

Amulet Motion Controller

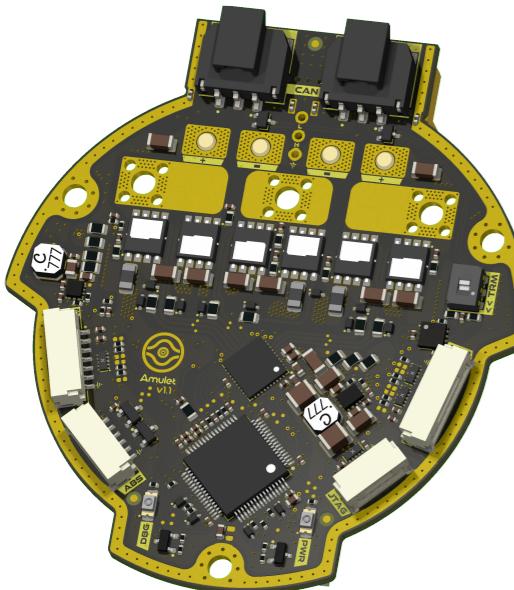
Variant: CHECKED

2024-11-29

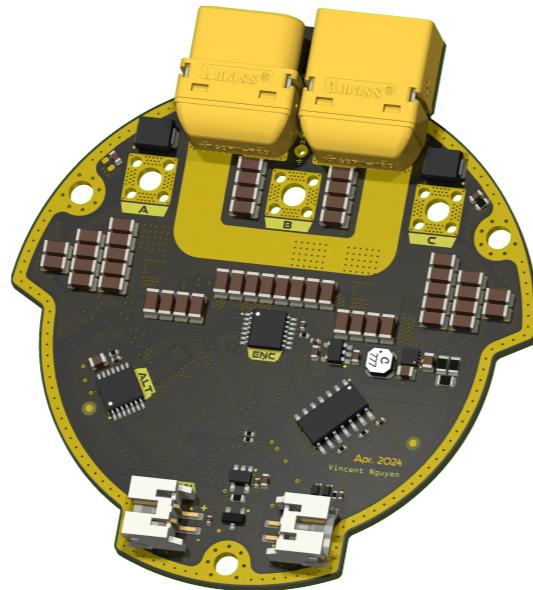
Rev 1.1.1+ (Unreleased)

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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.

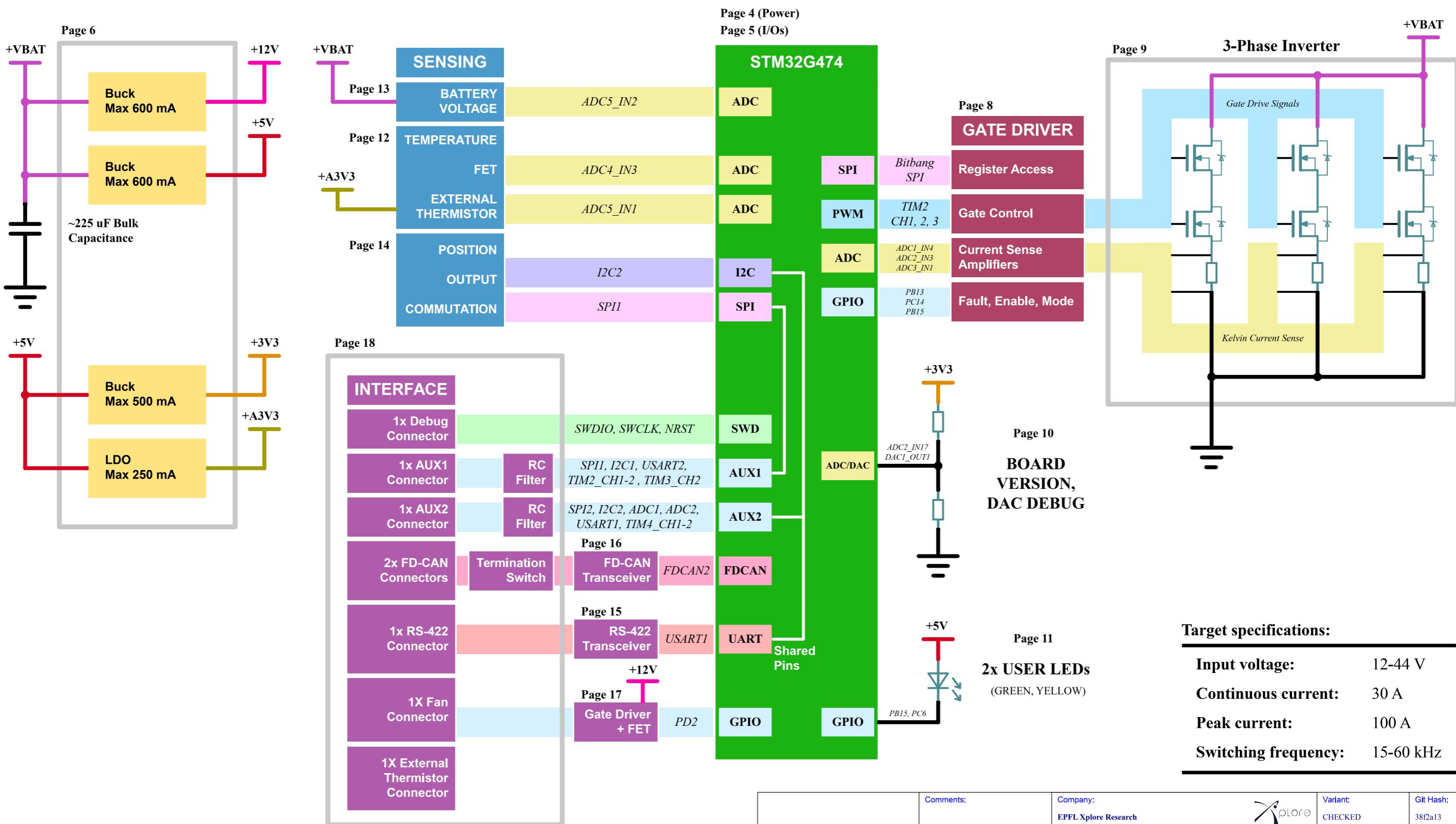
CHECKED - There shouldn't be any mistakes. Contact the engineer if you find any.

