Power

Power
SYS_RESET
I2C0_SDA
I2C0_SCL
power.sch

User LEDs

USR3 R1 1kΩ LED D3
USR2 R2 1kΩ LED D4
USR1 R3 1kΩ LED D5
USR0 R4 1kΩ LED D6
GND

eMMC

Flash
X1_ENDSTOP GPIO3_21 X_STEP
X2_ENDSTOP X2_ENDSTOP X_DIR
Y1_ENDSTOP Y1_ENDSTOP X_FAULT
Z1_ENDSTOP Z1_ENDSTOP Y_STEP
USR3 USR3 Y_DIR
USR2 USR2 Y_FAULT
USR1 USR1 Z_STEP
USR0 USR0 Z_DIR
I2C0_SDA I2C0_SDA E_STEP
I2C0_SCL I2C0_SCL E_DIR
ENC_A GPIO_48 E_FAULT
ENC_B ENC_B H_STEP
HDMI_INT HDMI_INT H_DIR
USB1_OC USB1_OC H_FAULT
DISP_INT DISP_INT SERVO_0
Unused on BBBW Y2_ENDSTOP
flash.sch

Microprocessor

XDMA_EVENT_INTRO
PWM_EN CLKOUT2
12MHz
SPI0_SCLK
SPI0_MISO
SPI0_MOSI
LCD SPI0_CS0
μSD SPI0_CS1
GPIO3_21 X1_ENDSTOP
Z2_ENDSTOP Z2_ENDSTOP
BED_THERM BED_THERM
ADC4 ADC
SPI1_SCLK SPI1_SCLK
SPI1_MISO SPI1_MISO
SPI1_MOSI SPI1_MOSI
SPI1_CS0 HDMI
SPI1_CS1 Shift Registers
mpu.sch

Feedback Input

VDD_3V3B
FB1
3V3_FILTERED
C1 100nF
C3 10nF
D2
GND GND
GND
VDD_5V
FB2
C2 100nF
C4 10nF
D1
GND GND
GND
BED_THERM
P9
P10 ADC
Thermistors
BED_THERM_IN BED_THERM
ADC_IN ADC
therm.sch
BED_THERM
ADC
SCLK FB12 SPI1_SCLK
DI FB11 MMZ1608A252BTA00 SPI1_MISO
DO FB13 SPI1_MOSI
MMZ1608A252BTA00
P1 TOOLHEAD0
FB3 SS_TOOLHEAD0_T
FB4 SS_TOOLHEAD0_NVM
P2 TOOLHEAD1
FB5 SS_TOOLHEAD1_T
FB6 SS_TOOLHEAD1_NVM
P3 DOCK0
FB7 SS_DOCK0_T
FB8 SS_DOCK0_NVM
P4 DOCK1
FB9 SS_DOCK1_T
FB10 SS_DOCK1_NVM
GND
Endstops
P5 X1
P6 Y1
P7 Z1
X1_IN X1 X1_ENDSTOP
Y1_IN Y1 Y1_ENDSTOP
Z1_IN Z1 Z1_ENDSTOP
GND
P8 ENC
ENC_A_IN ENC_A ENC_A
ENC_B_IN ENC_B ENC_B
endstop.sch

Interfaces

PWR_FLAG
USB_DC
P12 μUSB
USB
Z_FAULT
SR_EN
USB1_OC
I2C0_SDA
I2C0_SCL
I2C2_SDA
I2C2_SCL
USB.CLIENT.D−
USB.CLIENT.D+
USB.CLIENT.ID
USB.B.VBUS
USB.HOST.D−
USB.HOST.D+
UART0_TXD
UART0_RXD
usb.sch
P13 USB_Type_A_shield
Serial P11
3V3_FILTERED
SPI0_SCLK FB14
SPI0_MISO FB15
SPI0_MOSI FB16
SPI0_CS0 FB17
DISP_INT FB18
P18 LCD
GND
VDD_PHYA
R9 0Ω
P16 Ethernet
Ethernet
MMC0_DAT0
MMC0_DAT1
MMC0_CLK
MMC0_CMD
MMC0_DAT3
MMC0_DAT2
SYS_RESET
TD+
TD−
RD+
RD−
YELA
GRNA
eth.sch
TCT
TD+
TD−
RD+ NC
RD− GND
RCT
YELC SHD1
YELA SHD2
GRNC
GRNA
CGND
R5 470Ω
R7 10kΩ
R8 470Ω
C6 22nF
GND
P15 μSD
μSD_Connector
MMC0_DAT2
MMC0_DAT3
MMC0_CMD
MMC0_CLK
MMC0_DAT1
MMC0_DAT0
SPI0_CS1
SD.D2
SD.D3
SD.CMD
SD.CLK
SD.D0
SD.D1
SD.CD
sd.sch
VDD_3V3B
DAT2
DAT3/CD
CMD
VDD
CLK
VSS
DAT0
DAT1
SD.CD
CGND1
CGND2
CGND3
CGND4
CGND5
CGND6
CGND
GND
P14 HDMI
HDMI &Config
SPI1_MISO
SPI1_SCLK
SPI1_CS0
I2C0_SDA
I2C0_SCL
HDMI_INT
12MHz
HPD
TX2+
TX2−
TX1+
TX1−
TX0+
TX0−
TXC+
TXC−
CEC
DSCL
DSDA
DVI_5V
hdmi.sch
HOT.PLUG.DETECT
NC
TMDS.DATA2+
TMDS.DATA2.SHIELD
TMDS.DATA2−
TMDS.DATA1+
TMDS.DATA1.SHIELD
TMDS.DATA1−
TMDS.DATA0+
TMDS.DATA0.SHIELD
TMDS.DATA0−
TMDS.CLOCK+
TMDS.CLOCK.SHIELD
TMDS.CLOCK−
CEC
DDC/CEC/GND
SCL
SDA
5V
CG1
CG2
CG3
CG4
CGND
VDD_3V3B
R6 4.75kΩ
JTAG
JTAG_TRST
JTAG_TMS
JTAG_TDI
JTAG_TDO
JTAG_TCK
JTAG_EMU0
JTAG_EMU1
P17
TVDD
TCK
SYS_RESET
XDMA_EVENT_INTRO
SD.CD
CLKOUT2
JTAG
R11 4.75kΩ
R10 4.75kΩ
GND
jtag.sch
C5 100nF
C7 100nF
GND

Output

VDD_3V3B
VDD_5V
R12 4.7kΩ
2N7002
R13 4.7kΩ
SERVO_0
VDD_5V
EPM/Servo
FB19
FB20
P36 PWM
D7 D5V0F1U2S9
D8 D5V0F1U2S9
GND
Stepper Drivers
SR_EN
SPI1_SCLK
SPI1_MISO
SPI1_MOSI
SPI1_CS1
E_STEP
E_DIR
E_FAULT
H_STEP
H_DIR
H_FAULT
X_STEP
X_DIR
X2_ENDSTOP
X_FAULT
Y_STEP
Y_DIR
Y2_ENDSTOP
Y_FAULT
Z_STEP
Z_DIR
Z2_ENDSTOP
Z_FAULT
SS_TOOLHEAD0_T
SS_TOOLHEAD0_NVM
SS_TOOLHEAD1_T
SS_TOOLHEAD1_NVM
SS_DOCK0_T
SS_DOCK0_NVM
SS_DOCK1_T
SS_DOCK1_NVM
E_A1 E_A2 E_B1 E_B2 P19 E_MOTOR
H_A1 H_A2 H_B1 H_B2 P20 H_MOTOR
X0_A1 X0_A2 X0_B1 X0_B2 P21 X0_MOTOR
X1_B2 X1_B1 X1_A2 X1_A1 P22 X1_MOTOR
Y_A1 Y_B1 P23 Y0_MOTOR
Moves in opposing directions
Y_B2 Y_A2 P24 Y1_MOTOR
Z0_A1 Z0_A2 Z0_B1 Z0_B2 P25 Z0_MOTOR
Z1_A1 Z1_A2 Z1_B1 Z1_B2 P26 Z1_MOTOR
Z2_A1 Z2_A2 Z2_B1 Z2_B2 P27 Z2_MOTOR
stepper.sch
39532−1002 4.2x2.1 mm
PWM
I2C2_SCL
I2C2_SDA
PWM_EN
Heaters
BED_HEAT
E_HEAT
H_HEAT
DOCK0_HEAT
DOCK1_HEAT
BED_HEAT_IN
E_HEAT_IN
H_HEAT_IN
DOCK0_HEAT_IN
DOCK1_HEAT_IN
P28 BED_HEAT
P29 E_HEAT
P30 H_HEAT
P31 DOCK0_HEAT
P32 DOCK1_HEAT
heater.sch
Fans
E_FAN
H_FAN
CASE_FAN
E_FAN_IN
H_FAN_IN
CASE_FAN_IN
P33 E_FAN
P34 H_FAN
P35 CASE_FAN
pwm.sch
fan.sch
GND

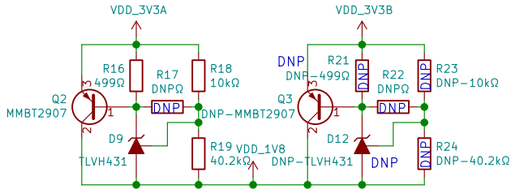
Aleph Objects Inc.
Sheet: /
File: KiMBo.sch
Title: KiMBo
Size: A3 | Date: 2017−03−17 | **Rev:**
KiCad E.D.A. kicad (2016−12−15 revision b13c7e4)−master | Id: 1/26

