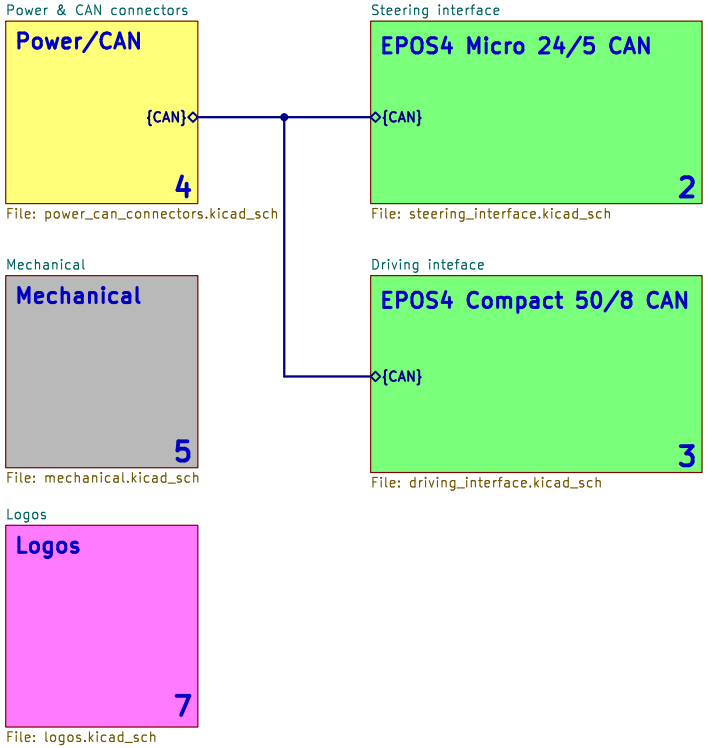
1 Overview



Authors: Vincent Nguyen, Yassine Bakkali

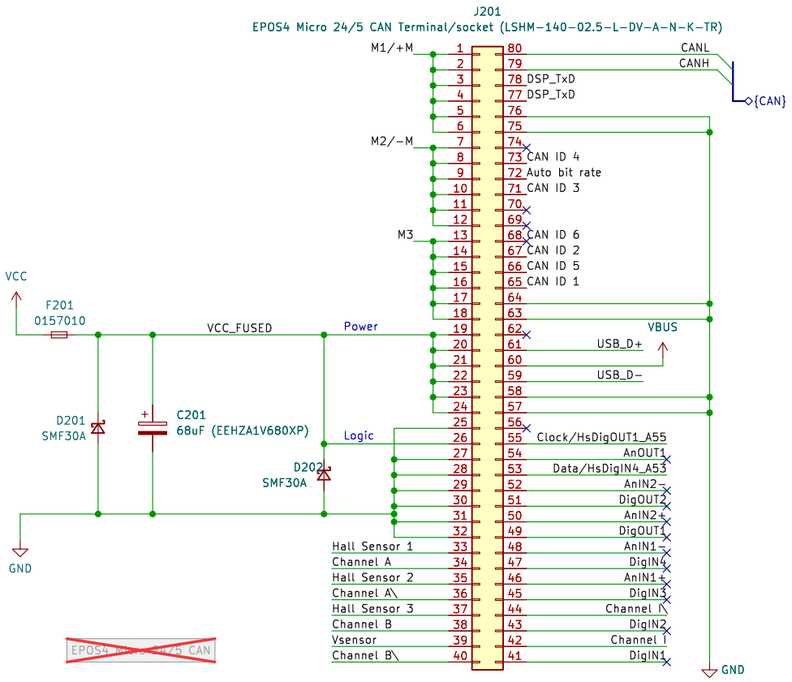
EPFL Xplore

Sheet: /
File: nav_controller_interface_v2.kicad_sch

Title: Steering/Driving CAN Controller Interfaces Overview

Size: A4	Date: 2023-03-22	**Rev:**
KiCad E.D.A. kicad 7.0.1		Id: 1/7

EPOS4 Micro 24/5 CAN connector



$L\_PHASE > 1/2*(24/(6*50000*1.88)-(0.3*0.428*10^(-3))) = -4.3*10^(-5)$
Negative -> no chokes are necessary

$$L_{Phase} \geq \frac{1}{2} \cdot \left(\frac{V_{CC}}{6 \cdot f_{PWM} \cdot I_N} - (0.3 \cdot L_{Motor}) \right)$$

