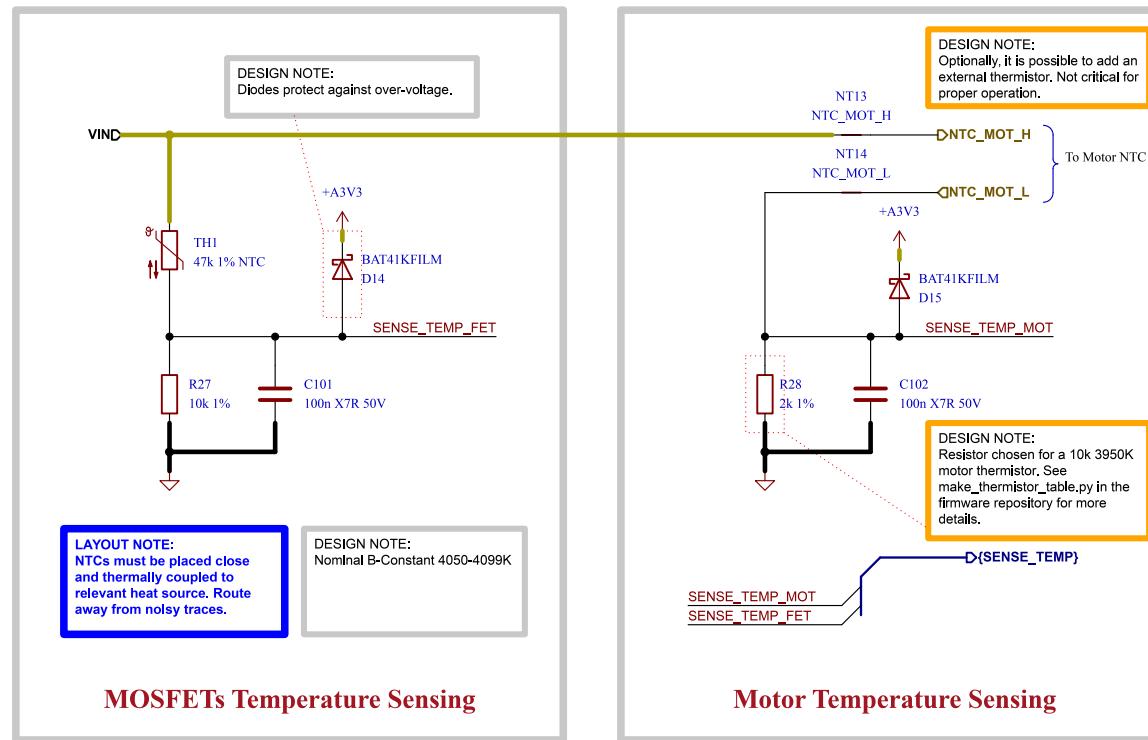
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		Board Name: <b>Amulet Motion Controller</b>		
Sheet Title:	File Name: Misc - Board Version DAC.kicad_sch	Designer: Vincent Nguyen	Date: 2024-04-13	Revision: Unreleased
Sheet Path: <a href="#">/Project Architecture/Misc - Board Version, DAC/</a>		Reviewer:	Size: <b>A4</b>	Sheet: <b>10</b> of <b>21</b>

