Power

Power
SYS_RESET
I2C0_SDA
I2C0_SCL
power.sch

User LEDs

USR3 — R1 R — LED D1
USR2 — R2 R — LED D2
USR1 — R3 R — LED D3
USR0 — R4 R — LED D4
GND

eMMC

Flash
X1_ENDSTOP
X2_ENDSTOP
Y1_ENDSTOP
Z1_ENDSTOP
USR3
USR2
USR1
USR0
I2C0_SDA
I2C0_SCL
ENC_A
HDMI_INT
USB1_OC
GPIO3_21
X2_ENDSTOP
Y1_ENDSTOP
Z1_ENDSTOP
USR3
USR2
USR1
USR0
I2C0_SDA
I2C0_SCL
GPIO_48
HDMI_INT
USB1_OC
X_STEP
X_DIR
X_FAULT
Y_STEP
Y_DIR
Y_FAULT
Z_STEP
Z_DIR
E_STEP
E_DIR
E_FAULT
H_STEP
H_DIR
H_FAULT
SERVO_0
SERVO_1
flash.sch

Microprocessor

XDMA_EVENT_INTRO
PWM_EN CLKOUT2
SPI0_CS1
SR_EN
SPI1_MISO
SPI1_MOSI
SPI1_SCLK
SPI1_CS1
XDMA_EVENT_INTRO
CLKOUT2
SPI0_CS1
SPI0_SCLK
SPI1_MISO
SPI1_MOSI
SPI1_SCLK
SPI1_CS1
GPIO3_21
SPI1_CS0
Z2_ENDSTOP
ENC_B
BED_THERM
ADC4
12MHz
X1_ENDSTOP
SPI1_CS0 Y2_ENDSTOP
Z2_ENDSTOP
ENC_B
BED_THERM
ADC
12MHz
mpu.sch

Feedback Input

Thermistors / Thermocouples
VDD_3V3B
P1 BED
P2 ADC
FB1
C1 100nF
C2 10nF
GND GND
BED_THERM_IN
ADC_IN
BED_THERM
ADC
therm.sch
P3 CONN_01X07
P4 CONN_01X07
P5 CONN_01X07
P6 CONN_01X07
DI
DO
SCLK
FB2 SS_TOOLHEAD0_T
FB3 SS_TOOLHEAD0_NVM
FB4 SS_TOOLHEAD1_T
FB5 SS_TOOLHEAD1_NVM
FB6 SS_DOCK0_T
FB7 SS_DOCK0_NVM
FB8 SS_DOCK1_T
FB9 SS_DOCK1_NVM
GND
DI
DO FB10 MMZ1608A252BTA00 SPI1_MOSI
SCLK FB12 MMZ1608A252BTA00 SPI1_SCLK
FB11 SPI1_MISO
MMZ1608A252BTA00

Endstops
P7 CONN_01X02
P8 CONN_01X02
P9 CONN_01X02
P10 CONN_01X02
X1_IN
Y1_IN
Z1_IN
ENC_A_IN
ENC_B_IN
X1
Y1
Z1
ENC_A
ENC_B
X1_ENDSTOP
Y1_ENDSTOP
Z1_ENDSTOP
ENC_A
ENC_B
endstop.sch

Interfaces

PWR_FLAG
USB_DC
P12 USB_OTG
VBUS
D−
D+
ID
GND
P13
USB_B_2Shield
Z_FAULT
USB1_OC
I2C0_SDA
I2C0_SCL
I2C2_SDA
I2C2_SCL
USB
Z_FAULT
USB1_OC
I2C0_SDA
I2C0_SCL
I2C2_SDA
I2C2_SCL
USB.CLIENT.ID
USB.CLIENT.D+
USB.CLIENT.D−
USB.B.VBUS
USB.HOST.D−
USB.HOST.D+
UART0_TXD
UART0_RXD
usb.sch
Serial P11
GND