Input

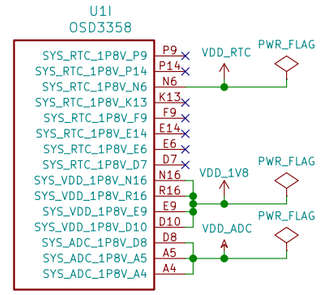
input.sch

Voltage_Regulator

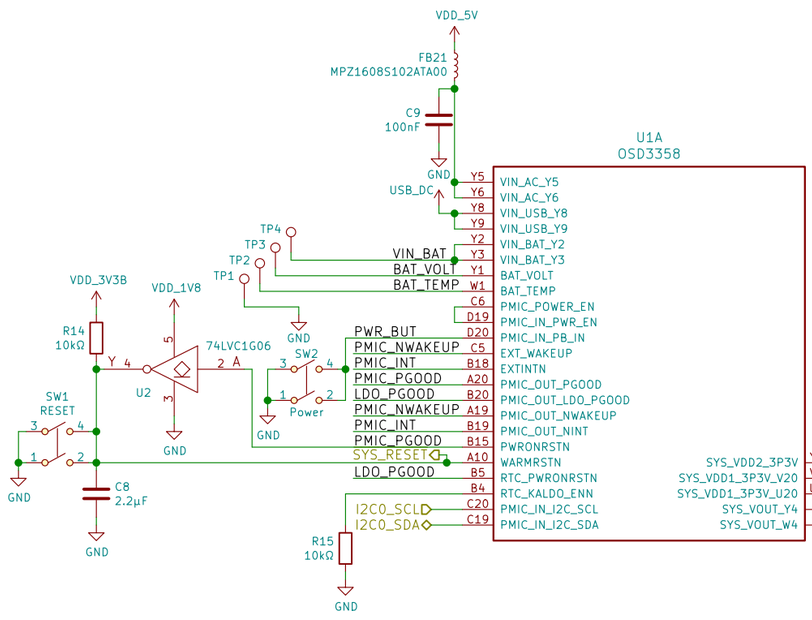
voltage_regulator.sch

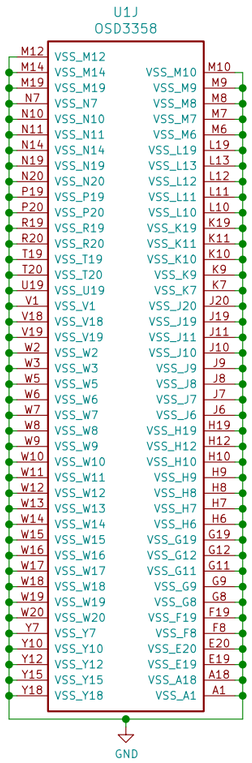


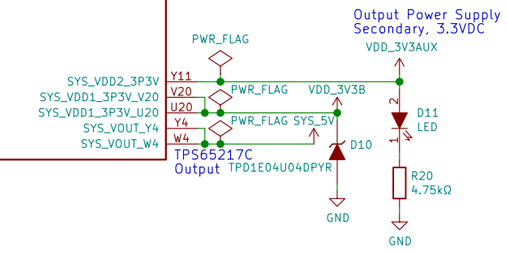
TLVH431IDBZR

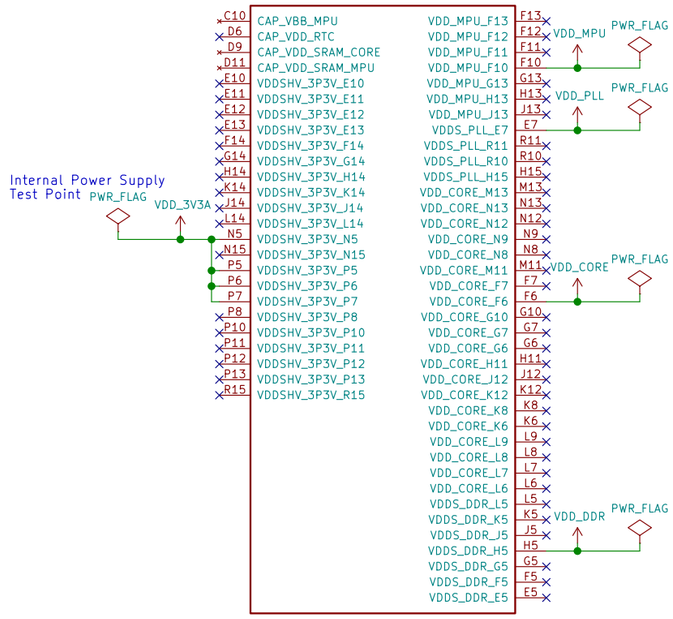


5V Input

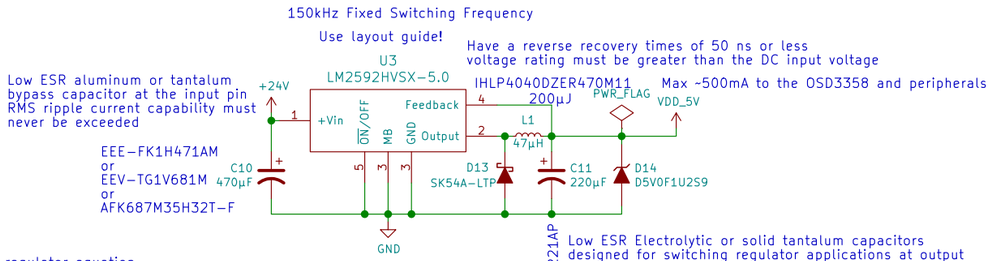








Sheet: /Power/		
File: power.sch		
Title:		
Size: A3	Date:	**Rev:**
KiCad E.D.A. kicad (2016-12-15 revision b13c7e4)-master		Id: 2/26

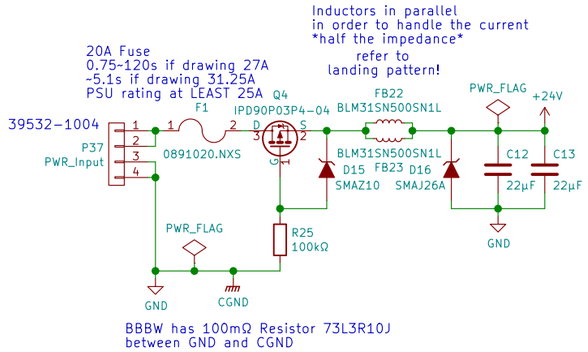


Inverting regulator equation

$$I_{PEAK} = I_{LOAD} \times \left(\frac{V_{IN} + V_{OUT}}{V_{IN}}\right) + \frac{V_{IN} \times V_{OUT} \times 10^6}{2 \times L \times f \times (V_{IN} + V_{OUT})}$$

2.3=I_Load×(24+5)/24+((24×5×10^6)/(2×47×0.8×150×10^6×(5+24)))×1.2
I_Load=1.90308

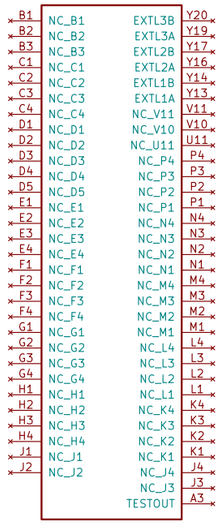
Sheet: /Power/Voltage Regulator/		
File: voltage_regulator.sch		
Title:		
Size: A3	Date:	**Rev:**
KiCad E.D.A. kicad (2016-12-15 revision b13c7e4)-master		Id: 3/26

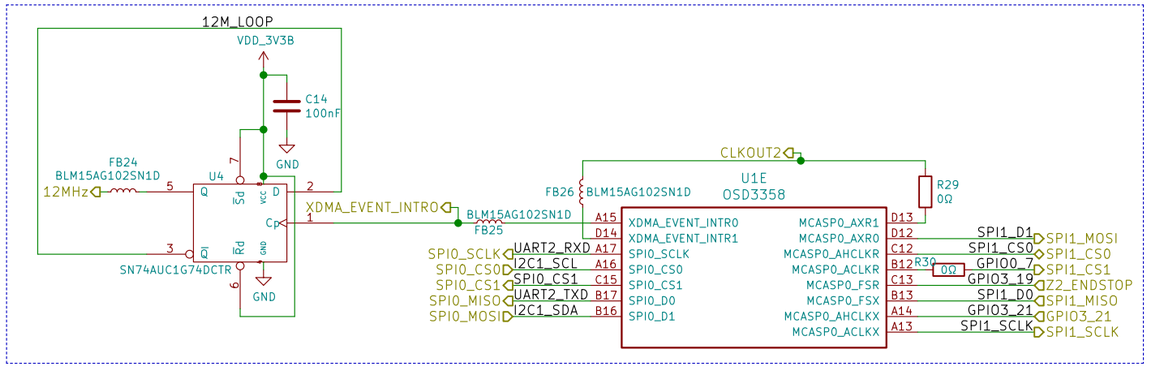


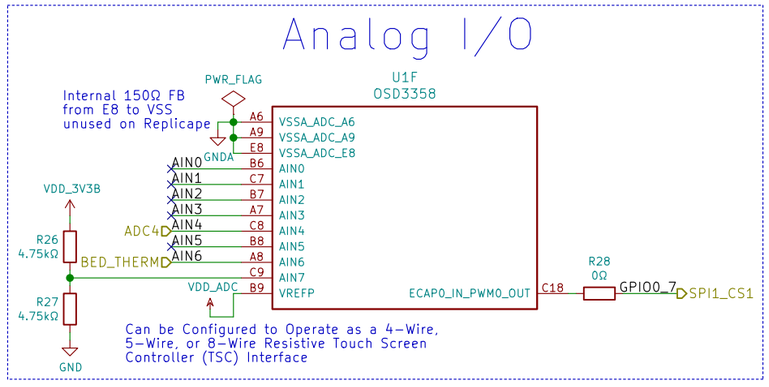
Sheet: /Power/Input/		
File: input.sch		
Title:		
Size: A3	Date:	**Rev:**
KiCad E.D.A. kicad (2016-12-15 revision b13c7e4)-master		Id: 4/26