# [11] User - LED Indicators



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



# [13] Sensing - Battery

A

A

B

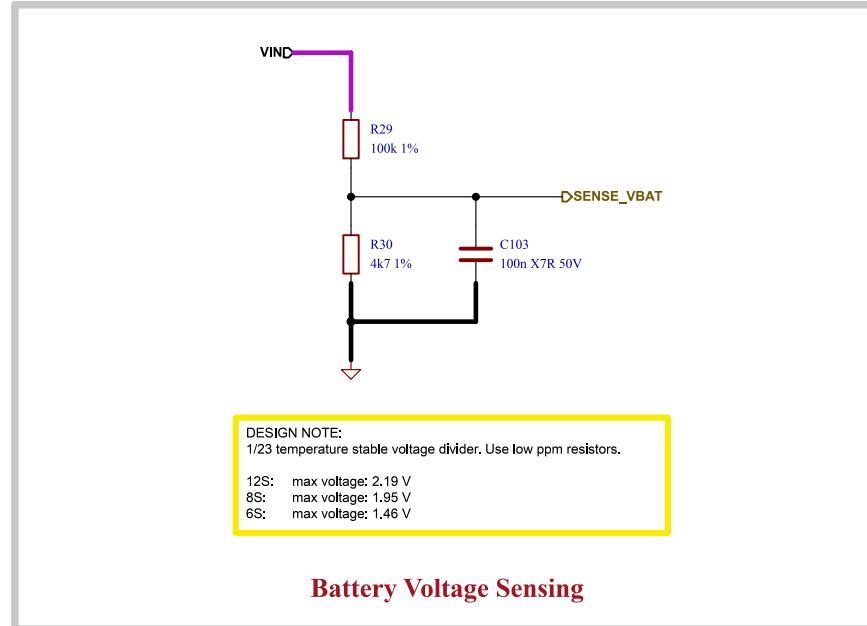
B

C

C

D

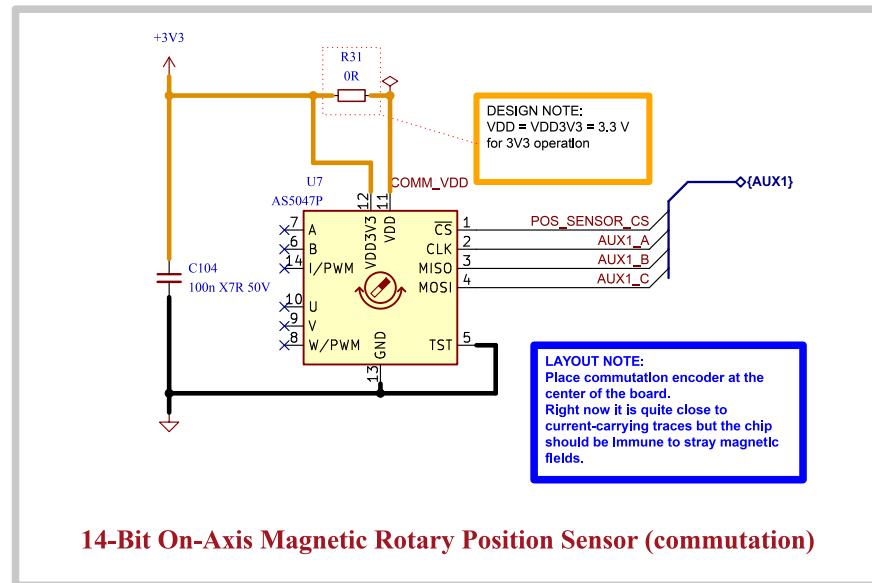
D



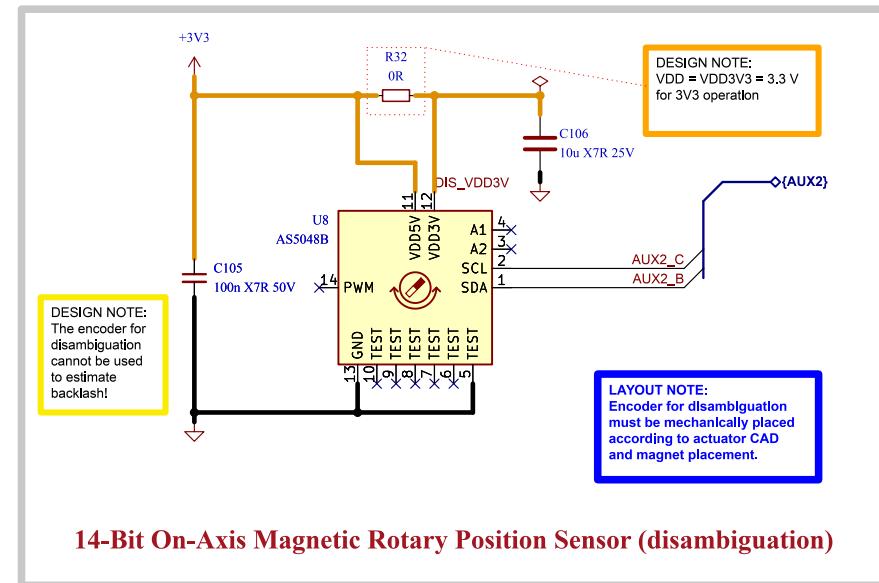
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	Board Name: <b>Amulet Motion Controller</b>			Project Name: <b>Chienpanzé</b>
	Sheet Title: Sensing - Battery	File Name: Sensing - Battery.kicad_sch	Designer: Vincent Nguyen	Date: 2023-10-14
	Sheet Path: /Project Architecture/Sensing - Battery/		Reviewer: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