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

Date: 29-Nov-2024

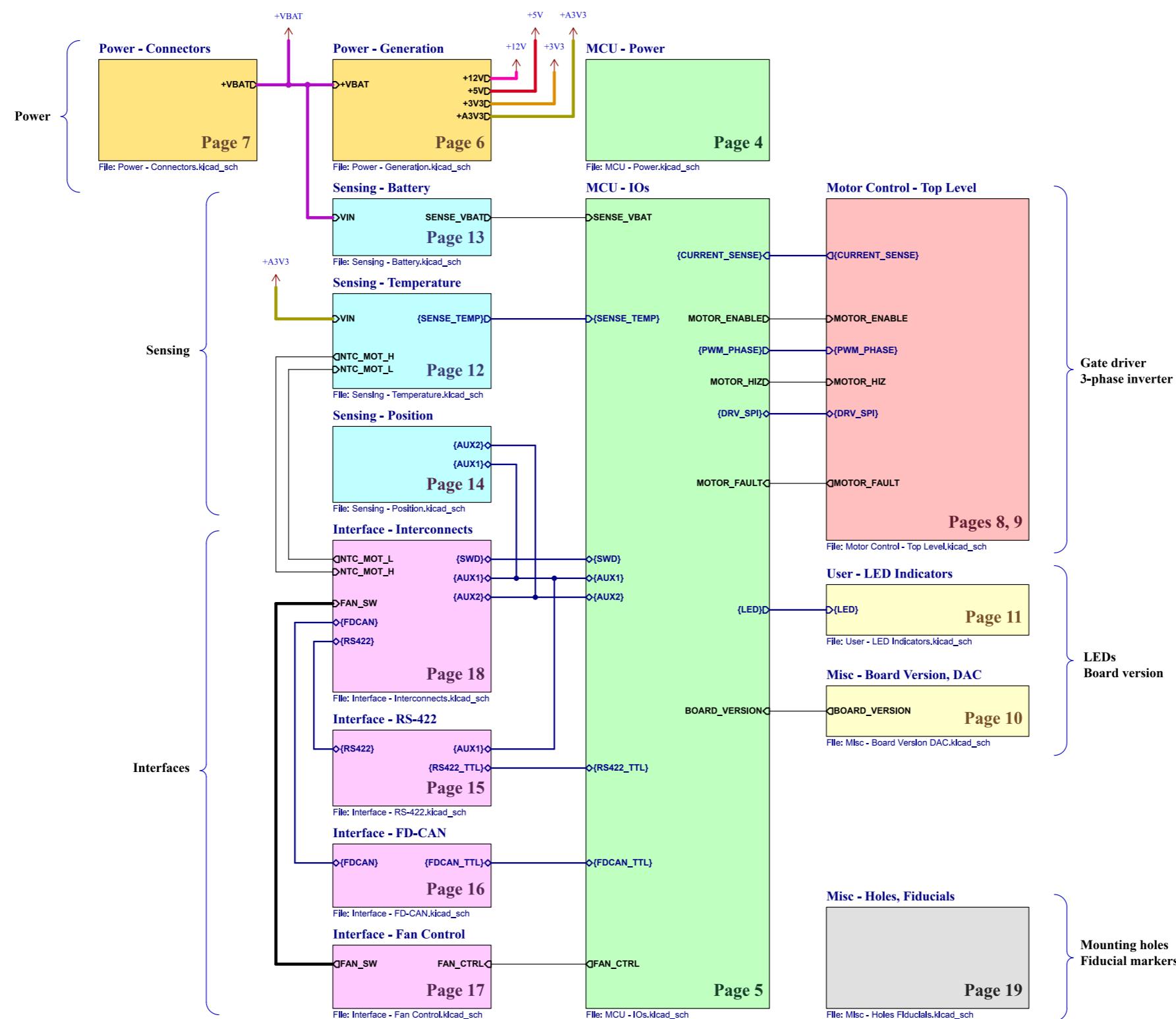
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| | Comments: | Company: | Xplore | Variant: | Git Hash: | | |
| | | EPFL Xplore Research | | | | | |
| | Board Name: | Amulet Motion Controller | | | Project Name: | | |
| | | Chienpanzé | | | | | |
| | Sheet Title: | File Name: | Designer: | Date: | Revision: | | |
| | Cover Page | amulet_controller.kicad_sch | Vincent Nguyen | 2024-04-13 | 1.1.1+ (Unreleased) | | |
| | Sheet Path: | / | | Reviewer: | Size: | | |
| | / | | | | Sheet: | | |
| | | A3 | | 1 | of 21 | | |
| | | | | | | | |

[2] Block Diagram



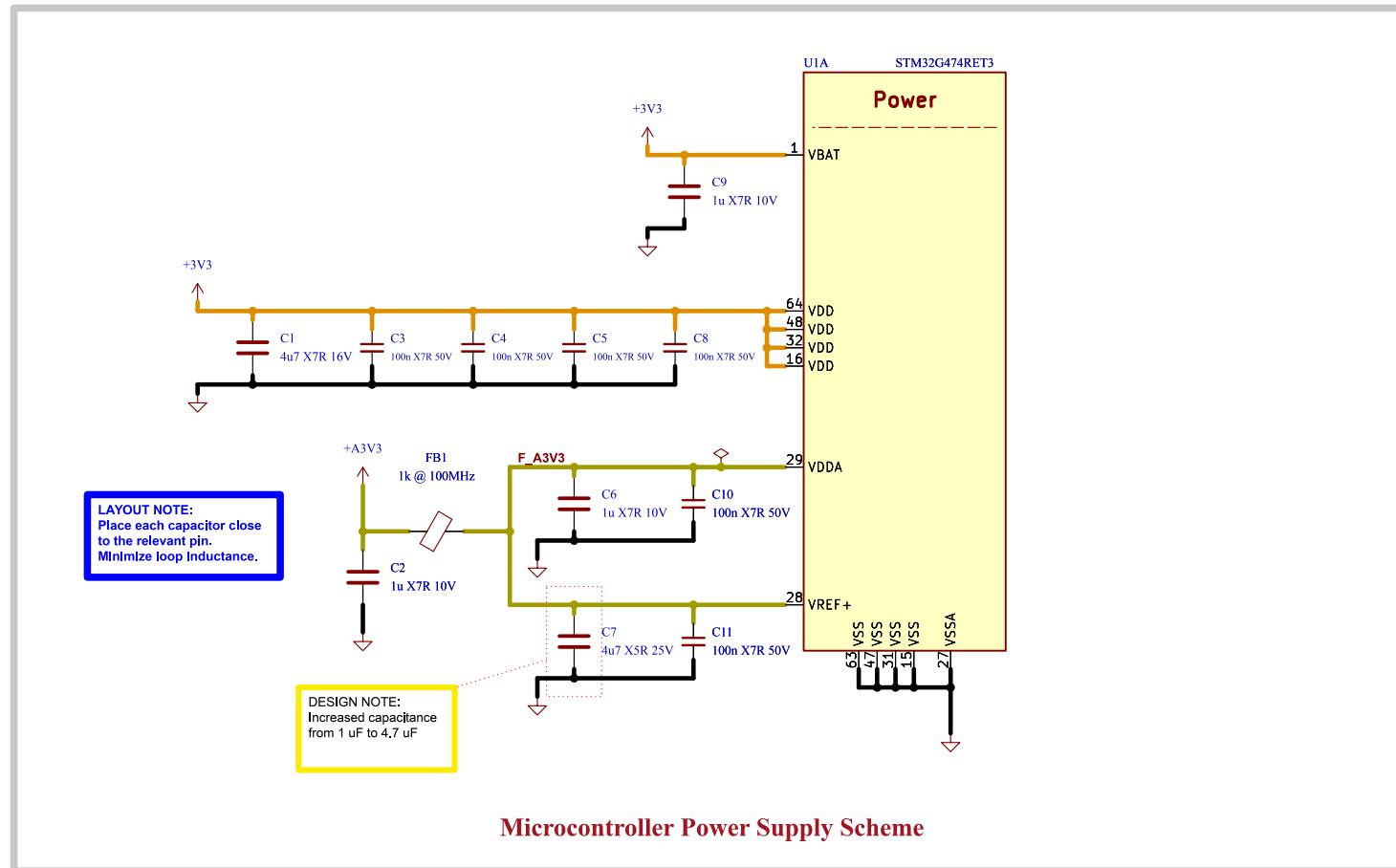
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| | Board Name: Amulet Motion Controller | | Project Name: Chienpanzé | |
| Sheet Title: Block Diagram | File Name: Block Diagram.kicad_sch | | Designer: Vincent Nguyen | Date: 2024-04-13 |
| Sheet Path: /Block Diagram/ | Reviewer: | | Size: A3 | Sheet: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