P14 Ethernet_Connector
Ethernet
MMC0_DAT0
MMC0_DAT1
MMC0_CLK
MMC0_CMD
MMC0_DAT3
MMC0_DAT2
SYS_RESET
TD+
TD−
RD+
RD−
YELA
GRNA
TCT
TD+
TD−
RD+
RD−
RCT
YELC SHD1
YELA SHD2
GRNC
GRNA
NC
GND
eth.sch
R5 R
R7 R
R8 R
C4 C
R9 R
VDD_PHYA
R10 100mΩ
CGND
GND

CON1 Micro_SD_Card_Shield
uSD 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
DAT2
DAT3/CD
CMD
VDD
CLK
VSS
DAT0
DAT1
SD.CD
CGND1
CGND2
CGND3
CGND4
CGND5
CGND6
sd.sch
VDD_3V3B
GND

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
X1 10118241−001RLF
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
hdmi.sch
CGND
GND

JTAG
R6 R
VDD_3V3B
JTAG_TRST
JTAG_TMS
JTAG_TDI
JTAG_TDO
JTAG_TCK
JTAG_EMU0
JTAG_EMU1
P15
TVDD
TCK
SYS_RESET
XDMA_EVENT_INTRO
SD.CD
R11 R
R12 R
CLKOUT2
JTAG
jtag.sch
C3 CP1
C5 CP1
GND

Output

U1 MAX3370
VDD_3V3B
VDD_5V
VL
VCC
I/O_VL
I/O_VCC
GND
SERVO_0
may be unneeded
FB13
FB14
P32 CONN_01X03
D5 D5V0F1U2S9

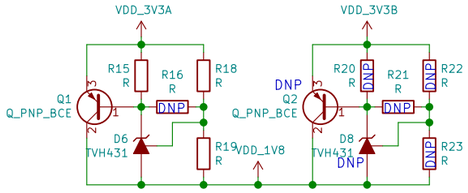
Stepper Drivers
SR_EN
SPI1_MISO
SPI1_MOSI
SPI1_CS1
SPI1_SCLK
E_STEP
E_DIR
E_FAULT
H_STEP
H_DIR
H_FAULT
X_STEP
X_DIR
X2_ENDSTOP
X_FAULT
Y_STEP
Y_DIR
Y2_ENDSTOP
Y_FAULT
Z_STEP
Z_DIR
Z2_ENDSTOP
Z_FAULT
SS_TOOLHEAD0_T
SS_TOOLHEAD0_NVM
SS_TOOLHEAD1_T
SS_TOOLHEAD1_NVM
SS_DOCK0_T
SS_DOCK0_NVM
SS_DOCK1_T
SS_DOCK1_NVM
SPI1_SS
E_A1
E_A2
E_B1
E_B2
H_A1
H_A2
H_B1
H_B2
X0_A1
X0_A2
X0_B1
X0_B2
X1_B2
X1_B1
X1_A2
X1_A1
Y_A1
Y_B1
Y_B2
Y_A2
Z0_A1
Z0_A2
Z0_B1
Z0_B2
Z1_A1
Z1_A2
Z1_B1
Z1_B2
Z2_A1
Z2_A2
Z2_B1
Z2_B2
P16 CONN_01X04
P17 CONN_01X04
P18 CONN_01X04
P19 CONN_01X04
P20 CONN_01X04
P21 CONN_01X04
P22 CONN_01X04
P23 CONN_01X04
P24 CONN_01X04
Moves in opposing directions
stepper.sch

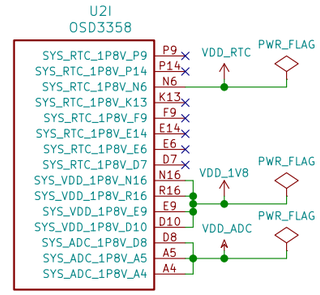
PWM
Heaters
I2C2_SCL
I2C2_SDA
PWM_EN
BED_HEAT
E_HEAT
H_HEAT
DOCK0_HEAT
DOCK1_HEAT
BED_HEAT_IN
E_HEAT_IN
H_HEAT_IN
DOCK0_HEAT_IN
DOCK1_HEAT_IN
P25 BED_HEAT
P26 E_HEAT
P27 H_HEAT
P28 DOCK0_HEAT
P29 DOCK1_HEAT
heater.sch
Fans
E_FAN
H_FAN
CASE_FAN
E_FAN_IN
H_FAN_IN
CASE_FAN_IN
P30 E_FAN
P31 H_FAN
P33 CASE_FAN
P34 HS_FAN
VDD_5V
FB15
pwm.sch
fan.sch
GND

