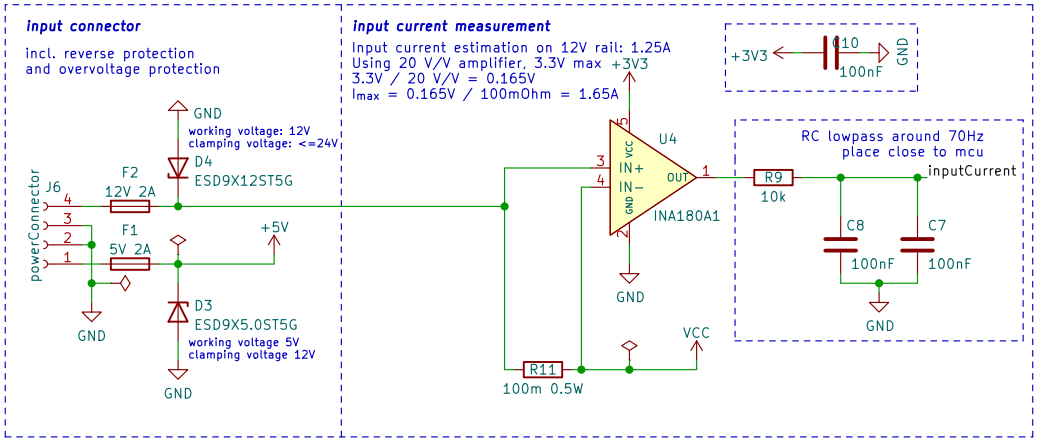
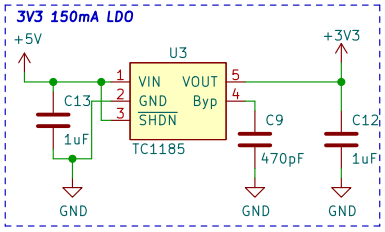
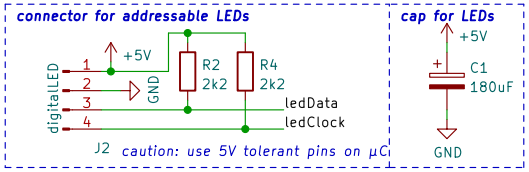
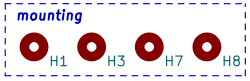
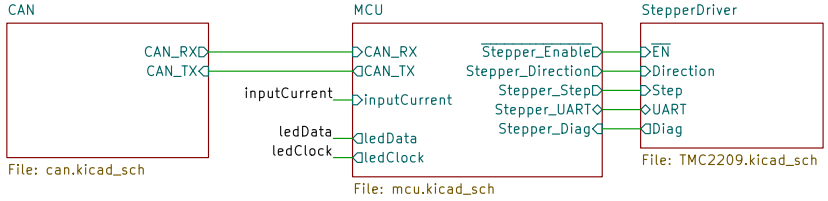










Power losses at motor:
cheap Stepper motor 42HB34F1AB-01 as reference:
- max 1 A phase current
- 4 Ohm coil resistance
-> 4V, 4W resistive losses

- gear reduction: 5
- revolutions: 2
- goal time: 2.5 sec
-> average speed (5*2)/2.5 rps = 4 rps
-> asume maximum speed = 8 rps

- holding torque: 0.23Nm
Back emf approximation:
(sqrt(2) * 3.14 * 0.23Nm * 8 1/s) / 1A = 8.16V

= (8.16V bemf + 4V resistive loss) * 1A
= 12.16W peak power needed from motor driver

Power losses at TMC2209:
From datasheet at 1A rms, 24V, Stealth P_{loss} = 1.4W
Loss is internal LDO + Drive Stage
LDO Current output = 7.5mA

at 24V, 1A rms:
LDO: 24V * 7.5mA = 0.18W
Drive: (1.4W - 0.18W) / 1A = 1.22 Ohm

at 12V, 1A rms:
LDO: 12V * 7.5mA = 0.09W
Drive: $(1A)^2$ * 1.22 Ohm = 1.22W
= 1.31W loss at TMC2209