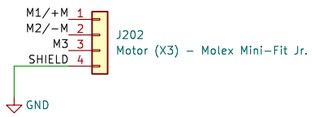
$L_{Phase}[H]$	Additional external inductance per phase
$V_{CC}[V]$	Operating voltage +V_{CC}
$f_{PWM}[Hz]$	Switching frequency of the power stage = 50'000 Hz
$I_N[A]$	Nominal current of the motor (➔line 6 in the maxon catalog)
$L_{Motor}[H]$	Terminal inductance of the motor (➔line 11 in the maxon catalog)

ECX TORQUE 22 M Ø22 mm, brushless, with Hall sensors

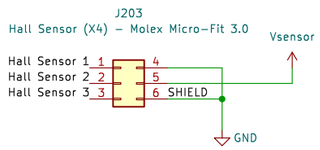
Motor Data					
Nominal voltage	V	18	24	36	48
No load speed	rpm	14300	15300	15100	13000
No load current	mA	175	145	94.8	56.5
Nominal speed	rpm	12200	13100	12900	10900
Nominal torque (max. continuous torque)	mNm	29.4	28.6	29.7	32.4
Nominal current (max. continuous current)	A	2.41	1.88	1.28	0.885
Stall torque	mNm	439	466	494	461
Stall current	A	37.1	31.5	21.9	13.2
Max. efficiency	%	86.9	87.1	87.4	87.5
Terminal resistance	Ω	0.486	0.763	1.64	3.63
Terminal inductance	mH	0.274	0.428	0.988	2.38
Torque constant	mNm/A	11.8	14.8	22.5	34.9
Speed constant	rpm/V	806	645	424	273
Speed/torque gradient	rpm/mNm	33.1	33.2	31	28.4
Mechanical time constant	ms	0.596	0.599	0.558	0.512
Rotor inertia	gcm²	1.72	1.72	1.72	1.72

Connectors

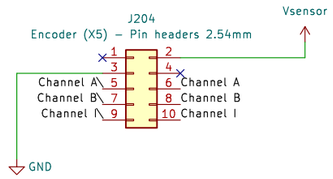
Motor connector



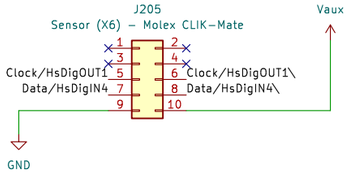
Hall sensors connector



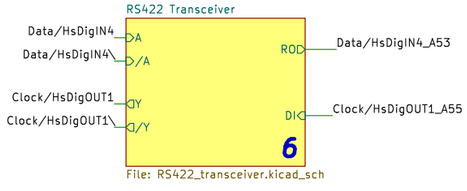
Encoder connector



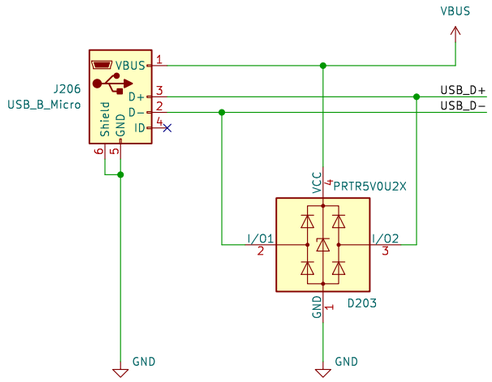
Sensor connector (SSI encoder)



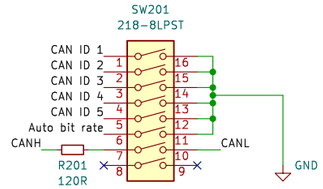
RS422 transceiver (SSI absolute encoder)



USB



CAN ID/Termination, ABR

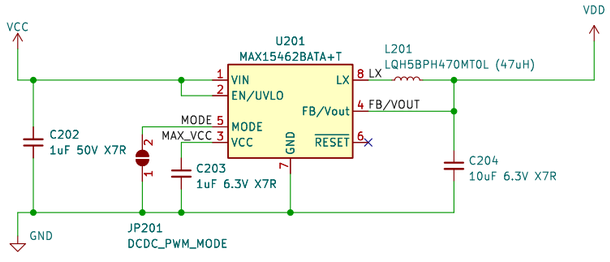


Setting	Switch 1	2	3	4	5	ID
↑OFF ↓ON	0	0	0	0	0	—
↑OFF ↓ON	**1**	0	0	0	0	1
↑OFF ↓ON	0	**1**	0	0	0	2
↑OFF ↓ON	0	0	**1**	0	0	4
↑OFF ↓ON	**1**	0	**1**	0	0	5
↑OFF ↓ON	0	0	0	**1**	0	8
↑OFF ↓ON	0	0	0	0	**1**	16
↑OFF ↓ON	**1**	**1**	**1**	**1**	**1**	31