[3] Project Architecture



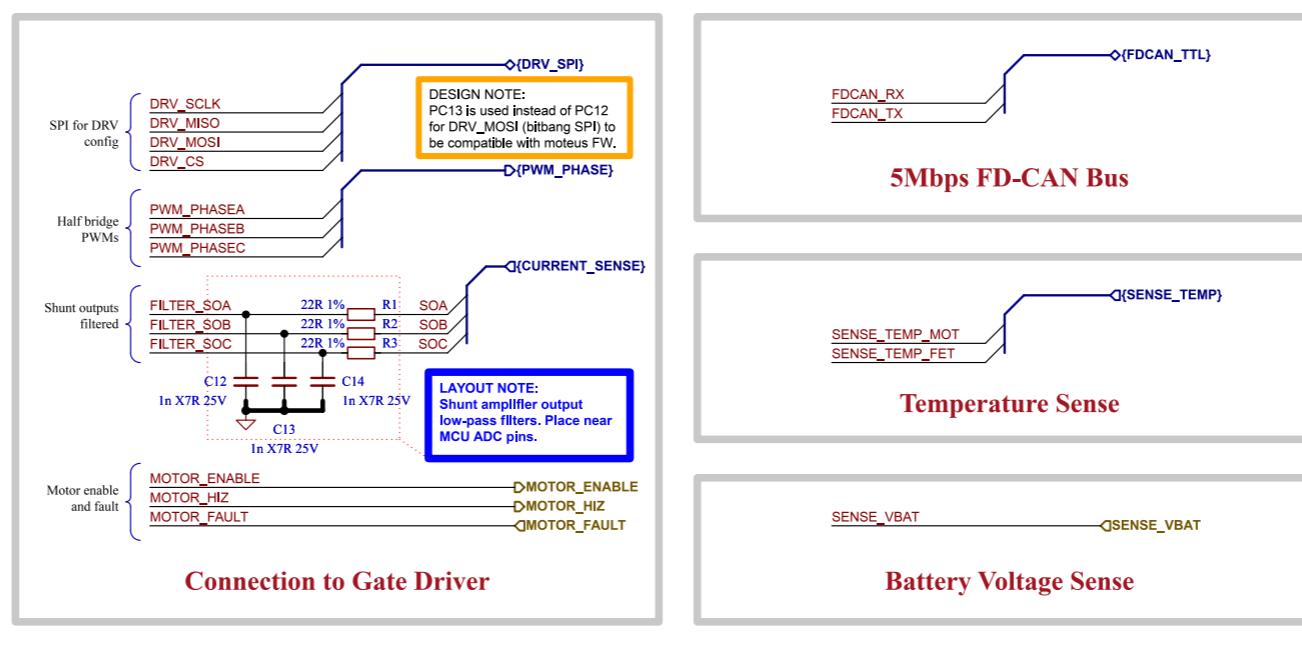
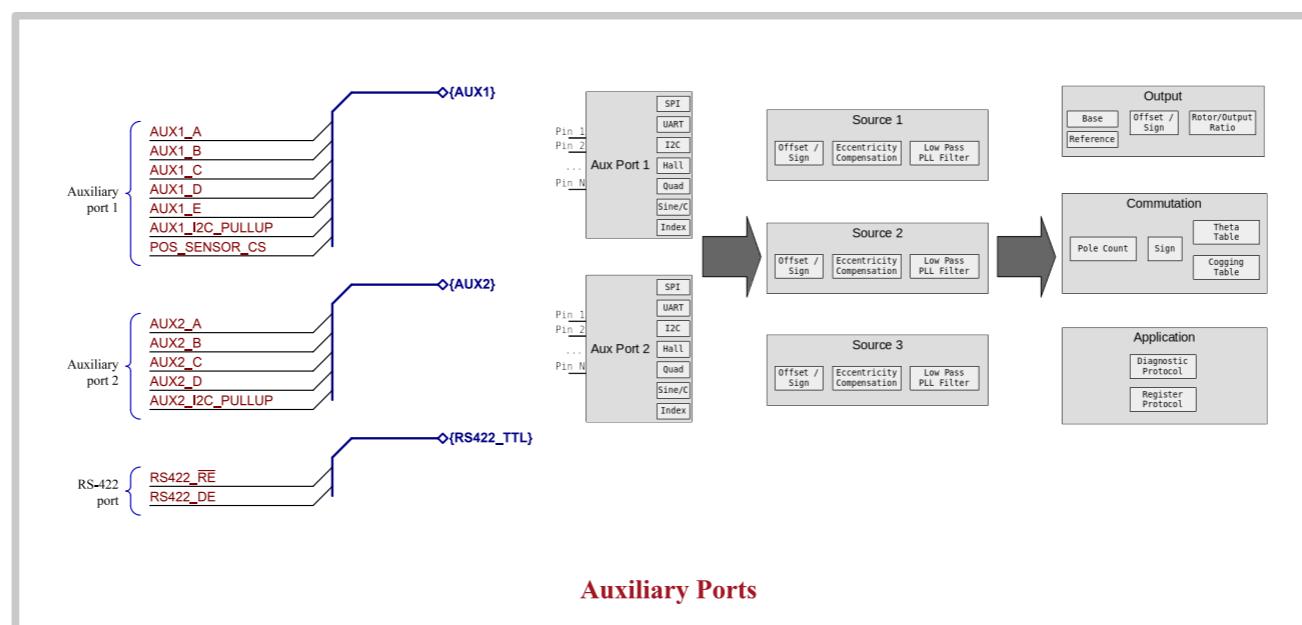
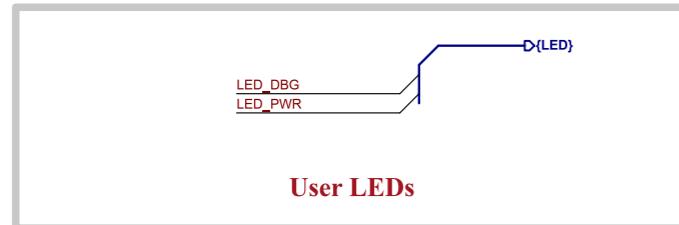
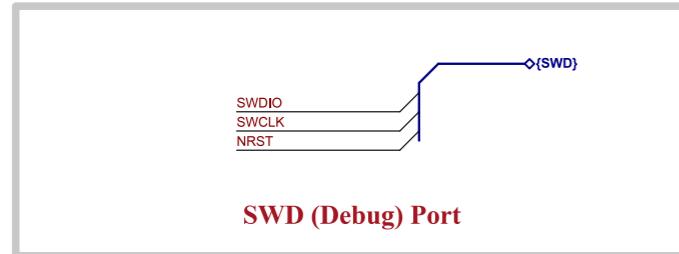
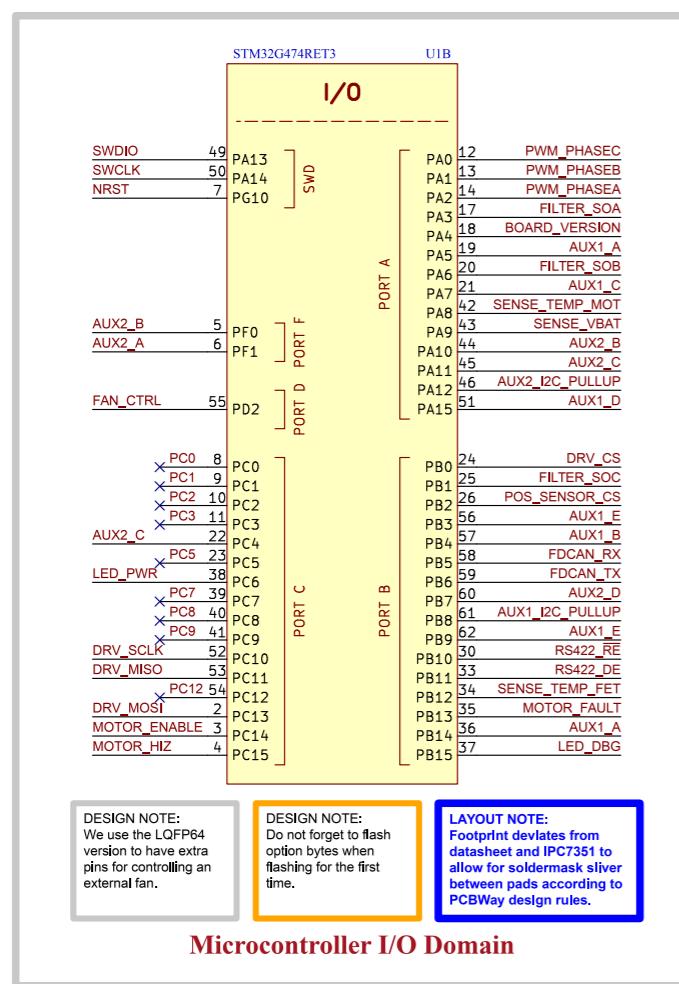
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| | Sheet Title: Project Architecture | File Name: Project Architecture.kicad_sch | Designer: Vincent Nguyen | Date: 2023-12-22 |
| | Sheet Path: /Project Architecture/ | | Reviewer: | Revision: 1.1.1+ (Unreleased) |
| | | | | Size: A3 |
| | | | | Sheet: 3 of 21 |