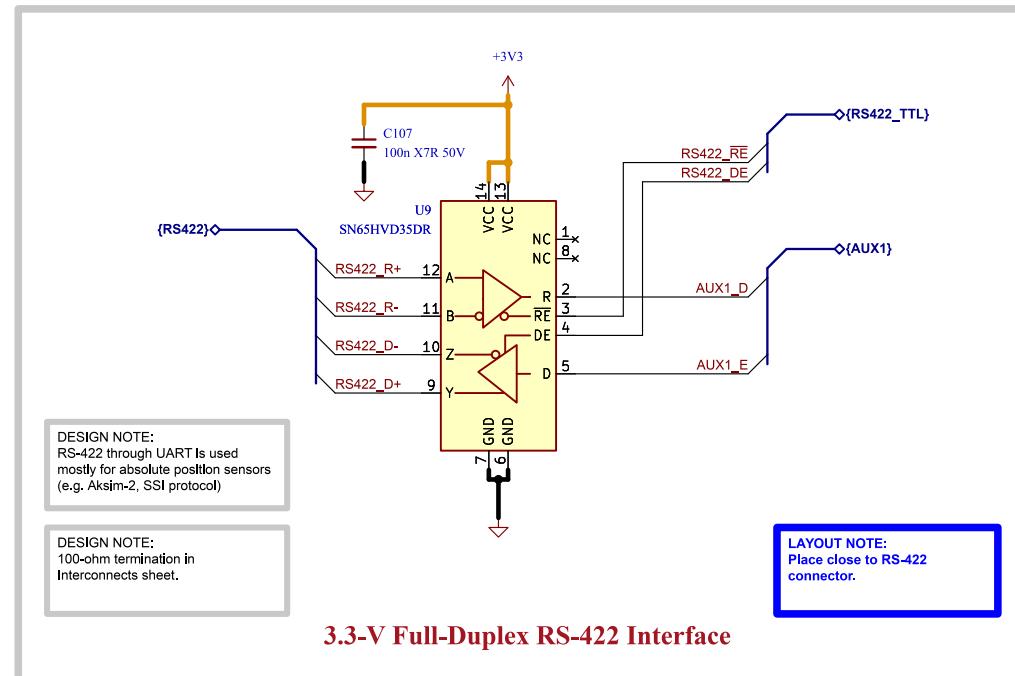


C

D

Comments:	Company: EPFL Xplore Research	Variant: RELEASED	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</b> of <b>21</b>