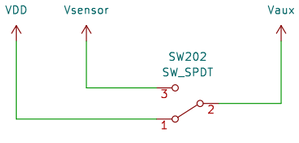
0 = Switch "OFF" 1 = Switch "ON"

Switch	OFF	ON
6	↑OFF ↓ON Automatic bit rate detection deactivated	↑OFF ↓ON Automatic bit rate detection activated (factory setting)

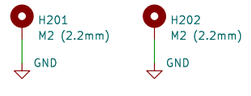
Step-Down 5v, 300mA DC/DC converter



Auxilliary power selection



Standoffs



Datasheet

Authors: Vincent Nguyen, Yassine Bakkali

EPFL Xplore

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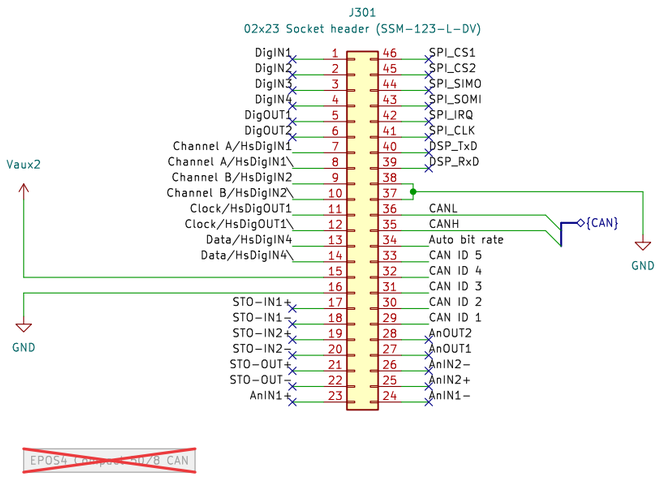
Sheet: /Steering interface/
File: steering_interface.kicad_sch

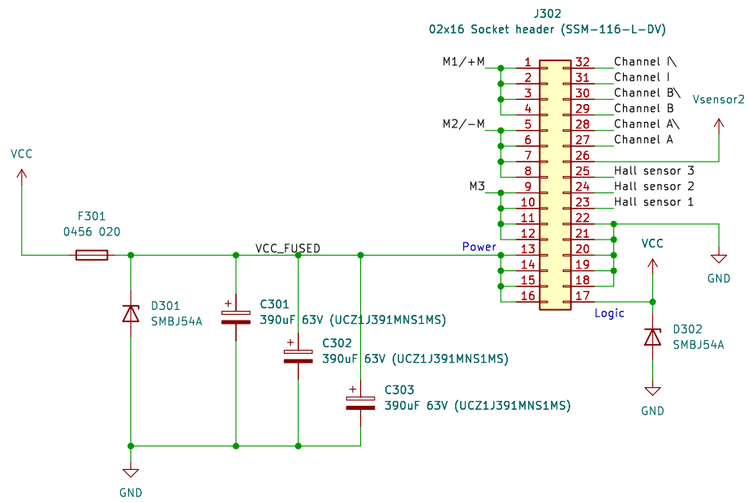
Title: Steering controller interface (EPOS4 Micro 24/5 CAN)

Size: A3	Date: 2023-03-22	Rev:
KiCad E.D.A. kicad 7.0.1		Id: 2/7

EPOS4 Compact 50/8 CAN connectors



EPOS4 Compact 50/8 CAN



L_PHASE > 1/2*(24/(6*50000*1.88)-(0.3*0.428*10^(-3))) = -4.3*10^(-5) = -3.54*10^(-5)
Negative -> no chokes are necessary

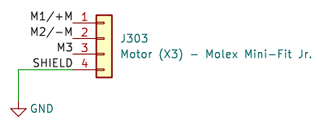
$$L_{Phase} \geq \frac{1}{2} \cdot \left(\frac{V_{CC}}{6 \cdot f_{PWM} \cdot I_N} - (0.3 \cdot L_{Motor}) \right)$$

$L_{Phase}[H]$	Additional external inductance per phase
$V_{CC}[V]$	Operating voltage $+V_{CC}$
$f_{PWM}[Hz]$	Switching frequency of the power stage = 50'000 Hz
$I_N[A]$	Nominal current of the motor (➔line 6 in the maxon catalog)
$L_{Motor}[H]$	Terminal inductance of the motor (➔line 11 in the maxon catalog)