[4] MCU - Power



| | | | | |
|--|--|--|------------------------------------|--|
| | Comments: AN5346 STM32G474 Datasheet p.81 J. Pieper ADC investigation | Company: EPFL Xplore Research | Variant: CHECKED | Git Hash: 38f2a13 |
| | Board Name: Amulet Motion Controller | | | Project Name: Chienpanzé |
| | Sheet Title: MCU - Power | File Name: MCU - Power.kicad_sch | Designer: Vincent Nguyen | Date: 2023-12-18 Revision: 1.1.1+ (Unreleased) |
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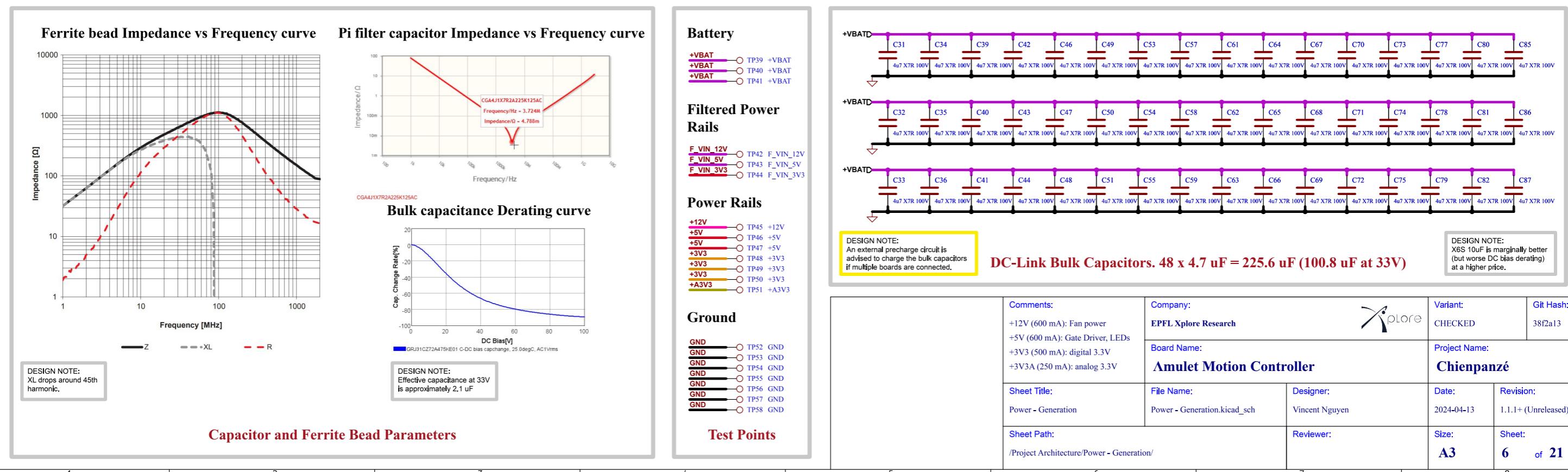
[5] MCU - I/Os