# [15] Interface - RS-422



A

A

B

B

C

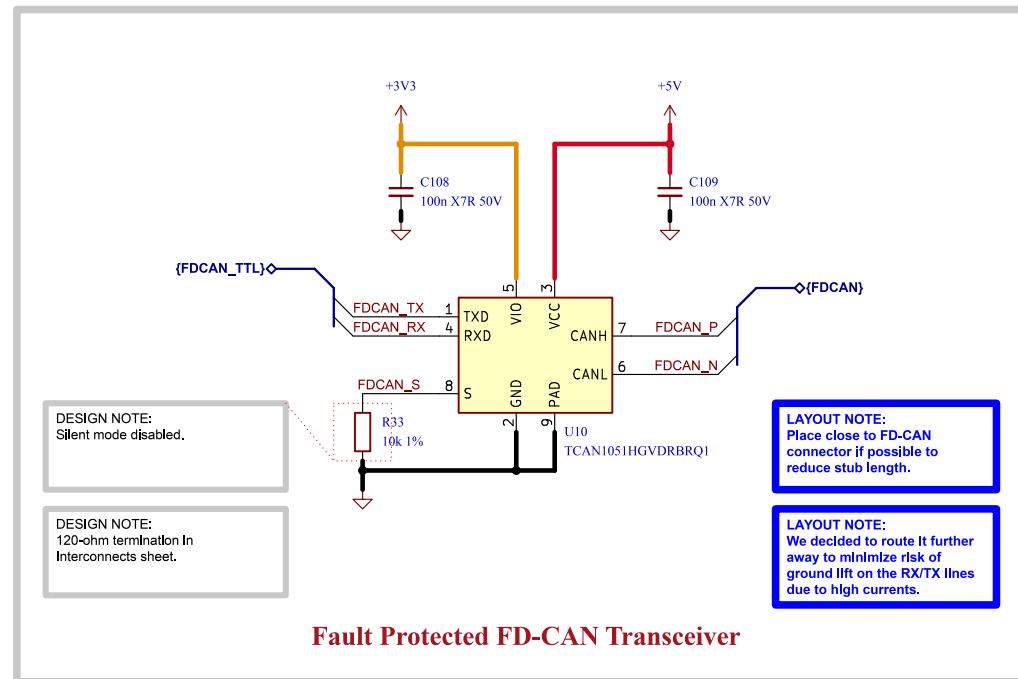
C

D

D

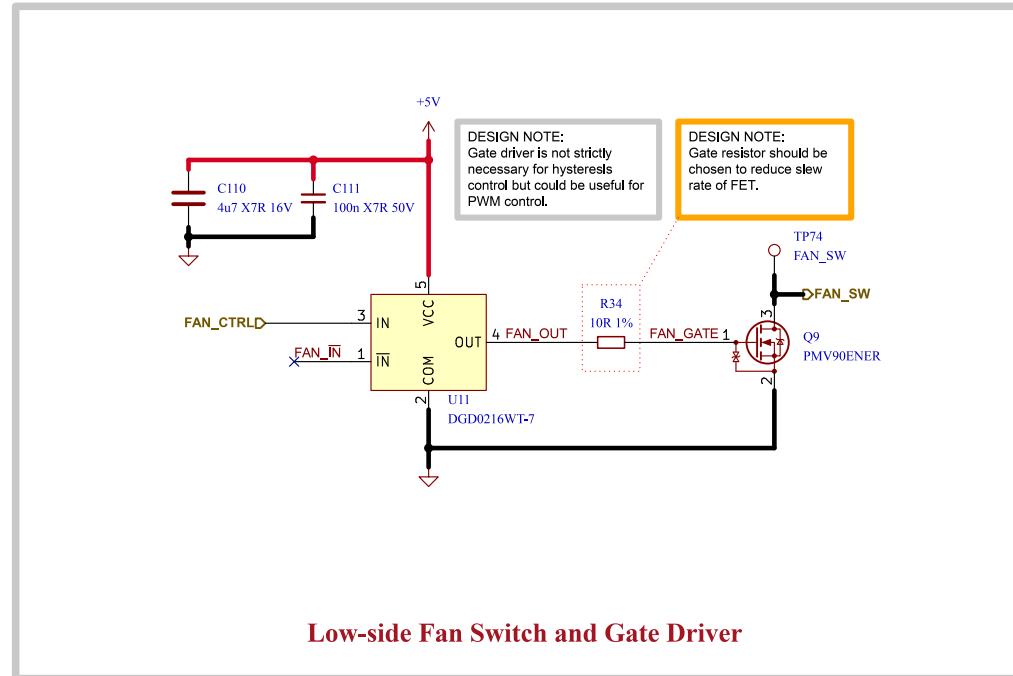
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	Board Name: <b>Amulet Motion Controller</b>			Project Name: <b>Chienpanzé</b>
	Sheet Title: Interface - RS-422	File Name: Interface - RS-422.kicad_sch	Designer: Vincent Nguyen	Date: 2023-10-15
	Sheet Path: /Project Architecture/Interface - RS-422/		Reviewer:	Size: <b>A4</b> Sheet: <b>15</b> of <b>21</b>