---

addressable LEDs:
one SK9822-LED draws ~50mA at full brightness
two LED-rings á 42 LEDs = 84 LEDs
$I_{84LEDs@full}$ = 50mA * 84 = 4.2A
Assuming only two colors are on at time -> 66%
Limit brightness by software -> 66%

$I_{84LEDs@limited}$ = 4.2A * 66% * 66% = 1.83A -> 2A
P_{LEDs} = 5V * 2A = 10W

Input Current:
Voltage about 12V
Motor: 12.16W
Driver: 1.31W

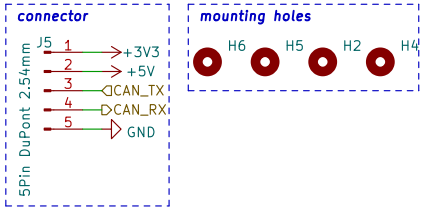
P_{total} = 12.16W + 1.31W = 13.47W -> 15W

I_{input} = 15W / 12V = 1.25A

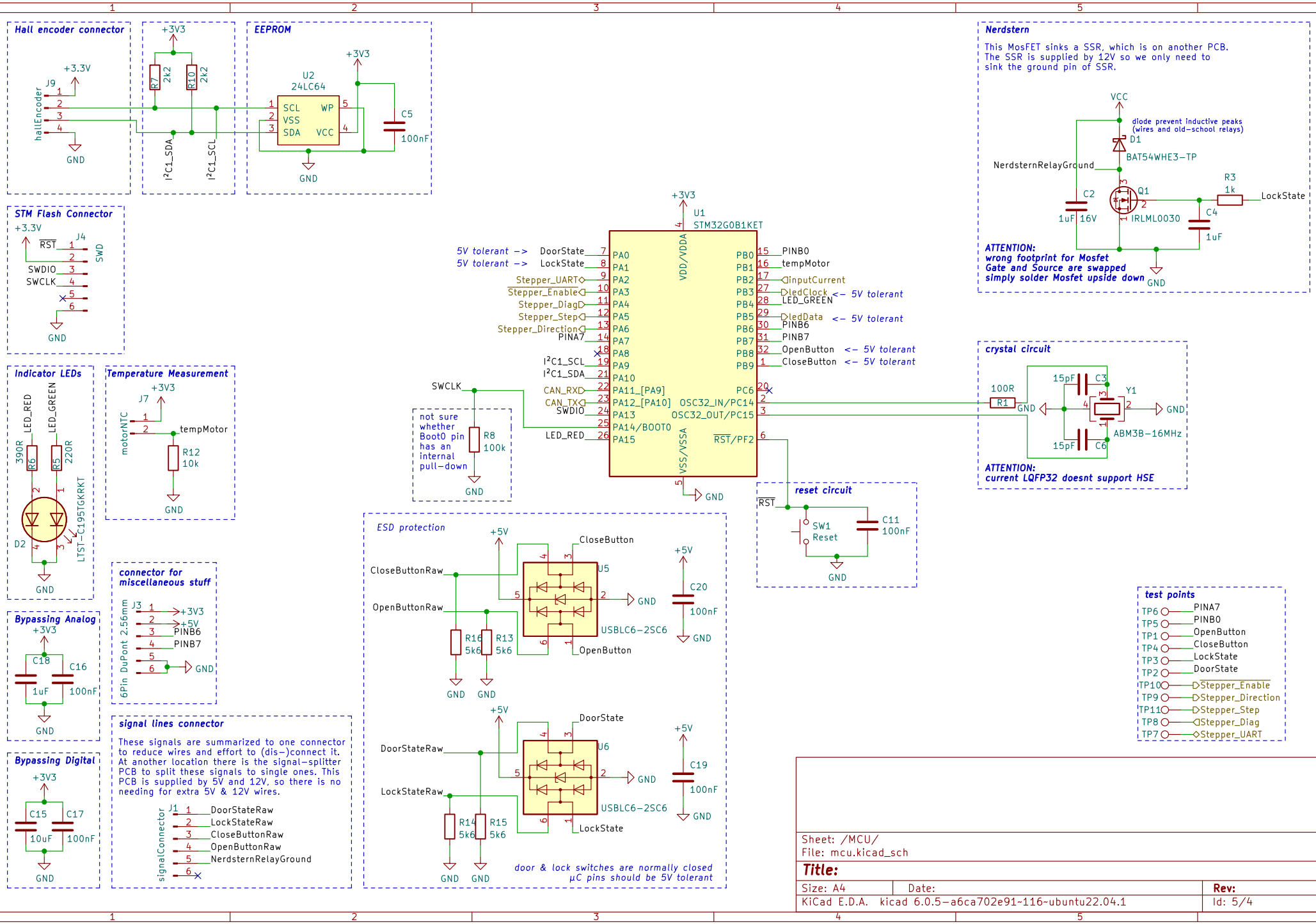
All caps without voltage rating default to 6.3V versions