Unused

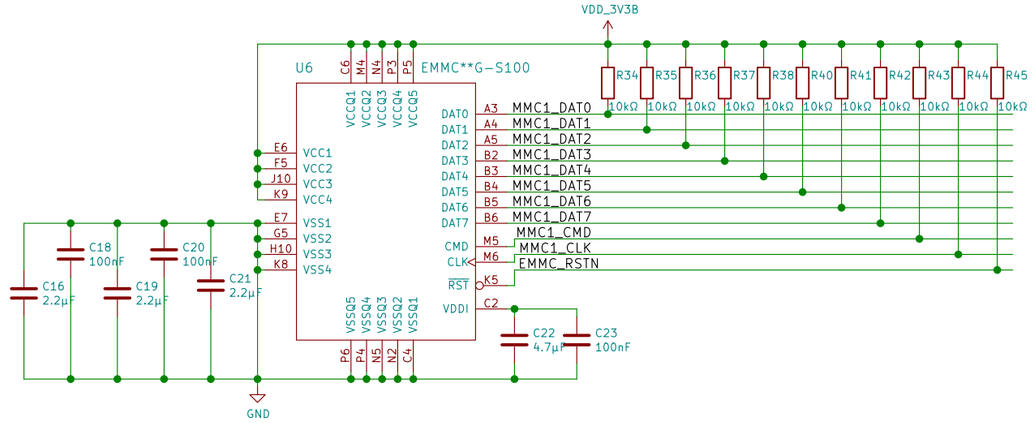
U1L
OSD3358

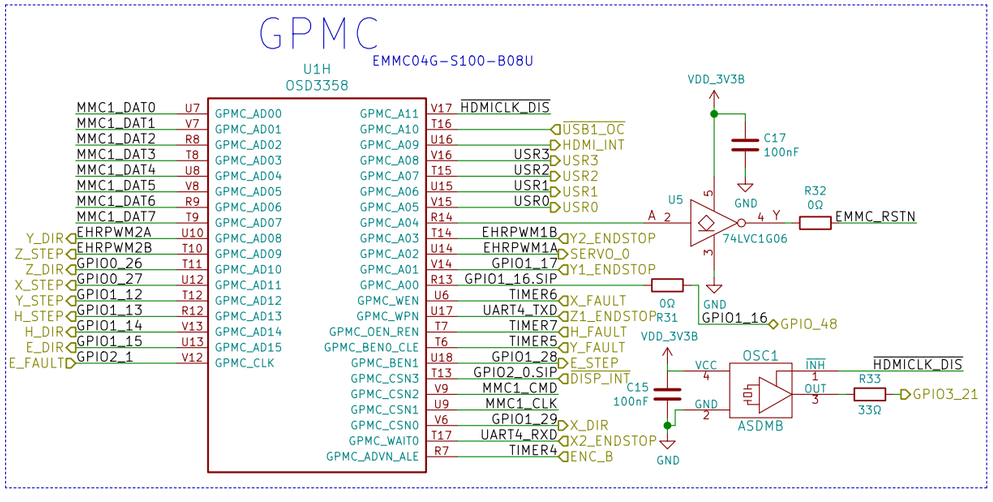


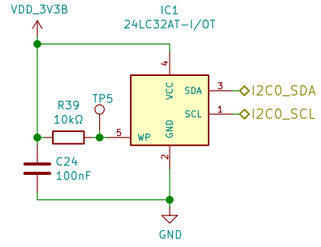




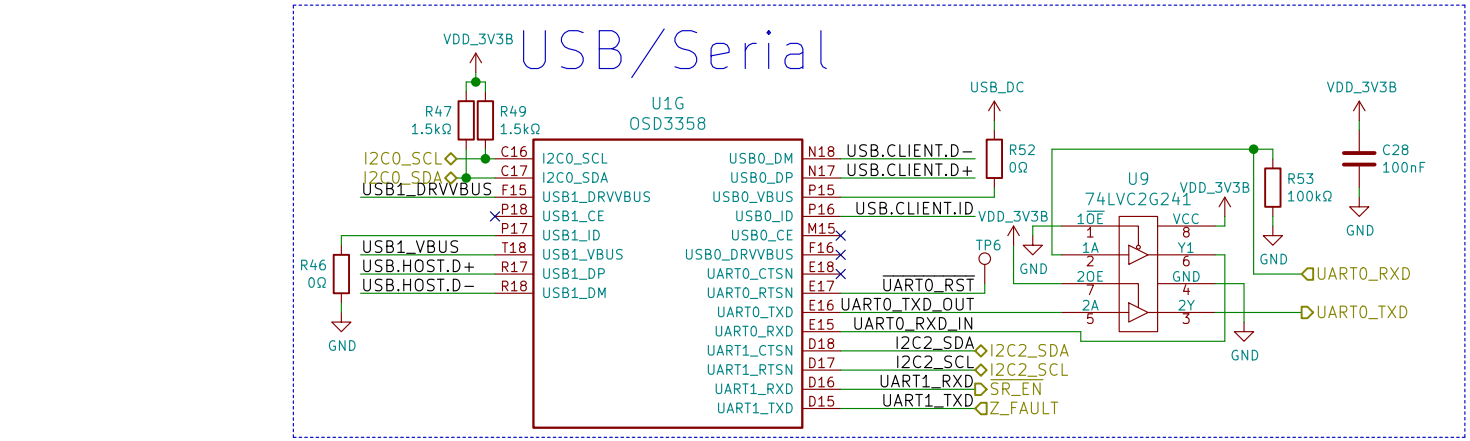
Sheet: /Microprocessor/		
File: mpu.sch		
Title:		
Size: A3	Date:	**Rev:**
KiCad E.D.A. kicad (2016-12-15 revision b13c7e4)-master		Id: 5/26



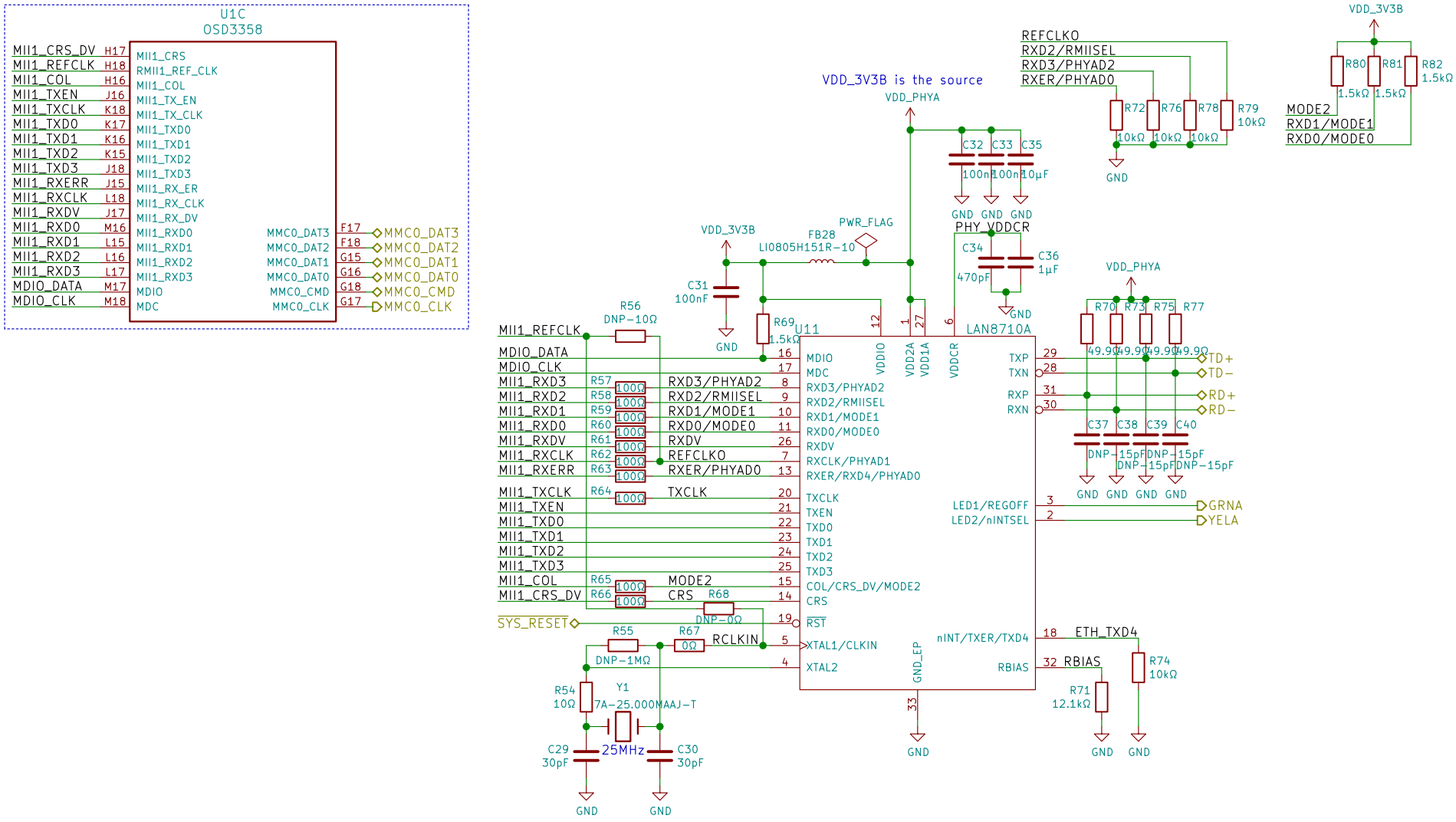




Sheet: /Flash/		
File: flash.sch		
Title:		
Size: A3	Date:	**Rev:**
KiCad E.D.A. kicad (2016-12-15 revision b13c7e4)-master		Id: 6/26