| Gate Driver | |
|-------------------------|------|
| 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 |
| Debug | |
| SWDIO | TP14 |
| SWCLK | TP15 |
| NRST | TP16 |
| Auxiliary pins 1 | |
| AUX1_A | TP17 |
| AUX1_B | TP18 |
| AUX1_C | TP19 |
| AUX1_D | TP20 |
| AUX1_E | TP21 |
| AUX1_I2C_PULLUP | TP22 |
| POS_SENSOR_CS | TP23 |
| Auxiliary pins 2 | |
| AUX2_A | TP24 |
| AUX2_B | TP25 |
| AUX2_C | TP26 |
| AUX2_D | TP27 |
| AUX2_I2C_PULLUP | TP28 |
| RS-422 | |
| RS422_RE | TP29 |
| RS422_DE | TP30 |
| LEDs | |
| LED_DBG | TP31 |
| LED_PWR | TP32 |
| FD-CAN | |
| FDCAN_RX | TP33 |
| FDCAN_TX | TP34 |
| Fan | |
| FAN_CTRL | TP35 |
| Sense | |
| SENSE_TEMP_MOT | TP36 |
| SENSE_TEMP_FET | TP37 |
| SENSE_VBAT | TP38 |
| Test Points | |

| | | | | |
|---|--|-----------------------------------|-----------------------------|----------------------------------|
| Comments: References: Flexible I/O worked examples Flexible I/O source configuration | Company: EPFL Xplore Research | | Variant: CHECKED | Git Hash: 38f2a13 |
| | Board Name: Amulet Motion Controller | | | |
| 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: A3 | | Sheet: 5 of 21 | | |

[6] Power - Generation

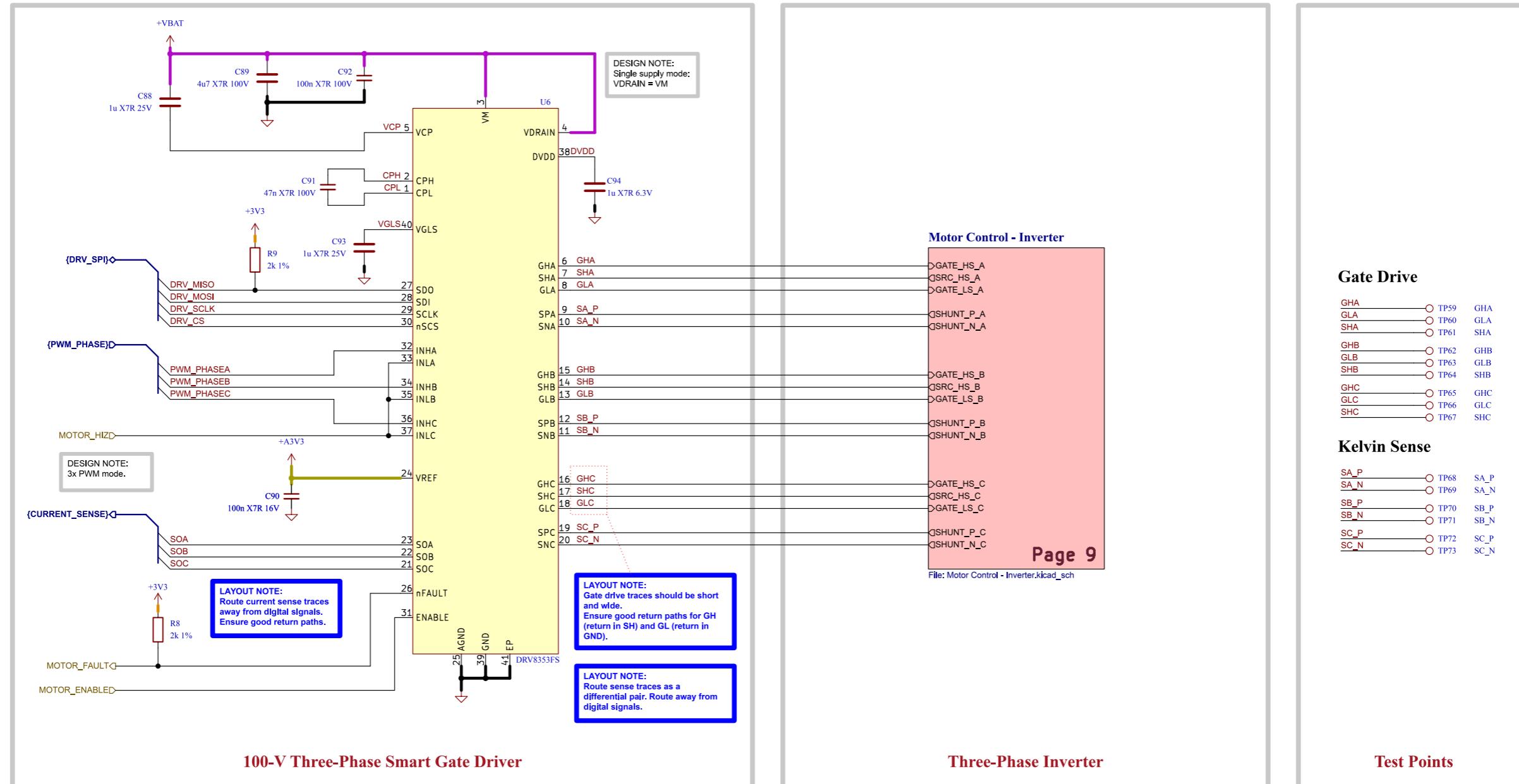


[7] Power - Connectors



| | | | | |
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| | Comments: | Company: EPFL Xplore Research  | Variant: CHECKED | Git Hash: 38f2a13 |
| | Board Name: Amulet Motion Controller | | | Project Name: Chienpanzé |
| | Sheet Title: Power - Connectors | File Name: Power - Connectors.kicad_sch | Designer: Vincent Nguyen | Date: 2023-12-31 Revision: 1.1.1+ (Unreleased) |
| | Sheet Path: /Project Architecture/Power - Connectors/ | | Reviewer: | Size: A4 Sheet: 7 of 21 |

[8] Motor Control - Top Level



| | | | | |
|--|---|---|-----------------------------|----------------------------------|
| | Comments: | Company: EPFL Xplore Research | Variant: CHECKED | Git Hash: 38f2a13 |
| | 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 | Date: 2023-12-20 |
| | Sheet Path: /Project Architecture/Motor Control - Top Level/ | | Reviewer: | Revision: 1.1.1+ (Unreleased) |
| | | | 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:
CHECKED

Git Hash:
38f2a13

Project Name:
Chienpanzé

Date:
2024-01-25

Revision:
1.1.1+ (Unreleased)