# [16] Interface - FD-CAN



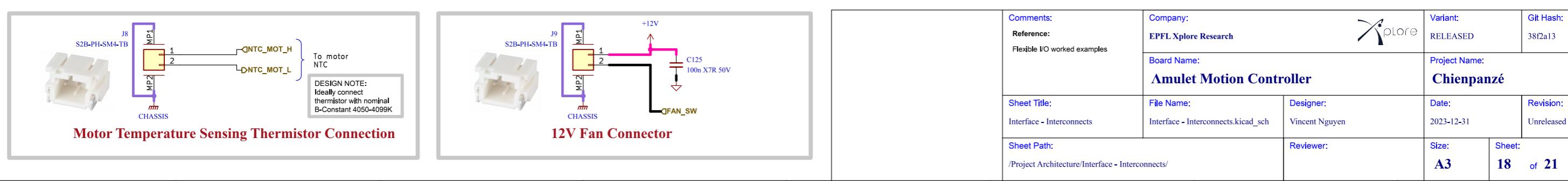
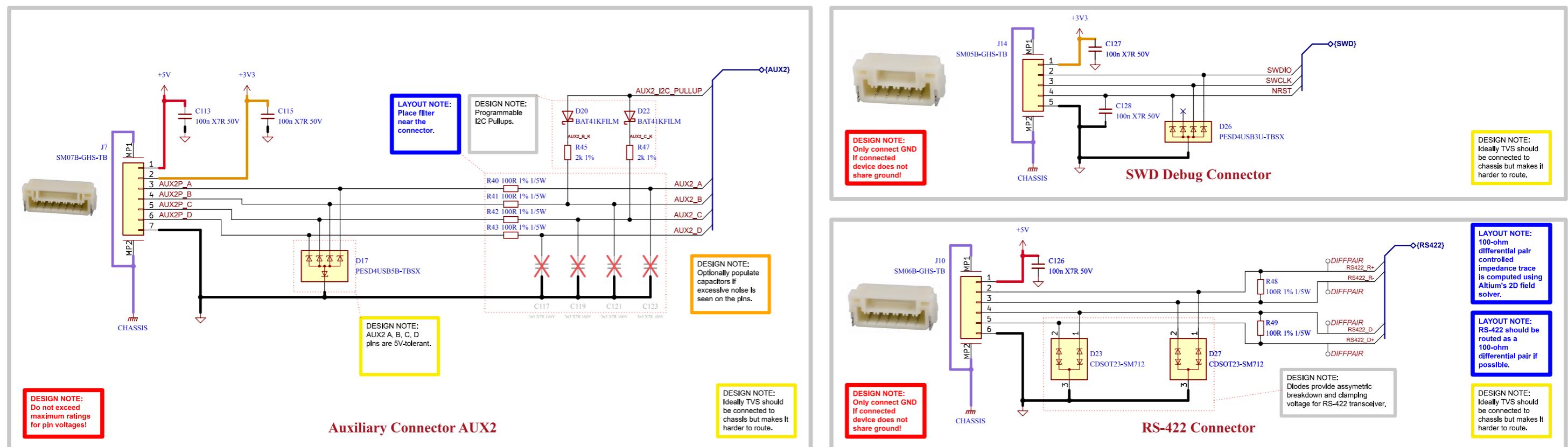
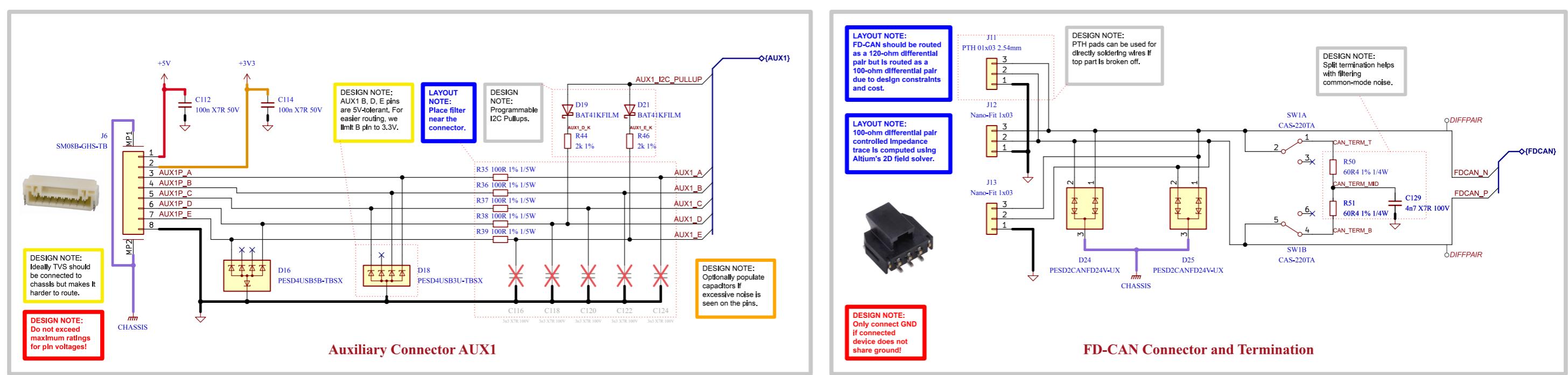
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	Board Name: <b>Amulet Motion Controller</b>			Project Name: <b>Chienpanzé</b>
	Sheet Title: Interface - FD-CAN	File Name: Interface - FD-CAN.kicad_sch	Designer: Vincent Nguyen	Date: 2023-10-15
	Sheet Path: /Project Architecture/Interface - FD-CAN/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