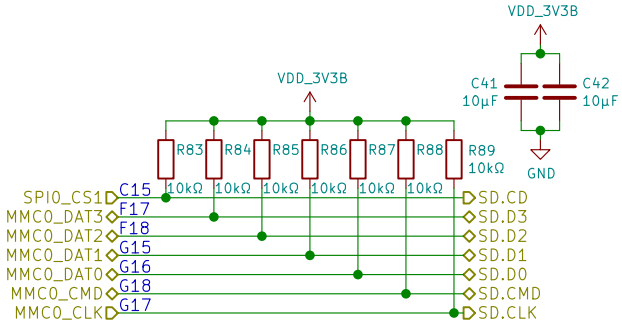
Sheet: /USB/ File: usb.sch		
Title:		
Size: A4	Date:	**Rev:**
KiCad E.D.A. kicad (2016−12−15 revision b13c7e4)−master		Id: 7/26



Sheet: /Ethernet/
File: eth.sch

Title:

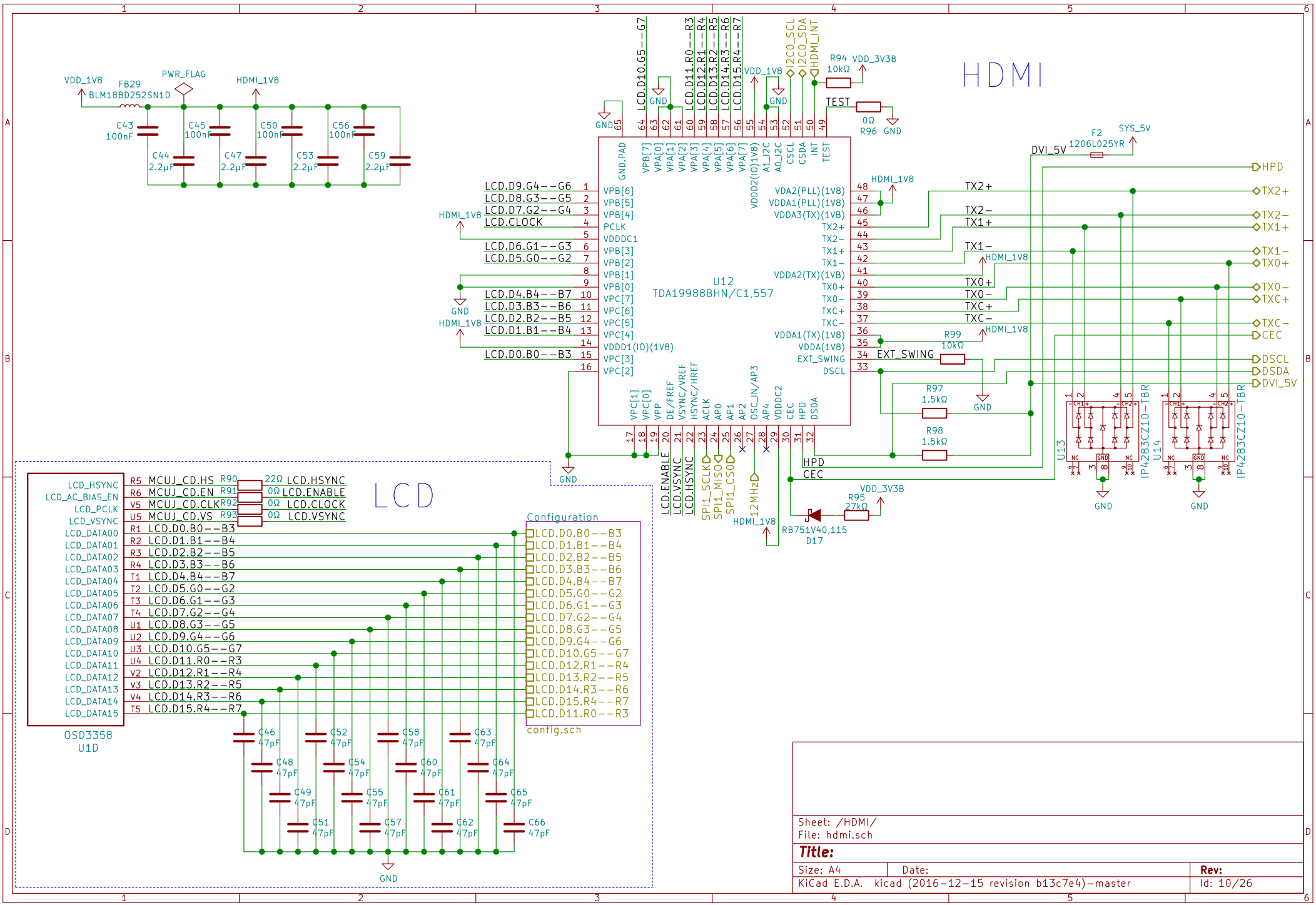
Size: A4	Date:	**Rev:**
KiCad E.D.A. kicad (2016-12-15 revision b13c7e4)-master		Id: 8/26

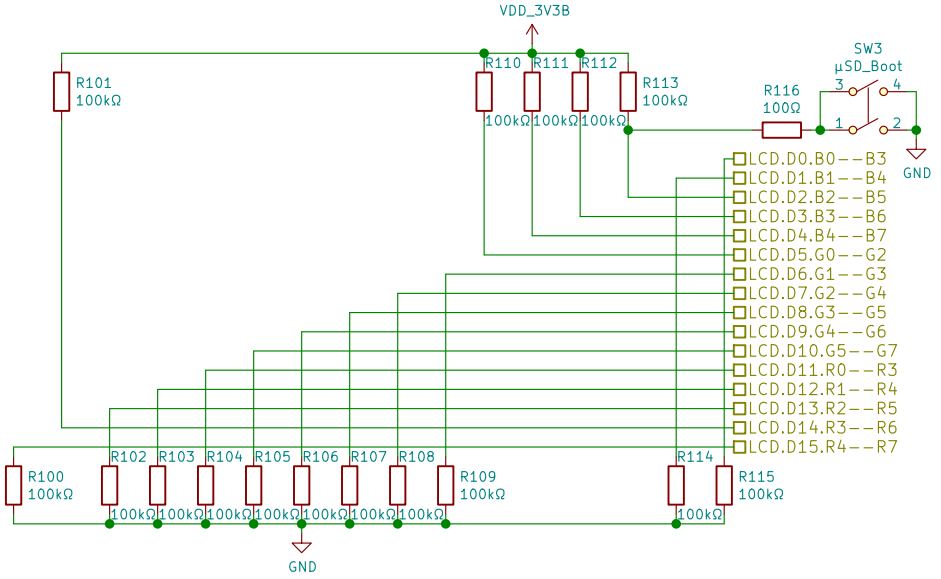


Sheet: /uSD Connector/
File: sd.sch

Title:

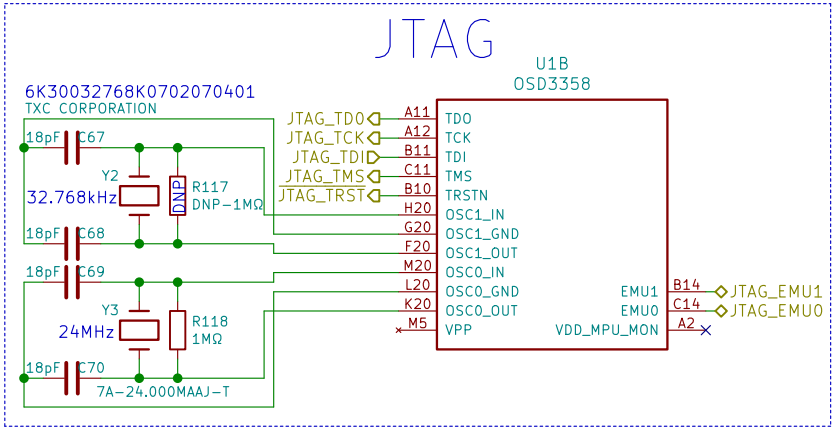
Size: A4	Date:	**Rev:**
KiCad E.D.A. kicad (2016-12-15 revision b13c7e4)-master		Id: 9/26


HDMI
LCD
U12
TDA19988BHN/C1,557
OSD3358
U1D
config.sch
U13
U14
IP4283CZ10-TBR
RB751V40,115
D17
Sheet: /HDMI/
File: hdmi.sch
Title:
Size: A4
Date:
Rev:
KiCad E.D.A. kicad (2016-12-15 revision b13c7e4)-master
Id: 10/26

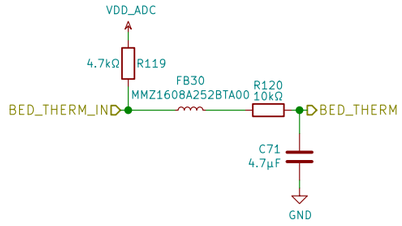


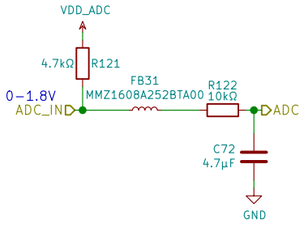
Sheet: /HDMI/Configuration/ File: config.sch		
Title:		
Size: A4	Date:	**Rev:**
KiCad E.D.A. kicad (2016-12-15 revision b13c7e4)-master		Id: 11/26

https://www.digikey.com/products/en/crystals-oscillators-resonators/crystals/171?k=&pkeyword=&pv46=14783&FV=8c0011%2C22c0060%2C8640003%2C1f140000%2Cffe000ab%2C402f3e&mnonly=0&newproducts=0&ColumnSort=0&page=1&quantity=0&ptm=0&fid=0&pageSize=25



Sheet: /JTAG/ File: jtag.sch		
Title:		
Size: A4	Date:	**Rev:**
KiCad E.D.A. kicad (2016-12-15 revision b13c7e4)-master		Id: 12/26