Size:
A4

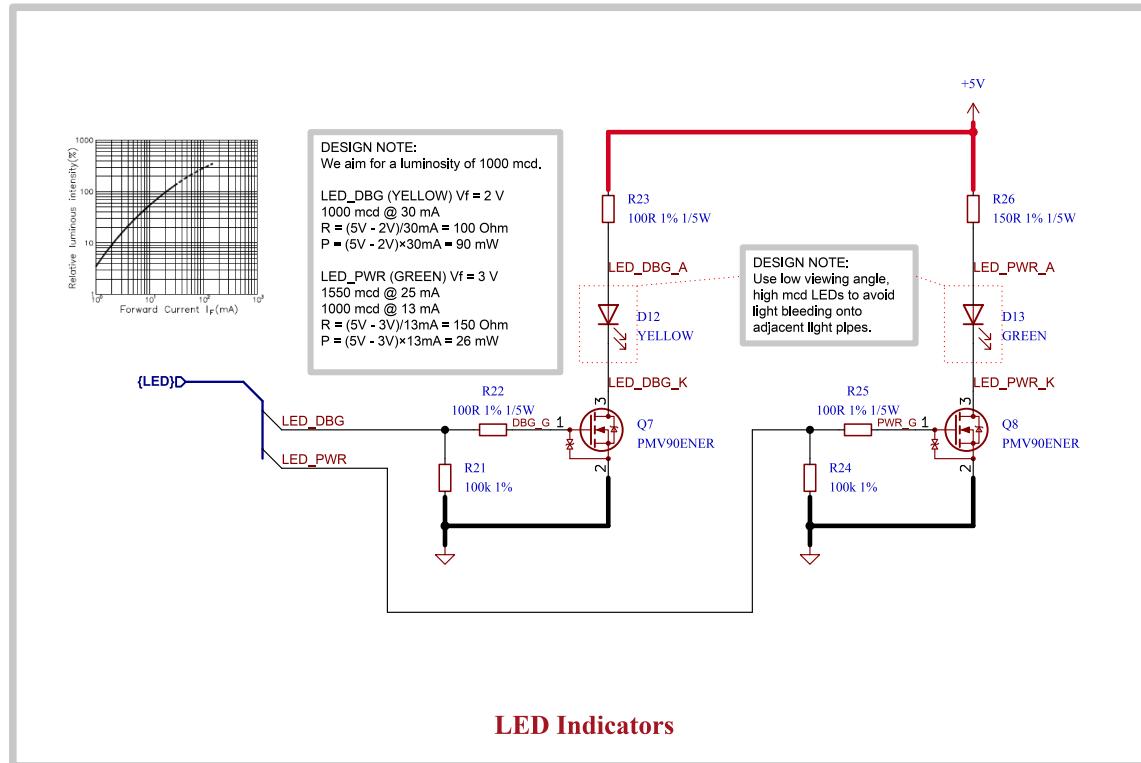
Sheet:
9 of 21

[10] Misc - Board Version, DAC



| | | | | |
|--|---|--|-----------------------------|---|
| | Comments: | Company: EPFL Xplore Research | Variant: CHECKED | Git Hash: 38f2a13 |
| | 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 | Date: 2024-04-13 Revision: 1.1.1+ (Unreleased) |
| | Sheet Path: /Project Architecture/Misc - Board Version, DAC/ | | Reviewer: | Size: A4 Sheet: 10 of 21 |

[11] User - LED Indicators



A

B

C

D

A

B

C

D

| | | | | |
|--|---|---|-----------------------------|---|
| | Comments: | Company: EPFL Xplore Research | Variant: CHECKED | Git Hash: 38f2a13 |
| | Board Name: Amulet Motion Controller | Project Name: Chienpanzé | | |
| | 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: /Project Architecture/User - LED Indicators/ | | Reviewer: | Size: A4 Sheet: 11 of 21 |

[12] Sensing - Temperature

A

B

C

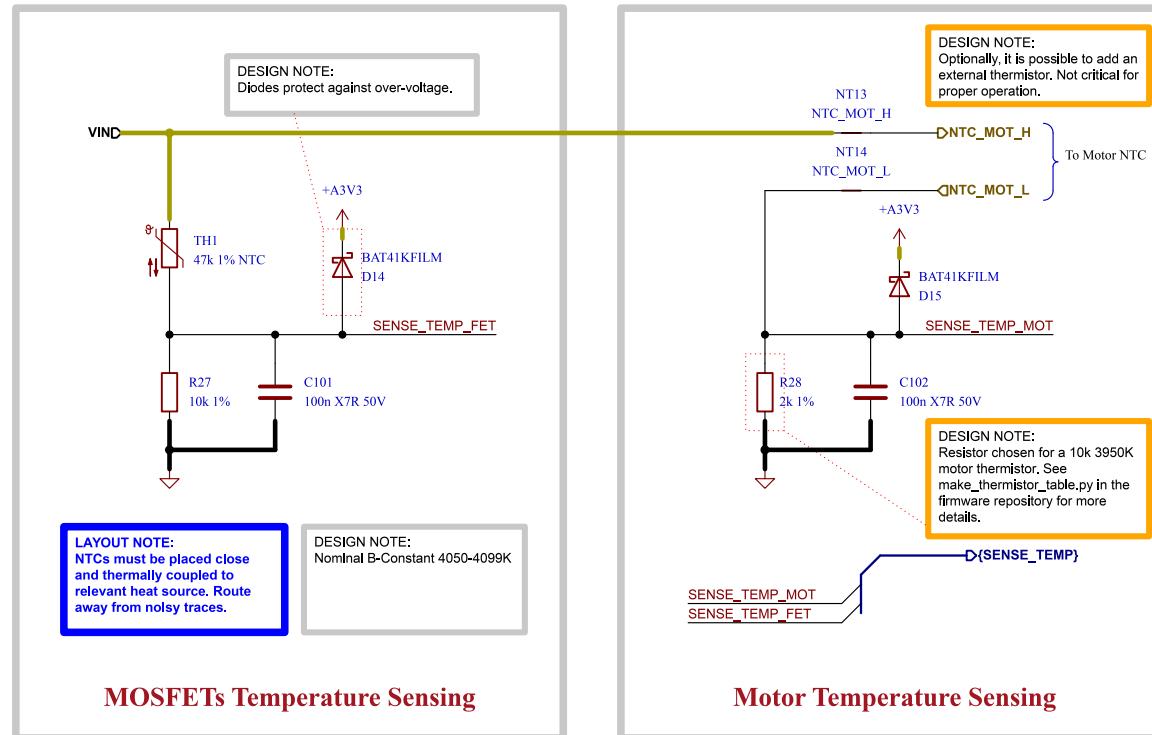
D

A

B

C

D



| | | | | |
|--|---|---|-----------------------------|------------------------|
| | Comments: | Company: EPFL Xplore Research | Variant: CHECKED | Git Hash: 38f2a13 |
| | Board Name: Amulet Motion Controller | Project Name: Chienpanzé | | |
| | Sheet Title: Sensing - Temperature | File Name: Sensing - Temperature.kicad_sch | Designer: Vincent Nguyen | Date: 2024-04-13 |
| | Sheet Path: /Project Architecture/Sensing - Temperature/ | Revision: 1.1.1+ (Unreleased) | | Size: A4 |
| | | Reviewer: | Sheet: | 12 of 21 |