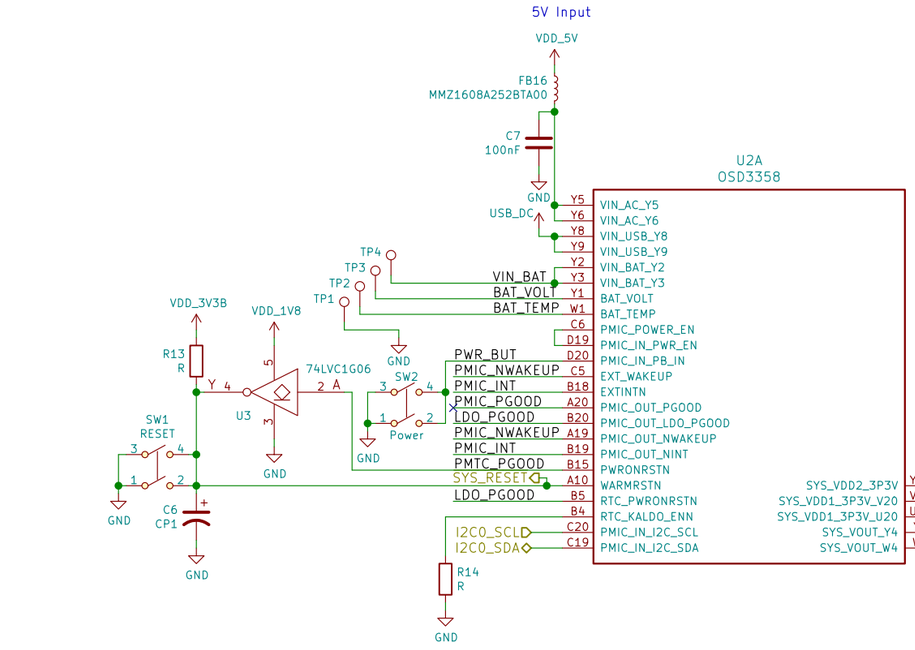
Aleph Objects Inc.
Sheet: /
File: KiMBo.sch
Title: KiMBo
Size: A3 | Date: 2017−03−07 | **Rev:**
KiCad E.D.A. kicad (2016−12−15 revision b13c7e4)−master | Id: 1/26