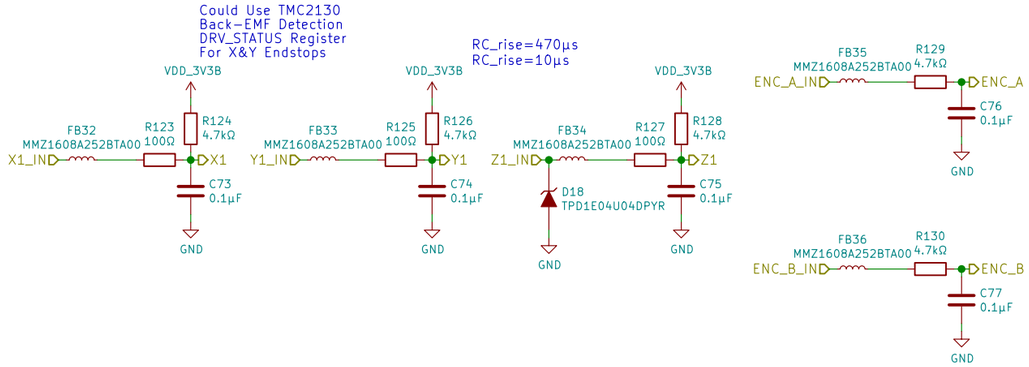




Sheet: /Thermistors/
File: therm.sch

Title:

Size: A3	Date:	**Rev:**
KiCad E.D.A. kicad (2016-12-15 revision b13c7e4)-master		Id: 13/26

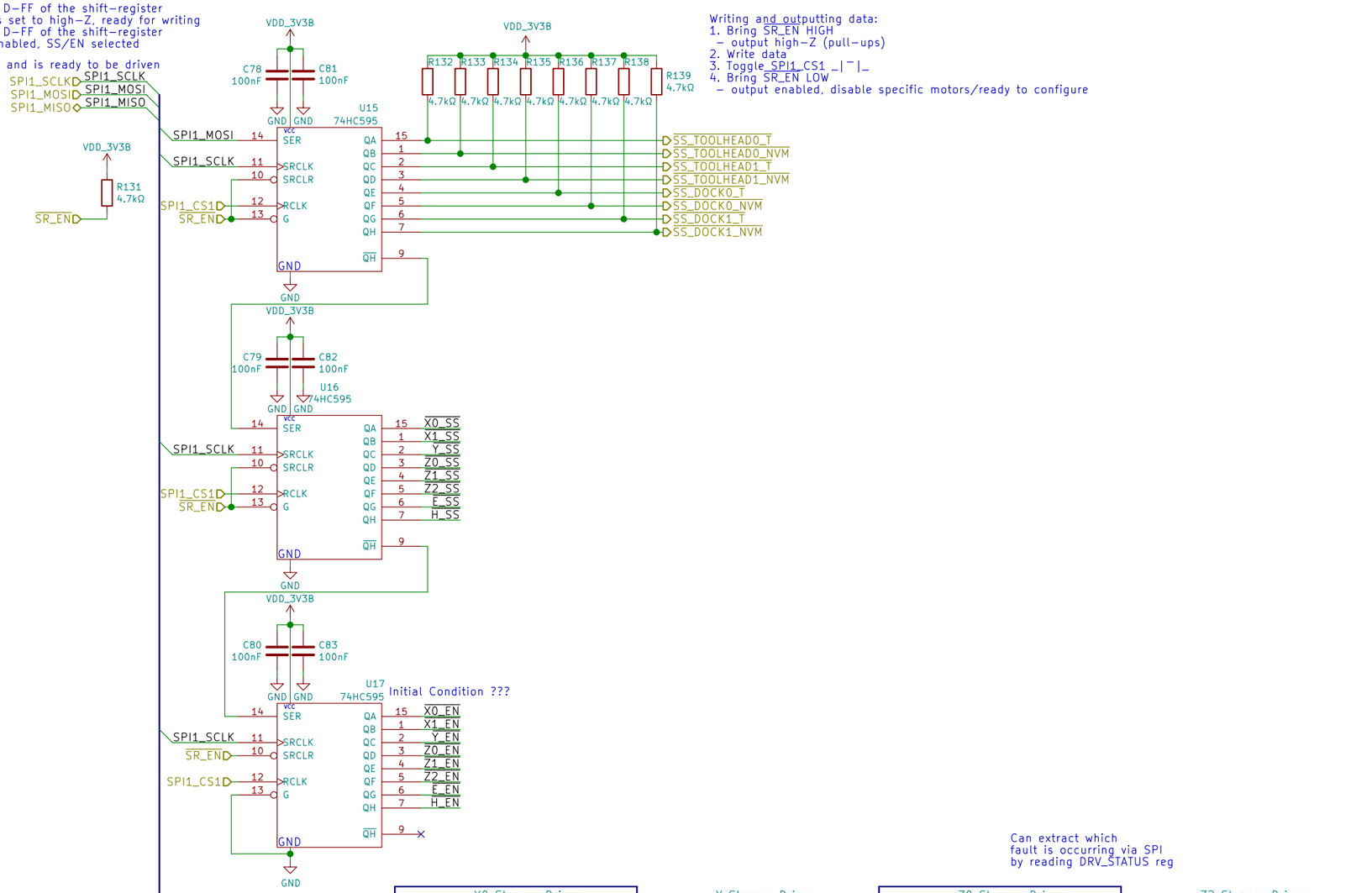


Sheet: /Endstops/		
File: endstop.sch		
Title:		
Size: A3	Date:	**Rev:**
KiCad E.D.A. kicad (2016-12-15 revision b13c7e4)-master		Id: 14/26

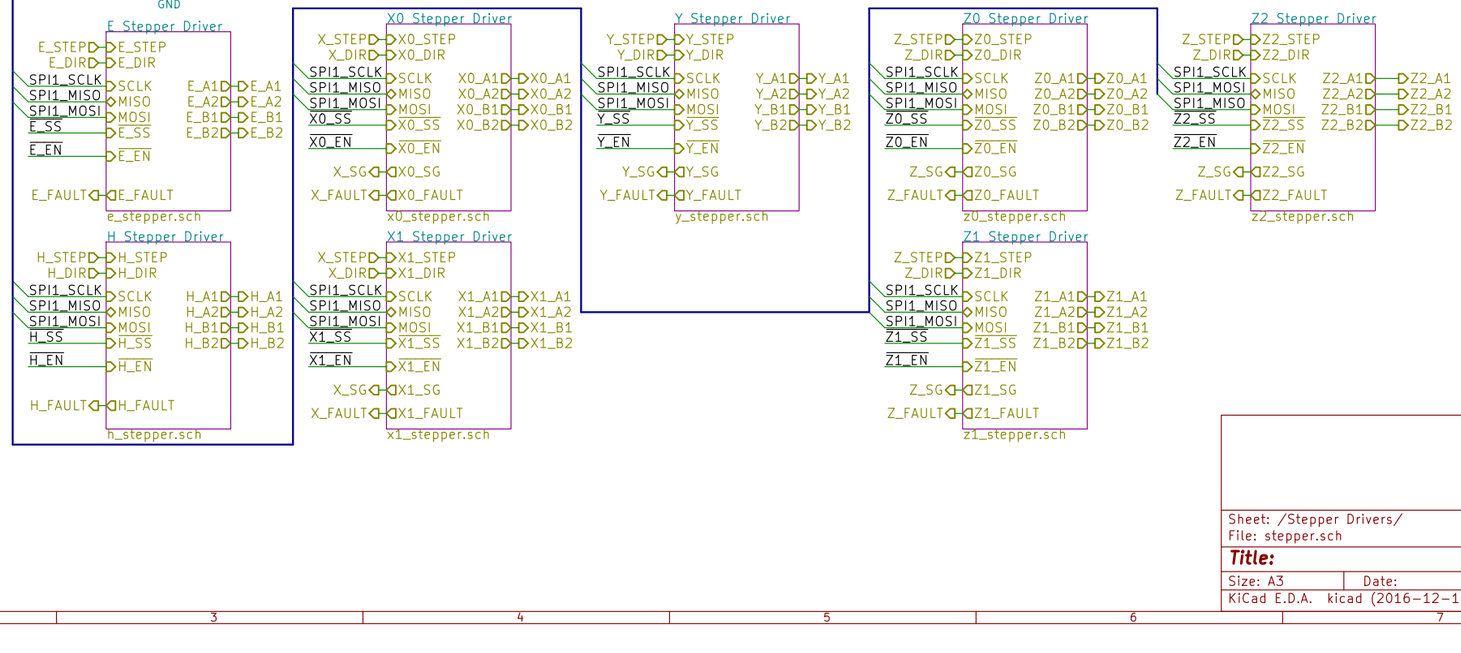
When $\overline{\text{SR\_EN}}$ transitions from LOW to HIGH each D-FF of the shift-register come out of their reset states and the output is set to high-Z, ready for writing
When SR_EN transitions from HIGH to LOW each D-FF of the shift-register goes into their reset states and the output is enabled, SS/EN selected

SPI1_CS1 captures the data in the shift register and is ready to be driven by the second stage of D-FFs

Writing and outputting data:
1. Bring SR_EN HIGH
   - output high-Z (pull-ups)
2. Write data
3. Toggle SPI1_CS1 _|‾|_
4. Bring SR_EN LOW
   - output enabled, disable specific motors/ready to configure