[13] Sensing - Battery

A

B

C

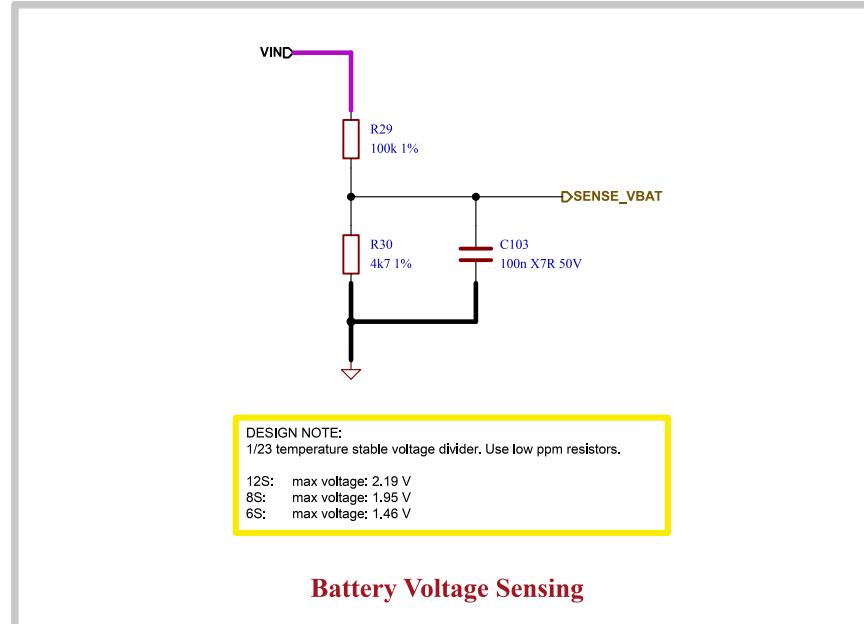
D

A

B

C

D



| | | | | |
|--|---|---|-----------------------------|---|
| | Comments: | Company: EPFL Xplore Research | Variant: CHECKED | Git Hash: 38f2a13 |
| | Board Name: Amulet Motion Controller | | | Project Name: Chienpanzé |
| | 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: A4 Sheet: 13 of 21 |

[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: CHECKED | Git Hash: 38f2a13 |
| | Board Name: Amulet Motion Controller | | | Project Name: Chienpanzé |
| | Sheet Title: Sensing - Position | File Name: Sensing - Position.kicad_sch | Designer: Vincent Nguyen | Date: 2023-10-14 |
| | Revision: 1.1.1+ (Unreleased) | | Reviewer: | Size: A4 |
| | Sheet Path: /Project Architecture/Sensing - Position/ | | Sheet: 14 of 21 | |

[15] Interface - RS-422



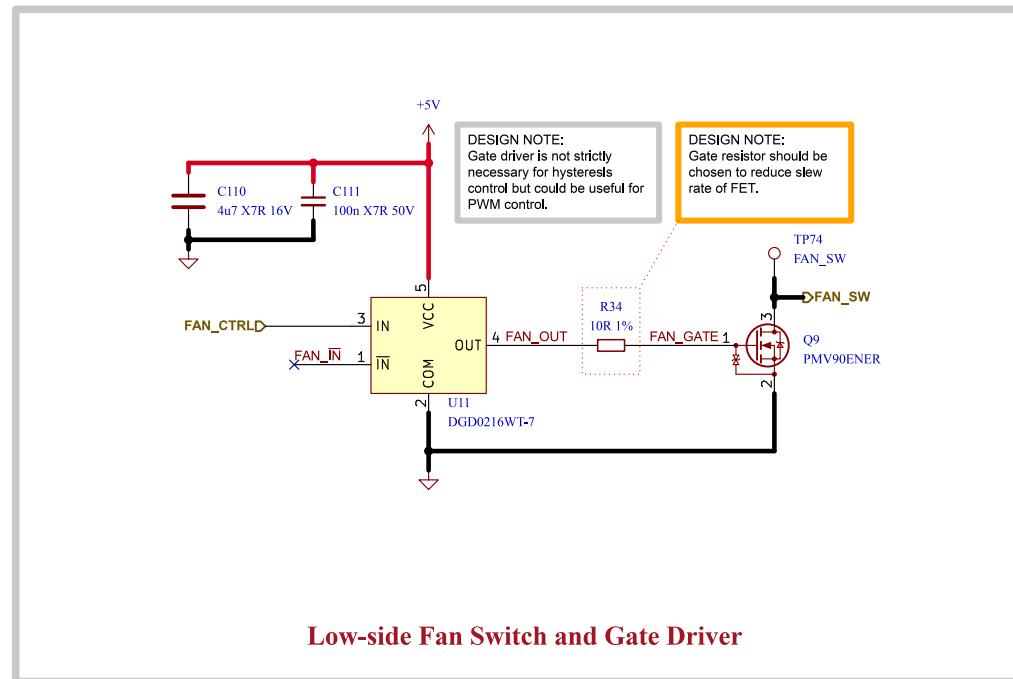
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| | Board Name: Amulette Motion Controller | | | Project Name: Chienpanzé |
| | Sheet Title: Interface - RS-422 | File Name: Interface - RS-422.kicad_sch | Designer: Vincent Nguyen | Date: 2023-10-15 Revision: 1.1.1+ (Unreleased) |
| | Sheet Path: /Project Architecture/Interface - RS-422/ | | Reviewer: | Size: A4 Sheet: 15 of 21 |

[16] Interface - FD-CAN



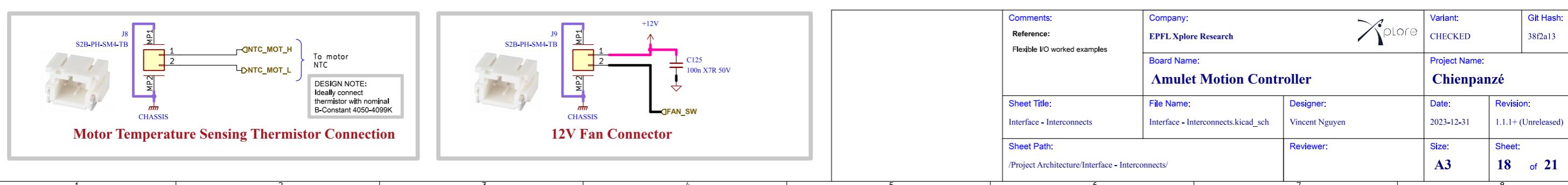
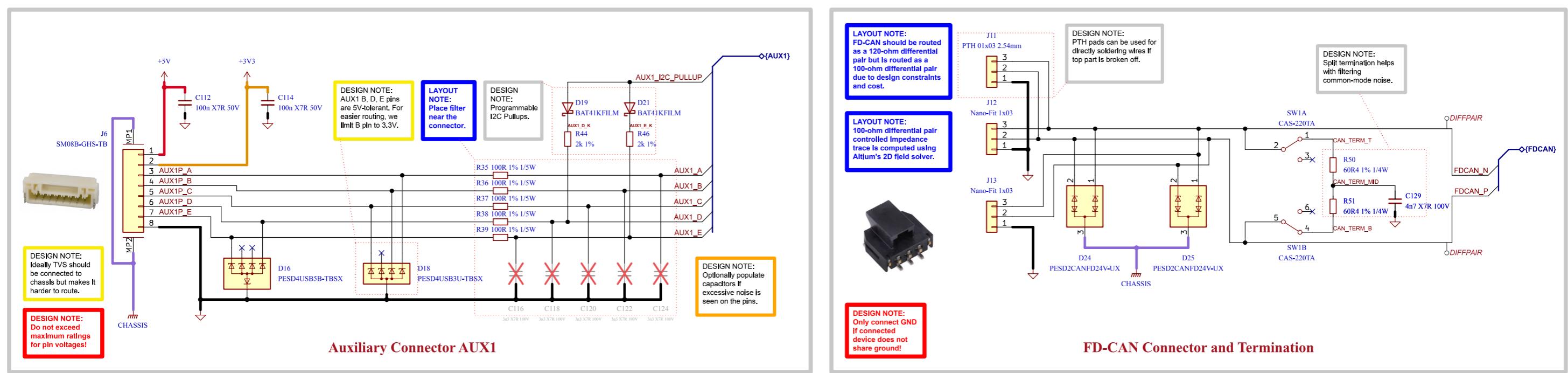
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| | Sheet Title: Interface - FD-CAN | File Name: Interface - FD-CAN.kicad_sch | Designer: Vincent Nguyen | Date: 2023-10-15 |
| | Sheet Path: /Project Architecture/Interface - FD-CAN/ | | Reviewer: | Size: A4 |
| | | | Revision: 1.1.1+ (Unreleased) | Sheet: 16 of 21 |