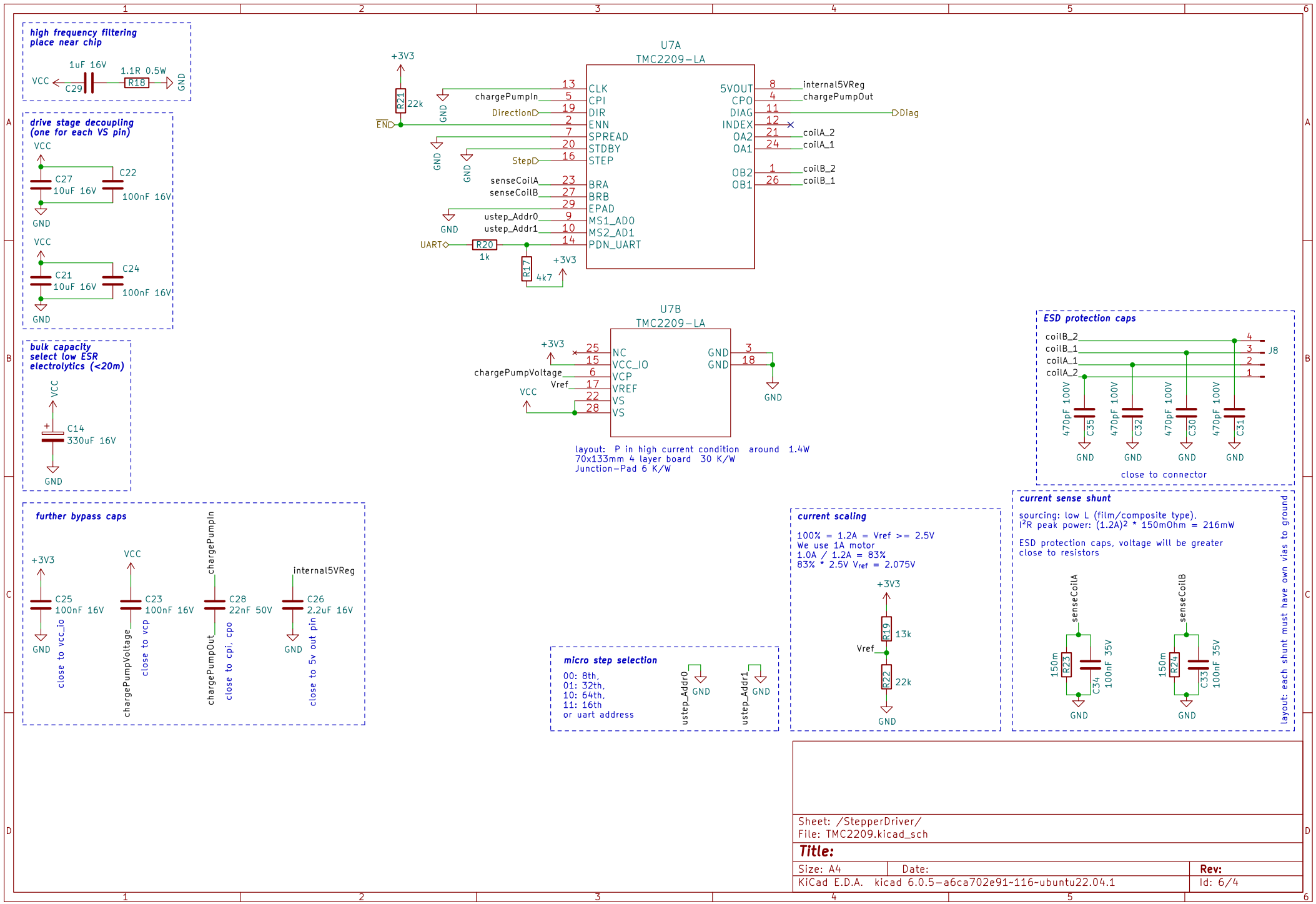
oTToCar		
Sheet: /		
File: StepperLockingSystem.kicad_sch		
Title: Stepper Servo		
Size: A4	Date:	**Rev:**
KiCad E.D.A. kicad 6.0.5-a6ca702e91~116~ubuntu22.04.1		Id: 1/4