Can extract which fault is occurring via SPI by reading DRV_STATUS reg



Sheet: /Stepper Drivers/
File: stepper.sch

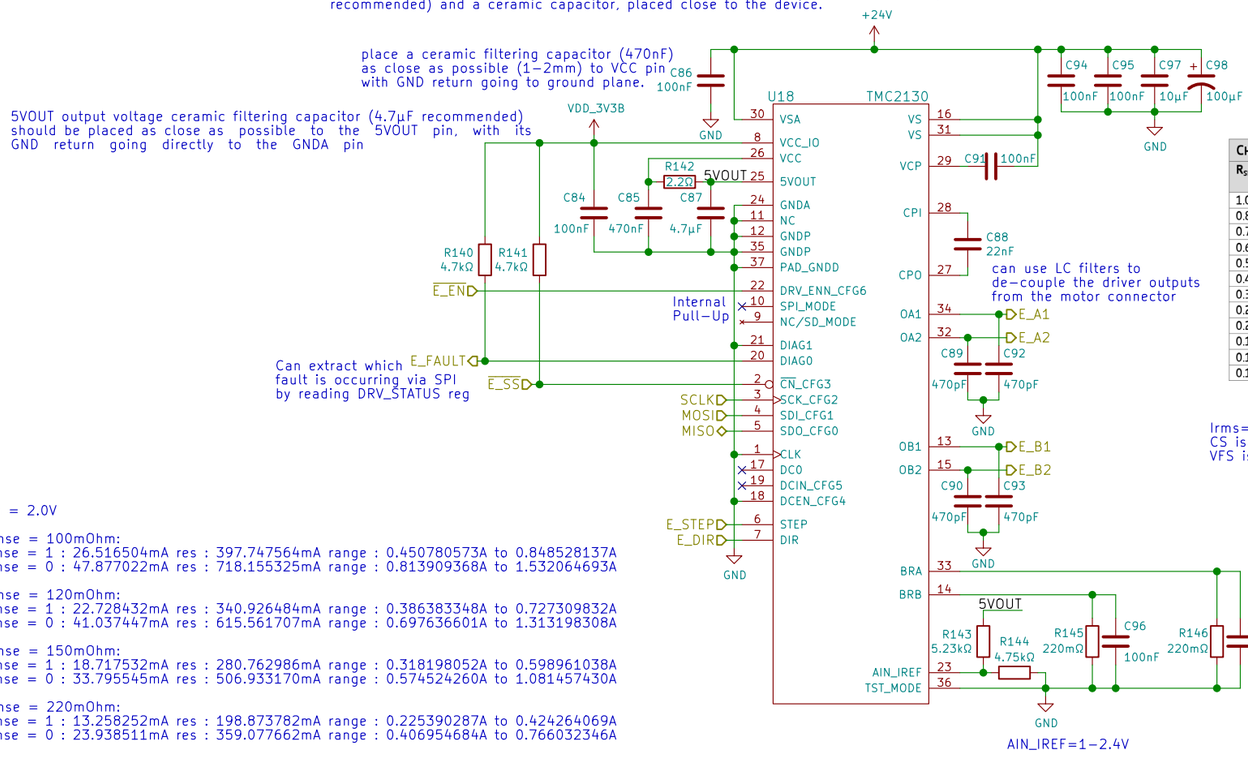
Title:

Size: A3 | Date: | **Rev:**
KiCad E.D.A. kicad (2016-12-15 revision b13c7e4)-master | Id: 15/26

See Chapter 29 of the datasheet for layout

Place sense resistors and all filter capacitors as close as possible to the related IC pins. Use a solid common GND for all GND connections, also for sense resistor GND. Connect 5VOUT filtering capacitor directly to 5VOUT and GNDA pin. See layout hints for more details. Low ESR electrolytic capacitors are recommended for VS filtering.

A 100nF filtering capacitor should be placed as close as possible to the VSA pin to ground plane. The motor supply pins VS should be decoupled with an electrolytic capacitor (47µF or larger is recommended) and a ceramic capacitor, placed close to the device.



CHOICE OF R_{SENSE} AND RESULTING MAX. MOTOR CURRENT		
R_{SENSE} [Ω]	*RMS current [A] (CS=31, vsense=0)*	*RMS current [A] (CS=31, vsense=1)*
1.00	0.23	0.12
0.82	0.27	0.15
0.75	0.30	0.17
0.68	0.33	0.18
0.50	0.44	0.24
0.47	0.47	0.26
0.33	0.66	0.36
0.27	0.79	0.44
0.22	0.96	0.53
0.15	1.35	0.75
0.12	1.64	0.91
0.10	1.92*)	1.06

Irms=(CS+1)/32 × Vfs/(Rsense+20mΩ) × 1/√2
CS is the current scale setting as set by IHOLD IRUN and coolStep
VFS is the full scale voltage as determined by vsense control bit

Vain = 2.0V

Rsense = 100mOhm:
Vsense = 1 : 26.516504mA res : 397.747564mA range : 0.450780573A to 0.848528137A
Vsense = 0 : 47.877022mA res : 718.155325mA range : 0.813909368A to 1.532064693A

Rsense = 120mOhm:
Vsense = 1 : 22.728432mA res : 340.926484mA range : 0.386383348A to 0.727309832A
Vsense = 0 : 41.037447mA res : 615.561707mA range : 0.697636601A to 1.313198308A

Rsense = 150mOhm:
Vsense = 1 : 18.717532mA res : 280.762986mA range : 0.318198052A to 0.598961038A
Vsense = 0 : 33.795545mA res : 506.933170mA range : 0.574524260A to 1.081457430A

Rsense = 220mOhm:
Vsense = 1 : 13.258252mA res : 198.873782mA range : 0.225390287A to 0.424264069A
Vsense = 0 : 23.938511mA res : 359.077662mA range : 0.406954684A to 0.766032346A

Vain = 2.4V

Rsense = 220mOhm:
Vsense = 1 : 15.909903mA res : 238.648538mA range : 0.270468344A to 0.509116882A
Vsense = 0 : 28.726213mA res : 430.893195mA range : 0.488345621A to 0.919238816A

Vain = 2.379759519V

Rsense = 220mOhm:
Vsense = 1 : 15.775726mA res : 236.635888mA range : 0.26818734A to 0.504823228A
Vsense = 0 : 28.483949mA res : 427.259243mA range : 0.484227141A to 0.911486384A

AIN_IREF=1–2.4V

Bit 0 of GCONF:
I_scale_analog
0: Normal operation, use internal reference voltage
1: Use voltage supplied to AIN as current reference

When *I_scale_analog* is enabled for analog scaling of V_{FS}, the resulting voltage V_{FS}' is calculated by:

$$V_{FS}' = V_{FS} * \frac{V_{AIN}}{2.5V}$$

Choose sense resistors in a way, that normal IRUN is 16 to 31 for best microstep performance.

For best precision, choose the sense resistors in a way that the desired maximum current is reached with AIN in the range 2V to 2.4V

Sense input tolerance / motor current full scale tolerance -using internal reference	I_{COIL}	*I_scale_analog*=0, *vsense*=0	-5		+5	%
Sense input tolerance / motor current full scale tolerance -using external reference voltage	I_{COIL}	*I_scale_analog*=1, V_{AIN}=2V, *vsense*=0 Vain = 2.379759519V	-2		+2	%

The sense resistor voltage range can be selected by the vsense bit in CHOPCONF. The low sensitivity setting (high sense resistor voltage, vsense=0) brings *best and most robust current regulation*, while high sensitivity (low sense resistor voltage, vsense=1) reduces power dissipation in the sense resistor. The high sensitivity setting reduces the power dissipation in the sense resistor by nearly half.

vsense	Allows control of the sense resistor *voltage range* for full scale current.	0	V_{FS} = 0.32 V
		1	V_{FS} = 0.18 V

Vsrtl=325mV

Sheet: /Stepper Drivers/E Stepper Driver/
File: e_stepper.sch

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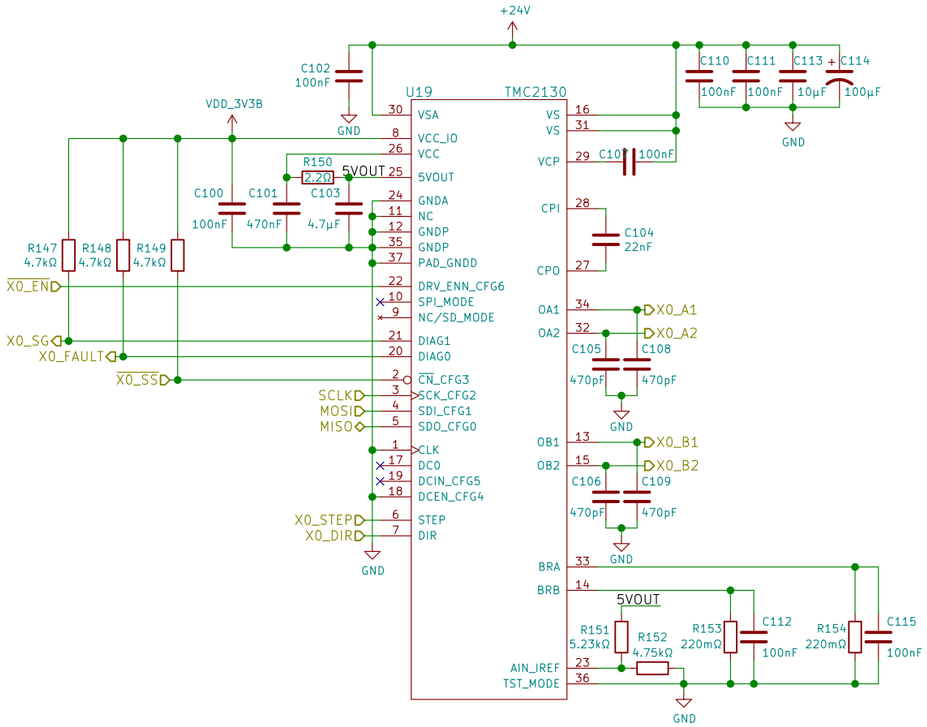