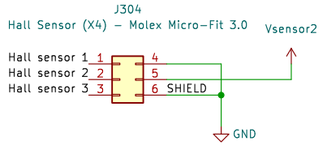
EC 45 flat Ø42.8 mm, brushless, 120 W, with Hall sensors

Motor Data (provisional)					
Values at nominal voltage					
1 Nominal voltage	V	24	36	48	60
2 No load speed	rpm	5600	5930	5580	3720
3 No load current	mA	277	204	138	58.2
4 Nominal speed	rpm	4520	4820	4510	2900
5 Nominal torque (max. continuous torque)	mNm	174	147	146	169
6 Nominal current (max. continuous current)	A	4.13	2.53	1.78	1.06
7 Stall torque[1]	mNm	1690	1320	1260	1240
8 Stall current	A	42	23	16	8
9 Max. efficiency	%	84.7	82.5	82.4	84.1
Characteristics					
10 Terminal resistance phase to phase	Ω	0.573	1.560	3.070	7.370
11 Terminal inductance phase to phase	mH	0.301	0.601	1.210	4.270
12 Torque constant	mNm / A	40.4	57	80.8	152
13 Speed constant	rpm / V	236	167	118	62.8
14 Speed / torque gradient	rpm / mNm	3.350	4.580	4.490	3.040
15 Mechanical time constant	ms	6.350	8.680	8.510	5.770
16 Rotor inertia	gcm²	181	181	181	181

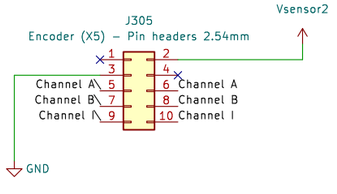
Motor connector



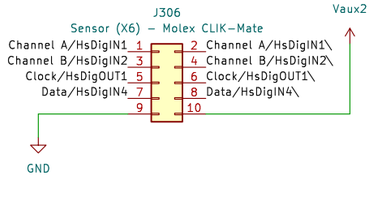
Hall sensors connector



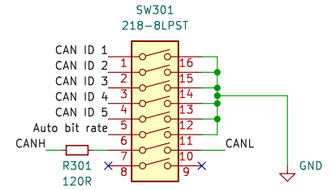
Encoder connector



Sensor connector



CAN ID/Termination, ABR

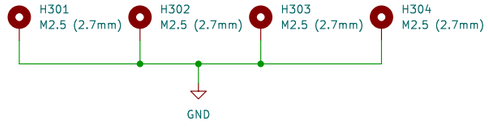


Setting	Switch 1	2	3	4	5	Node Address
1 8 ON OFF	0	0	0	0	0	–
1 8 ON OFF	1	0	0	0	0	1
1 8 ON OFF	0	1	0	0	0	2
1 8 ON OFF	0	0	1	0	0	4
1 8 ON OFF	1	0	1	0	0	5
1 8 ON OFF	0	0	0	1	0	8
1 8 ON OFF	0	0	0	0	1	16
1 8 ON OFF	1	1	1	1	1	31

0 = Switch "OFF" 1 = Switch "ON"

Switch	OFF	ON
6	1 8 ON OFF Automatic bit rate detection deactivated	1 8 ON OFF Automatic bit rate detection activated (factory setting)

Mounting holes



Datasheet

Authors: Vincent Nguyen, Yassine Bakkali

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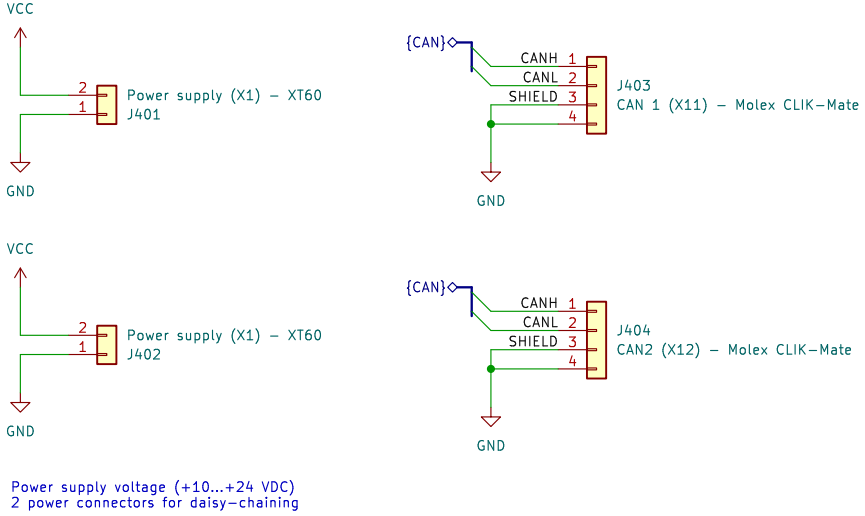
Sheet: /Driving inteface/
File: driving_interface.kicad_sch