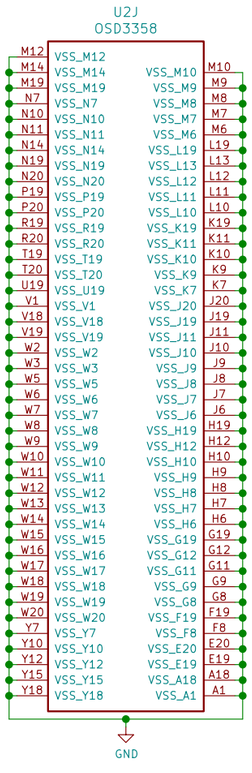
Input
input.sch

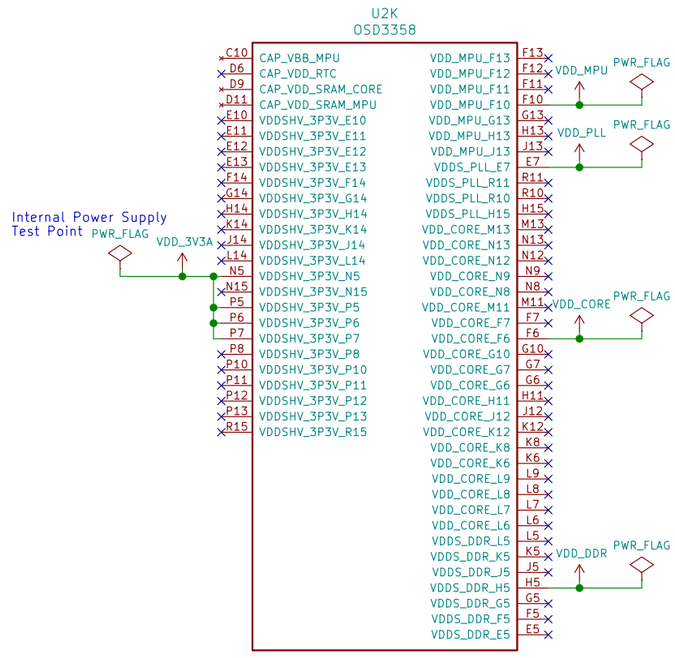
Voltage_Regulator
voltage_regulator.sch









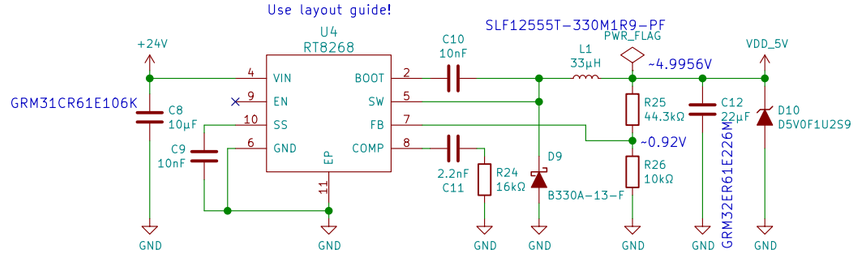


Sheet: /Power/ File: power.sch		
Title:		
Size: A3	Date:	**Rev:**
KiCad E.D.A. kicad (2016-12-15 revision b13c7e4)-master		Id: 2/26

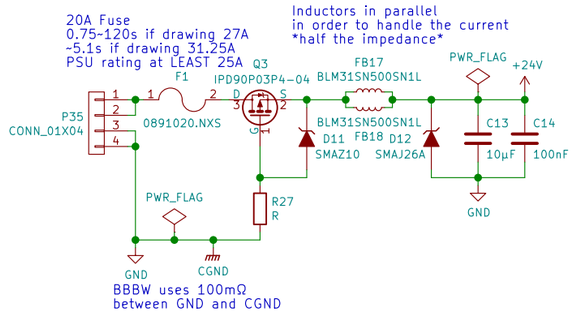
400kHz Fixed Switching Frequency

more expensive ferrite or mollypermalloy cores will be a better choice
Ferrite designs are preferred at high switching frequency
due to the characteristics of very low core losses

Use layout guide!