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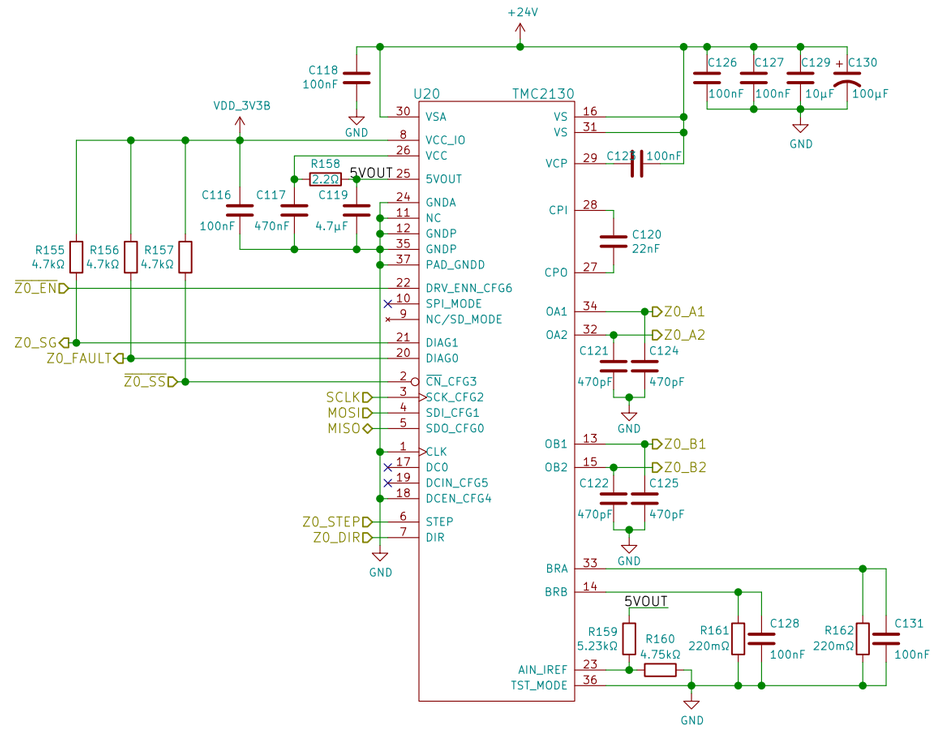

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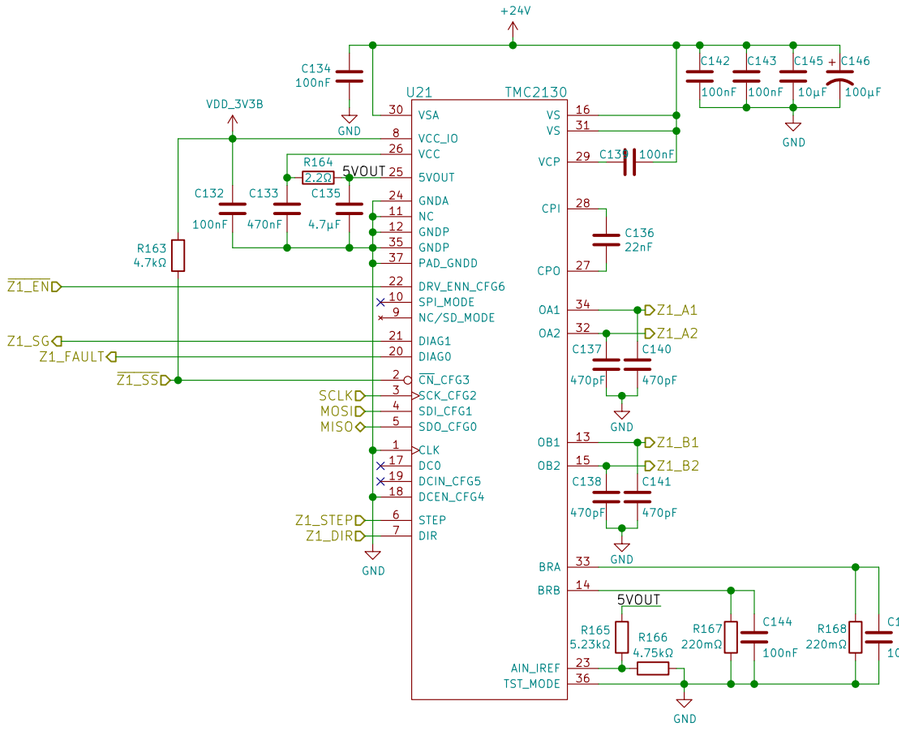

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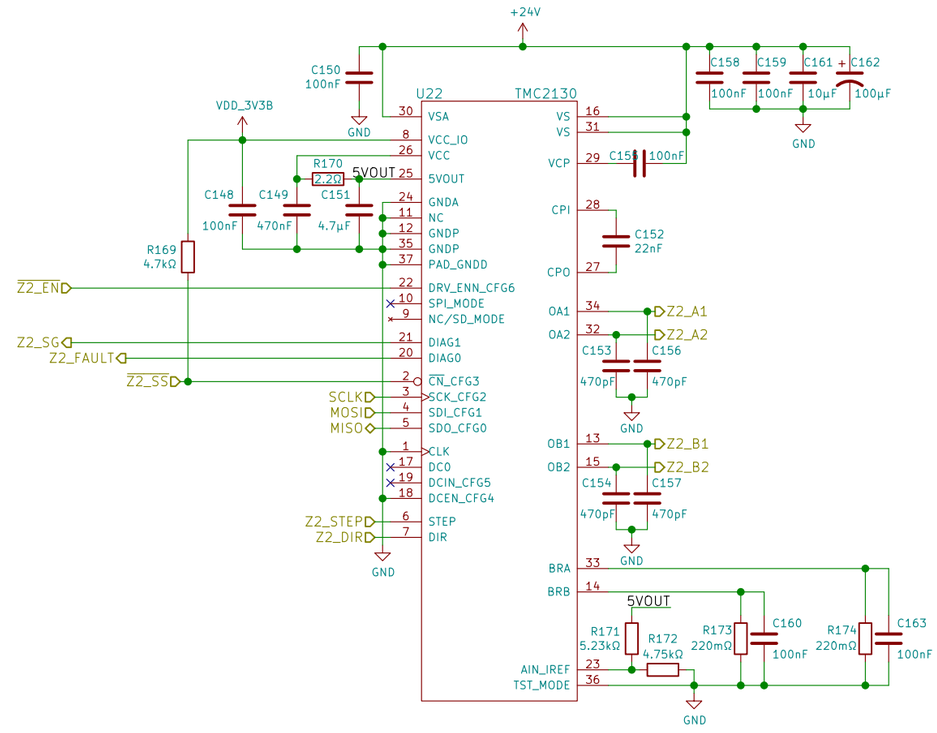

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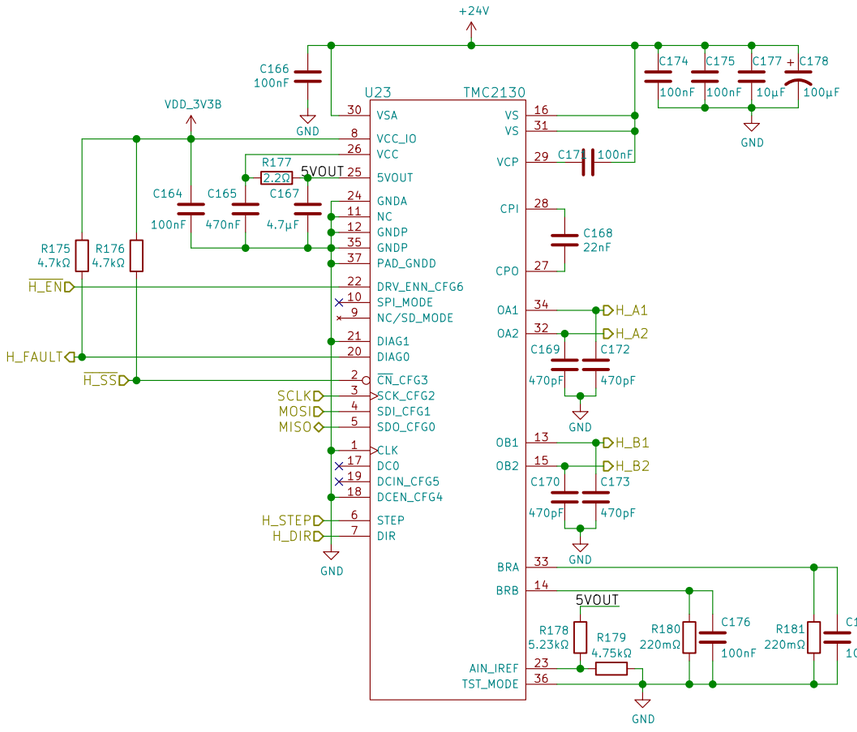

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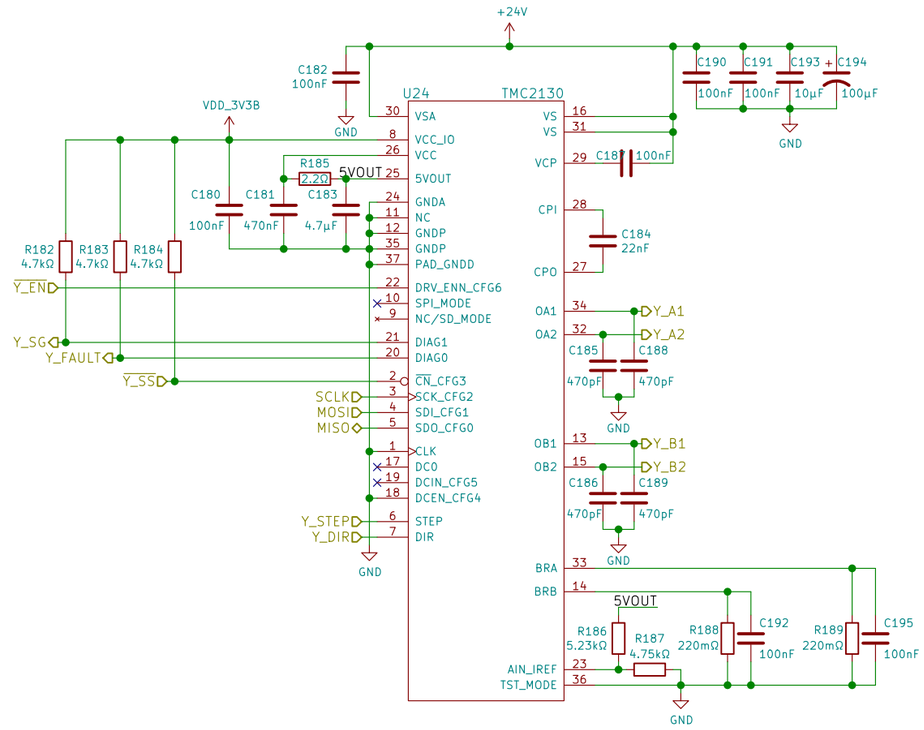