CAN requierements:
- galvanic isolation
- isolated DC/DC converter
- base is a dedicated PCB due
  different chip/converter impl.
  (because semiconductor componts are rare)



Sheet: /CAN/		
File: can.kicad_sch		
Title:		
Size: A4	Date:	**Rev:**
KiCad E.D.A. kicad 6.0.5-a6ca702e91~116~ubuntu22.04.1		Id: 4/4


Hall encoder connector
+3.3V
J9
hallEncoder
GND
+3V3
R7 2k2
R10 2k2
I²C1_SDA
I²C1_SCL
EEPROM
U2
24LC64
SCL
SDA
WP
VCC
VSS
C5
100nF
GND
STM Flash Connector
+3.3V
J4
RST
SWDIO
SWCLK
SWD
GND
Indicator LEDs
LED_RED
LED_GREEN
390R
R6
220R
R5
D2
LTST-C195TGKRKT
GND
Temperature Measurement
+3V3
J7
motorNTC
tempMotor
R12
10k
GND
Bypassing Analog
+3V3
C18
1uF
C16
100nF
GND
Bypassing Digital
+3V3
C15
10uF
C17
100nF
GND
connector for miscellaneous stuff
J3
6Pin DuPont 2.56mm
+3V3
+5V
PINB6
PINB7
GND
signal lines connector
These signals are summarized to one connector to reduce wires and effort to (dis-)connect it. At another location there is the signal-splitter PCB to split these signals to single ones. This PCB is supplied by 5V and 12V, so there is no needing for extra 5V & 12V wires.
J1
signalConnector
DoorStateRaw
LockStateRaw
CloseButtonRaw
OpenButtonRaw
NerdsternRelayGround
+3V3
U1
STM32G0B1KET
VDD/VDDA
VSS/VSSA
5V tolerant -> DoorState
5V tolerant -> LockState
Stepper_UART
Stepper_Enable
Stepper_Diag
Stepper_Step
Stepper_Direction
PINA7
I²C1_SCL
I²C1_SDA
CAN_RX
CAN_TX
SWDIO
LED_RED
PINB0
tempMotor
inputCurrent
ledClock <- 5V tolerant
LED_GREEN
ledData <- 5V tolerant
PINB6
PINB7
OpenButton <- 5V tolerant
CloseButton <- 5V tolerant
OSC32_IN/PC14
OSC32_OUT/PC15
RST/PF2
SWCLK
not sure whether Boot0 pin has an internal pull-down
R8
100k
GND
ESD protection
+5V
CloseButtonRaw
OpenButtonRaw
U5
USBLC6-2SC6
CloseButton
OpenButton
R16
5k6
R13
5k6
C20
100nF
DoorStateRaw
LockStateRaw
U6
DoorState
LockState
R14
5k6
R15
5k6
C19
100nF
door & lock switches are normally closed
µC pins should be 5V tolerant
reset circuit
RST
SW1
Reset
C11
100nF
GND
crystal circuit
100R
R1
15pF
C3
Y1
ABM3B-16MHz
C6
ATTENTION:
current LQFP32 doesnt support HSE
Nerdstern
This MosFET sinks a SSR, which is on another PCB.
The SSR is supplied by 12V so we only need to sink the ground pin of SSR.
VCC
diode prevent inductive peaks (wires and old-school relays)
D1
BAT54WHE3-TP
NerdsternRelayGround
Q1
IRLML0030
R3
1k
LockState
C2
1uF 16V
C4
1uF
ATTENTION:
wrong footprint for Mosfet
Gate and Source are swapped
simply solder Mosfet upside down
test points
TP6 PINA7
TP5 PINB0
TP1 OpenButton
TP4 CloseButton
TP3 LockState
TP2 DoorState
TP10 Stepper_Enable
TP9 Stepper_Direction
TP11 Stepper_Step
TP8 Stepper_Diag
TP7 Stepper_UART
Sheet: /MCU/
File: mcu.kicad_sch
Title:
Size: A4
Date:
Rev:
KiCad E.D.A. kicad 6.0.5-a6ca702e91~116~ubuntu22.04.1
Id: 5/4