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

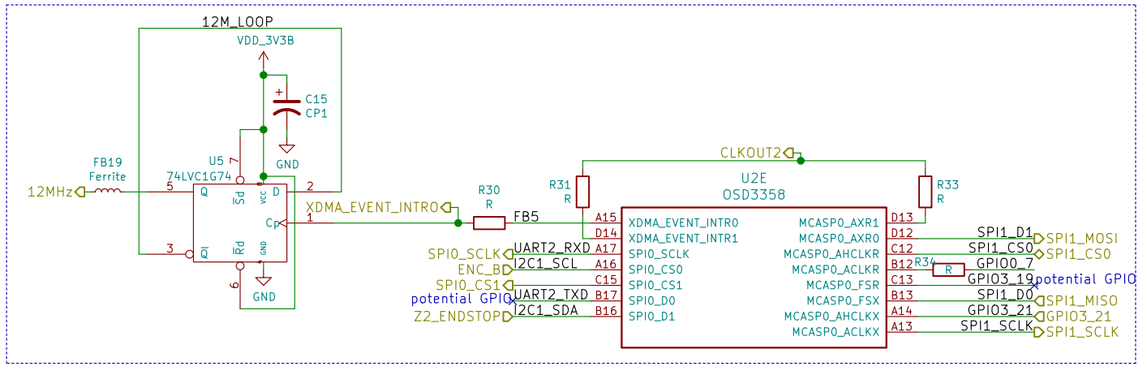


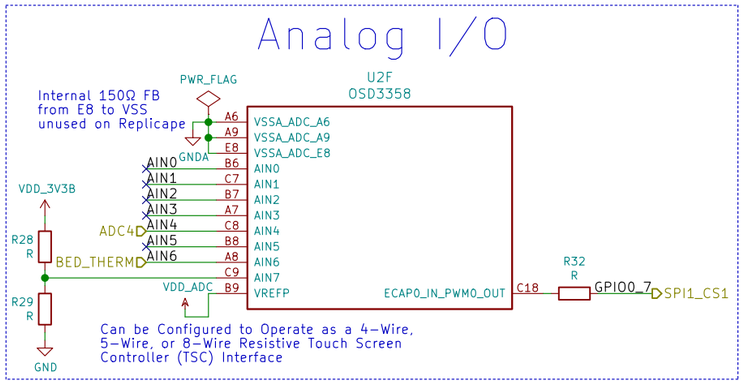
Sheet: /Power/Input/
File: input.sch

Title:

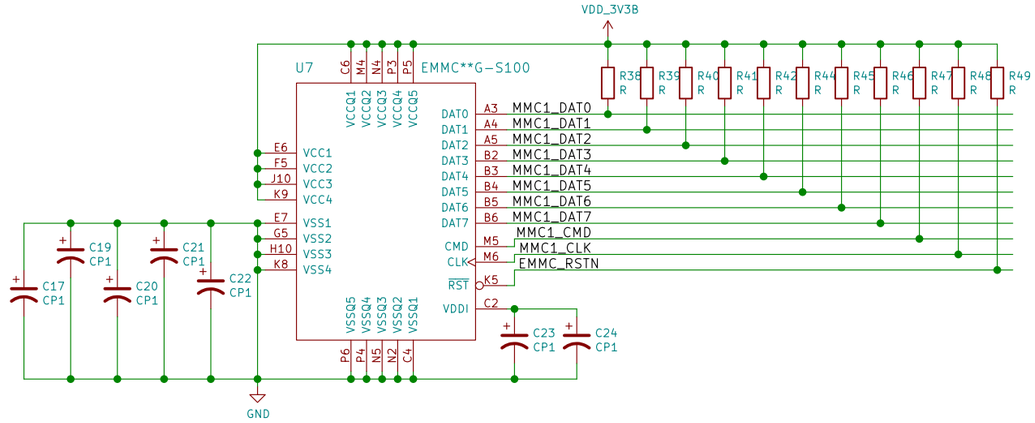
Size: A3	Date:	**Rev:**
KiCad E.D.A. kicad (2016-12-15 revision b13c7e4)-master		Id: 4/26

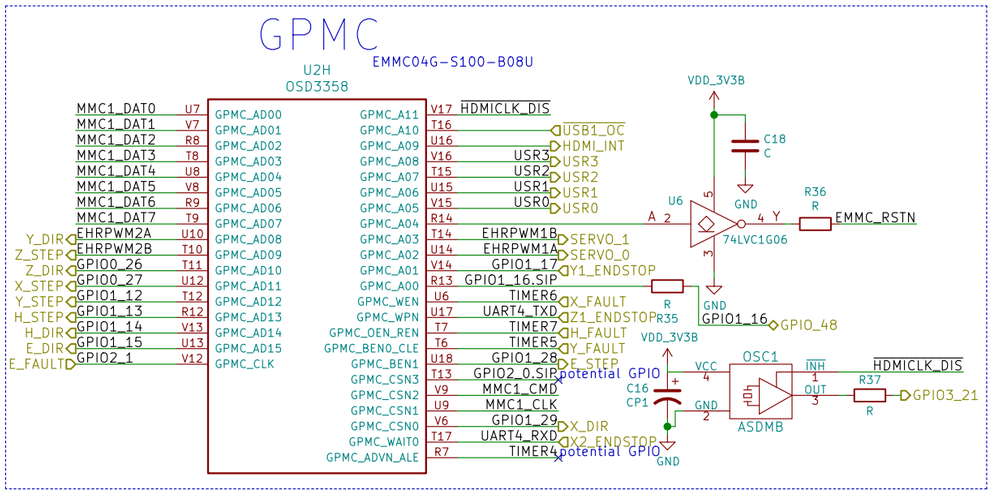
Unused

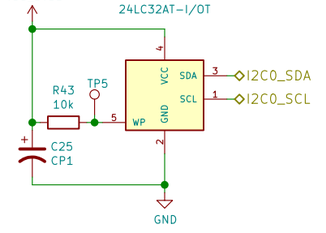




Sheet: /Microprocessor/		
File: mpu.sch		
Title:		
Size: A3	Date:	**Rev:**
KiCad E.D.A. kicad (2016-12-15 revision b13c7e4)-master		Id: 5/26