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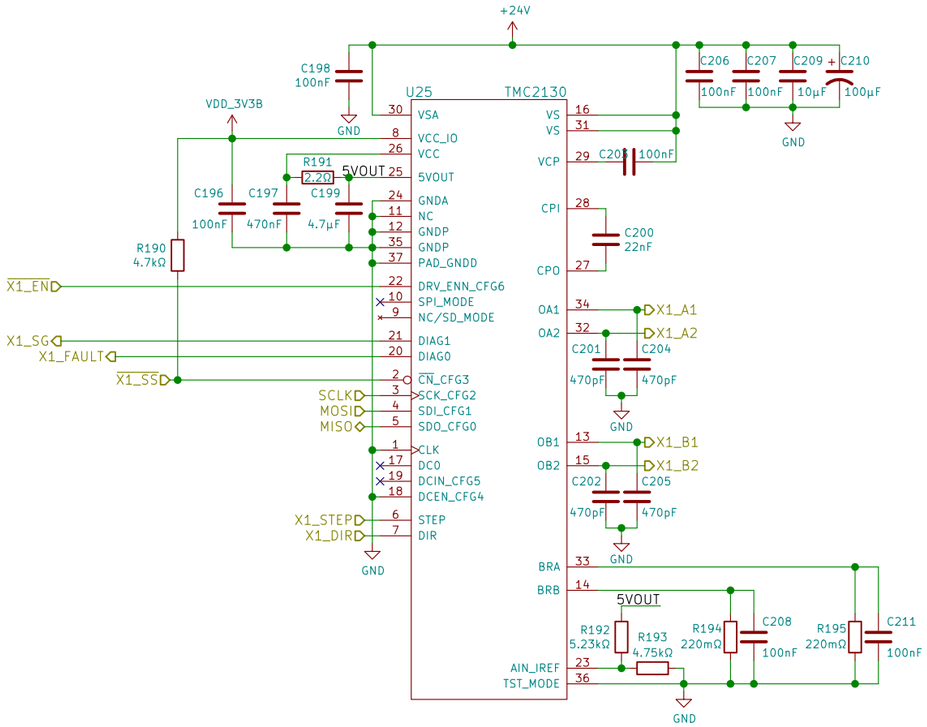

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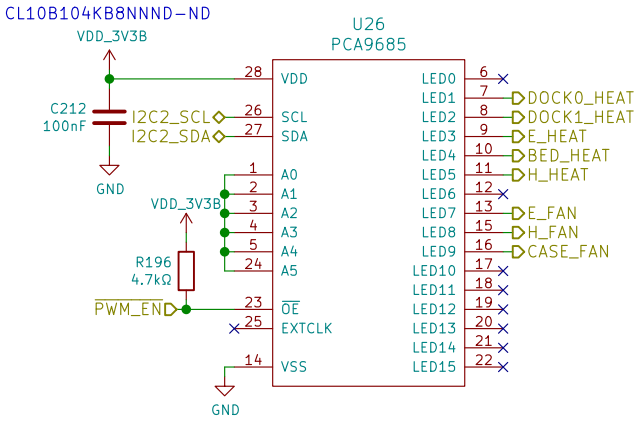

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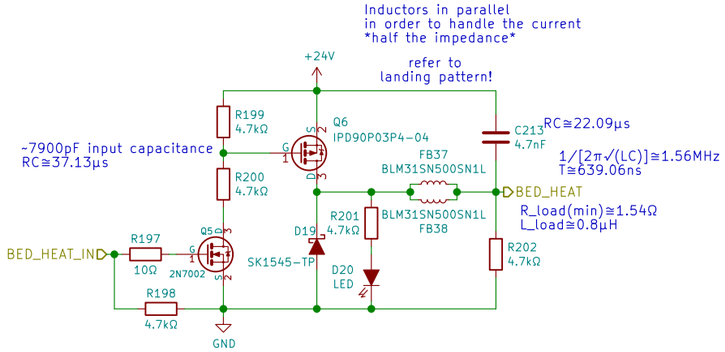
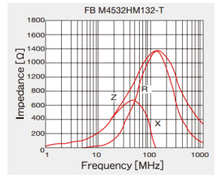
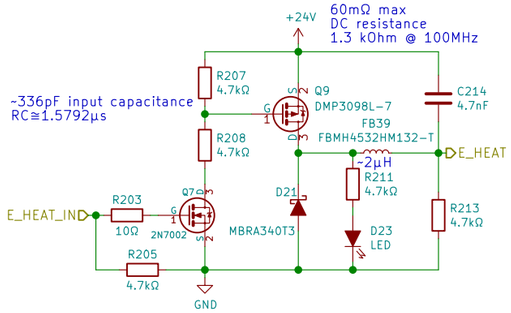
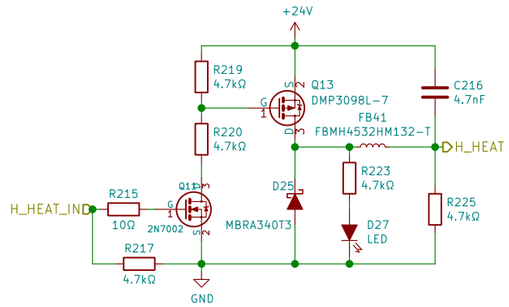
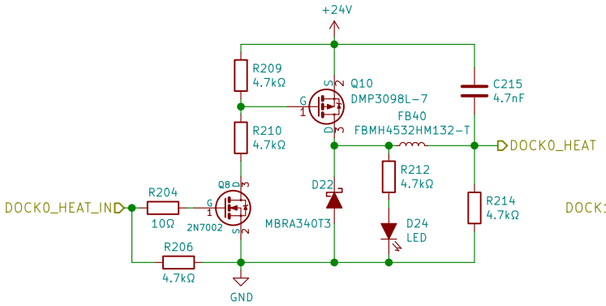
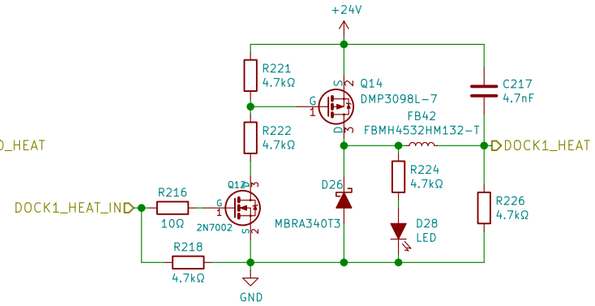








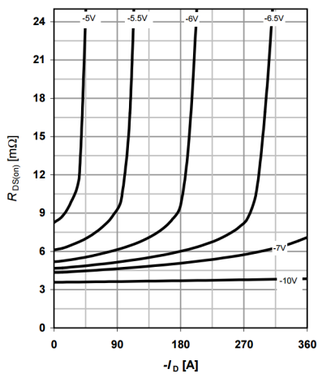




6 Typ. drain-source on-state resistance

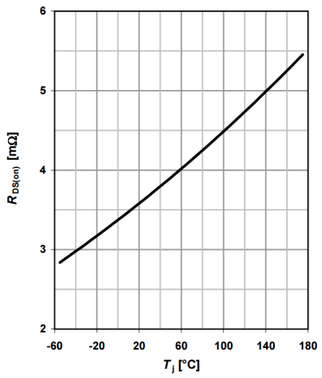
$R_{DS(on)} = (I_D)$; $T_j = 25$ °C

parameter: V_{GS}



8 Typ. drain-source on-state resistance

$R_{DS(on)} = f(T_j)$; $I_D = -90$ A; $V_{GS} = -10$ V



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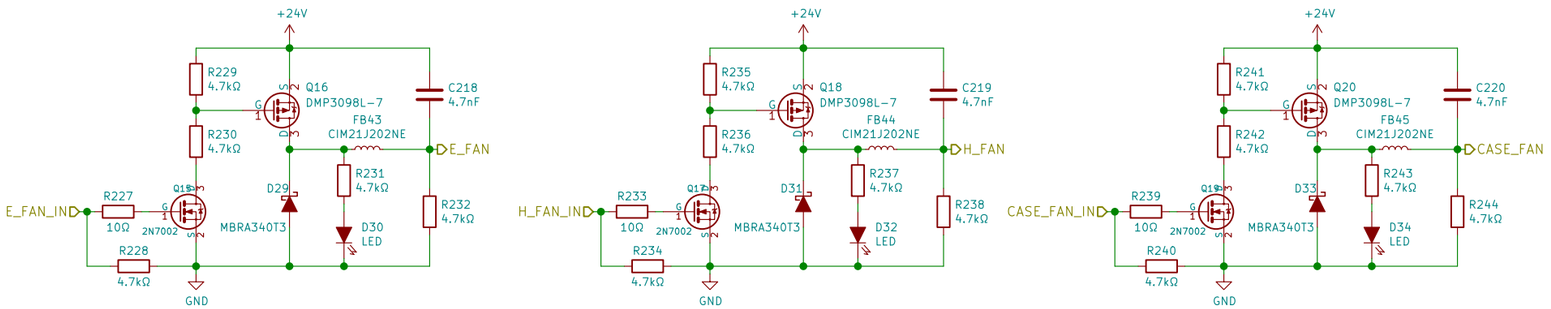

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