# [17] Interface - Fan Control



	Comments:	Company: EPFL Xplore Research	Variant: RELEASED	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
	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

B

C

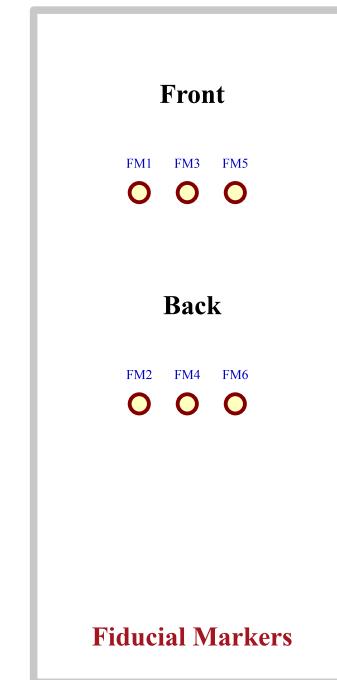
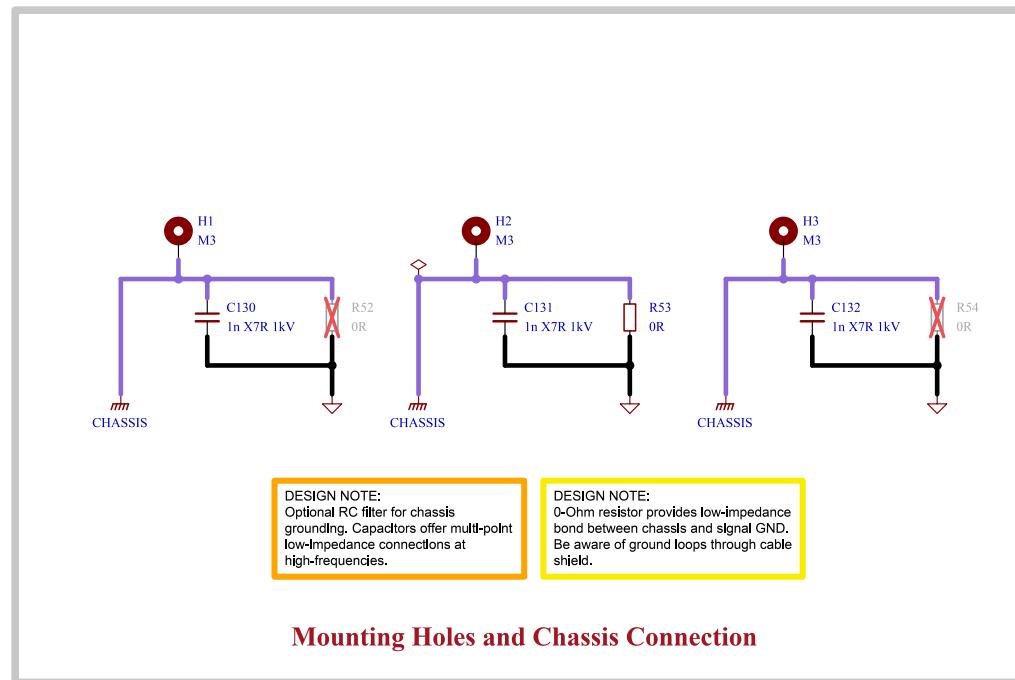
D

A

B

C

D



		Comments:	Company: EPFL Xplore Research	Variant: RELEASED	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
		Sheet Path: /Project Architecture/Misc - Holes, Fiducials/		Reviewer:	Size: <b>A4</b> Sheet: <b>19</b> of <b>21</b>

# [20] Power - Sequencing

A



B

C

D

	Comments:	Company: EPFL Xplore Research	Variant: RELEASED	Git Hash: 38f2a13
		Board Name: <b>Amulet Motion Controller</b>		
	Sheet Title: Power - Sequencing	File Name: Power - Sequencing.kicad_sch	Designer: Vincent Nguyen	Date: 2024-03-12
	Sheet Path: /Power - Sequencing/			Revision: Unreleased
		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: RELEASED	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> 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>