Title: Driving controller interface (EPOS4 Compact 50/8 CAN)

Size: A3	Date: 2023-03-22	Rev:
KiCad E.D.A. kicad 7.0.1		Id: 3/7



Authors: Vincent Nguyen, Yassine Bakkali

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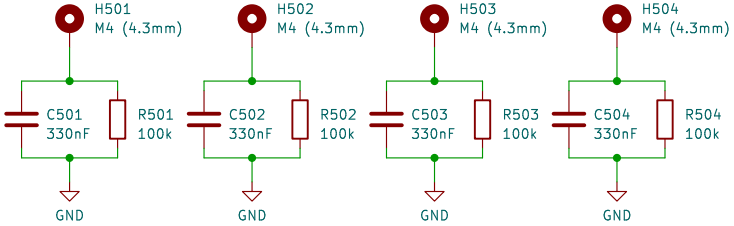
Sheet: /Power & CAN connectors/
File: power_can_connectors.kicad_sch

Title: Power and CAN connectors

Size: A5	Date: 2023–03–11	**Rev:**
KiCad E.D.A. kicad 7.0.1		Id: 4/7



Authors: Vincent Nguyen, Yassine Bakkali

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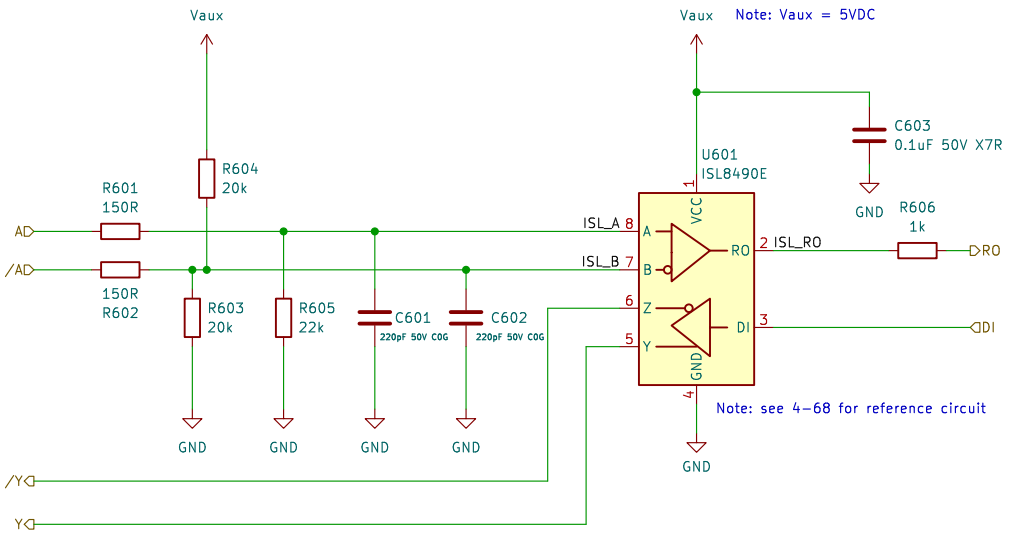
Sheet: /Mechanical/
File: mechanical.kicad_sch

Title: Mechanical parts

Size: A5	Date: 2023-03-11	**Rev:**
KiCad E.D.A. kicad 7.0.1		Id: 5/7



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Author: Vincent Nguyen

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Sheet: /Steering interface/RS422 Transceiver/
File: RS422_transceiver.kicad_sch

Title: RS422 interface for SSI sensor

Size: A4	Date: 2023-03-21	**Rev:**
KiCad E.D.A. kicad 7.0.1		Id: 6/7

Authors: Vincent Nguyen, Yassine Bakkali

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Sheet: /Logos/
File: logos.kicad_sch

Title: Logos

Size: A5	Date: 2023-03-22	**Rev:**
KiCad E.D.A. kicad 7.0.1		Id: 7/7