[17] Interface - Fan Control



| | | | | |
|--|---|---|-----------------------------|---|
| | Comments: | Company: EPFL Xplore Research | Variant: CHECKED | Git Hash: 38f2a13 |
| | Board Name: Amulet Motion Controller | Project Name: Chienpanzé | | |
| | 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: /Project Architecture/Interface - Fan Control/ | | Reviewer: | Size: A4 Sheet: 17 of 21 |

[18] Interface - Interconnects



[19] Misc - Holes, Fiducials

A

B

C

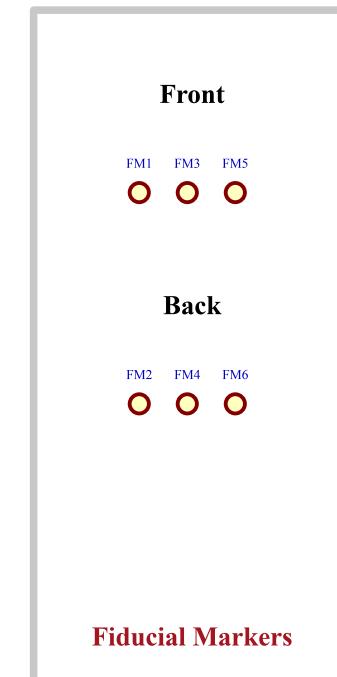
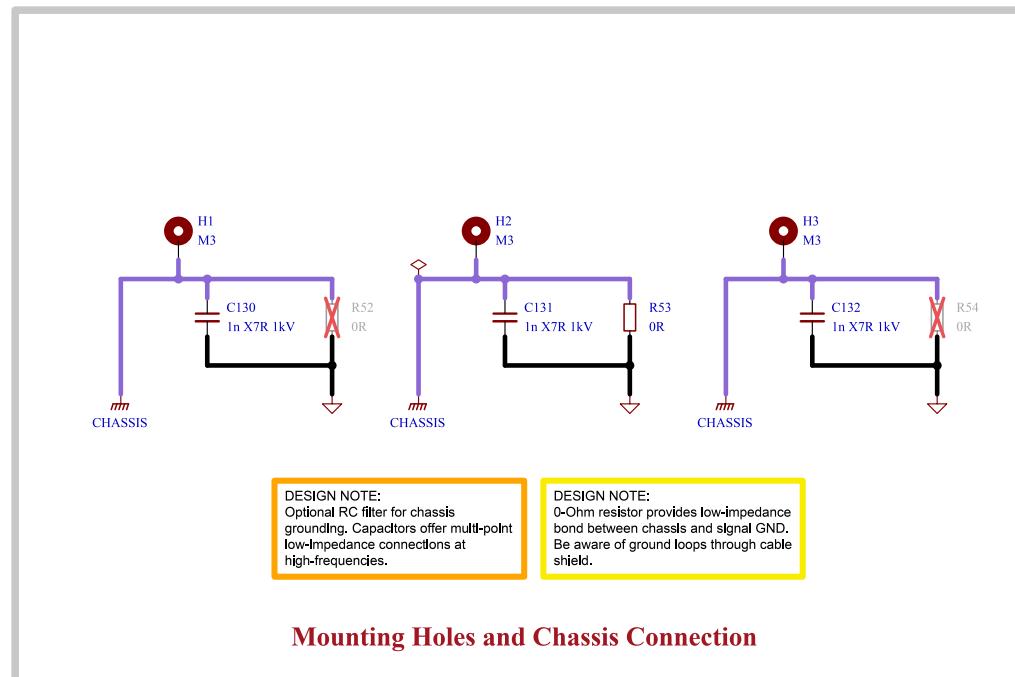
D

A

B

C

D



| | | | | |
|--|---|--|-----------------------------|---------------------------|
| | Comments: | Company: EPFL Xplore Research | Variant: CHECKED | Git Hash: 38f2a13 |
| | Board Name: Amulet Motion Controller | Project Name: Chienpanzé | | |
| | Sheet Title: Misc - Holes, Fiducials | File Name: Misc - Holes Fiducials.kicad_sch | Designer: Vincent Nguyen | Date: 2023-10-22 |
| | Revision: 1.1.1+ (Unreleased) | | Reviewers: | Size: A4 |
| | Sheet Path: /Project Architecture/Misc - Holes, Fiducials/ | | | Sheet: 19 of 21 |

[20] Power - Sequencing

A



B

C

D

| | | | | |
|--|---|--|------------------------------------|----------------------------------|
| | Comments: | Company: EPFL Xplore Research | Variant: CHECKED | Git Hash: 38f2a13 |
| | | Board Name: Amulet Motion Controller | Project Name: Chienpanzé | |
| | Sheet Title: Power - Sequencing | File Name: Power - Sequencing.kicad_sch | Designer: Vincent Nguyen | Date: 2024-03-12 |
| | Sheet Path: /Power - Sequencing/ | | Reviewer: | Size: A4 |
| | | | | Sheet: 20 of 21 |

[21] Revision History

| | | | | | |
|--|-----------------------------------|--|--|------------------------------------|----------------------------------|
| | Comments: | Company: EPFL Xplore Research |  xplore | Variant: CHECKED | Git Hash: 38f2a13 |
| | | Board Name: Amulet Motion Controller | | Project Name: Chienpanzé | |
| | Sheet Title: Revision History | File Name: Revision History.kicad_sch | Designer: Vincent Nguyen | Date: 2024-01-03 | Revision: 1.1.1+ (Unreleased) |
| | Sheet Path: /Revision History/ | | Reviewer: | Size: A4 | Sheet: 21 of 21 |