high frequency filtering
place near chip
1uF 16V
1.1R 0.5W
VCC
C29
R18
GND
drive stage decoupling
(one for each VS pin)
VCC
C27
10uF 16V
C22
100nF 16V
GND
VCC
C21
10uF 16V
C24
100nF 16V
GND
bulk capacity
select low ESR
electrolytics (<20m)
VCC
C14
330uF 16V
GND
U7A
TMC2209-LA
+3V3
R21
22k
GND
ENN
chargePumpIn
Direction
Step
senseCoilA
senseCoilB
ustep_Addr0
ustep_Addr1
UART
R20
1k
R17
4k7
13 CLK
5 CPI
19 DIR
2 ENN
7 SPREAD
20 STDBY
16 STEP
23 BRA
27 BRB
29 EPAD
9 MS1_AD0
10 MS2_AD1
14 PDN_UART
8 5VOUT
4 CPO
11 DIAG
12 INDEX
21 OA2
24 OA1
1 OB2
26 OB1
internal5VReg
chargePumpOut
Diag
coilA_2
coilA_1
coilB_2
coilB_1
U7B
TMC2209-LA
+3V3
chargePumpVoltage
Vref
VCC
25 NC
15 VCC_IO
6 VCP
17 VREF
22 VS
28 VS
3 GND
18 GND
GND
layout: P in high current condition around 1.4W
70x133mm 4 layer board 30 K/W
Junction-Pad 6 K/W
ESD protection caps
coilB_2
coilB_1
coilA_1
coilA_2
J8
4
3
2
1
470pF 100V
C35
C32
C30
C31
GND
close to connector
further bypass caps
+3V3
C25
100nF 16V
GND
close to vcc_io
VCC
C23
100nF 16V
chargePumpVoltage
close to vcp
chargePumpIn
C28
22nF 50V
chargePumpOut
close to cpi, cpo
internal5VReg
C26
2.2uF 16V
GND
close to 5v out pin
micro step selection
00: 8th,
01: 32th,
10: 64th,
11: 16th
or uart address
ustep_Addr0
GND
ustep_Addr1
GND
current scaling
100% = 1.2A = Vref >= 2.5V
We use 1A motor
1.0A / 1.2A = 83%
83% * 2.5V Vref = 2.075V
+3V3
R19
13k
Vref
R22
22k
GND
current sense shunt
sourcing: low L (film/composite type),
I²R peak power: (1.2A)² * 150mOhm = 216mW
ESD protection caps, voltage will be greater
close to resistors
senseCoilA
150m
R23
C34
100nF 35V
GND
senseCoilB
150m
R24
C33
100nF 35V
GND
layout: each shunt must have own vias to ground
Sheet: /StepperDriver/
File: TMC2209.kicad_sch
Title:
Size: A4
Date:
Rev:
KiCad E.D.A. kicad 6.0.5-a6ca702e91~116~ubuntu22.04.1
Id: 6/4