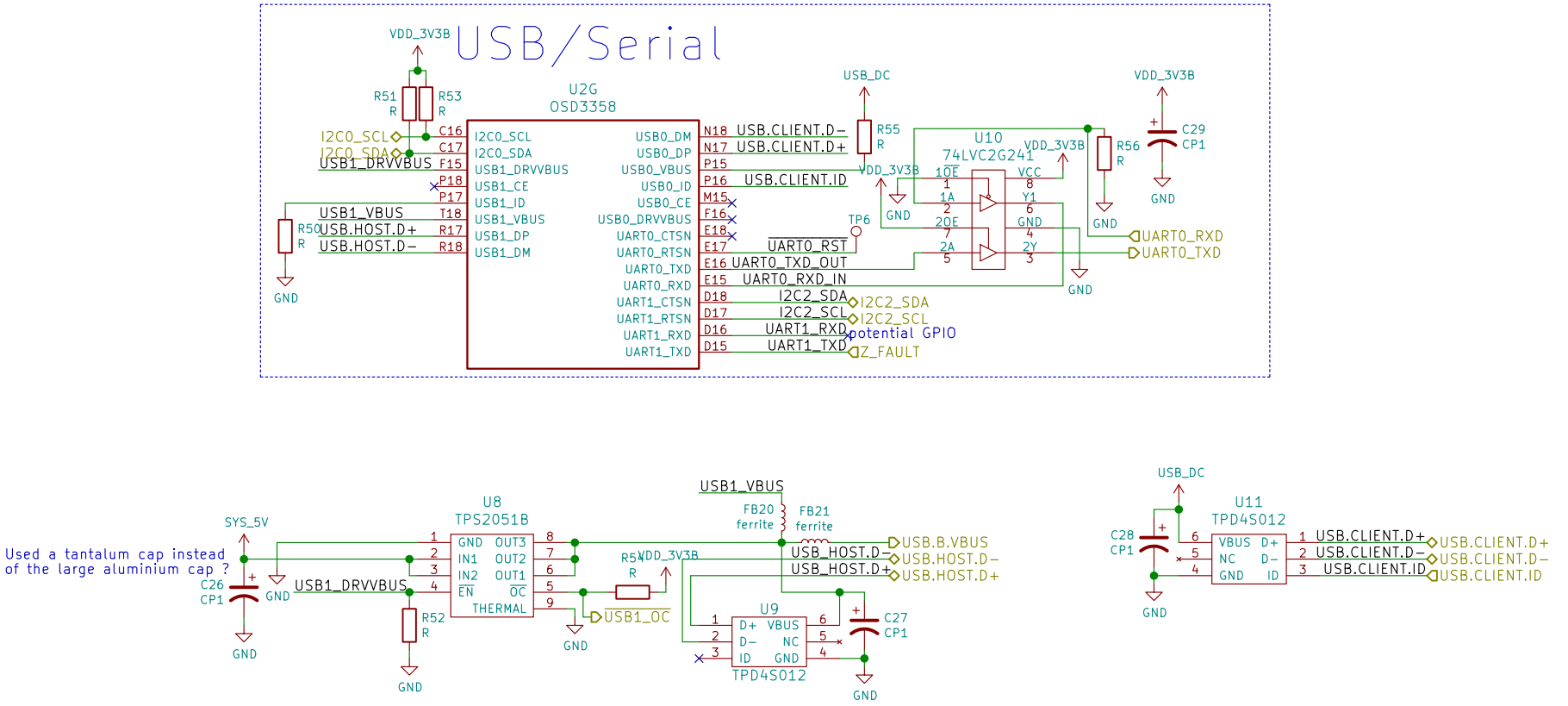




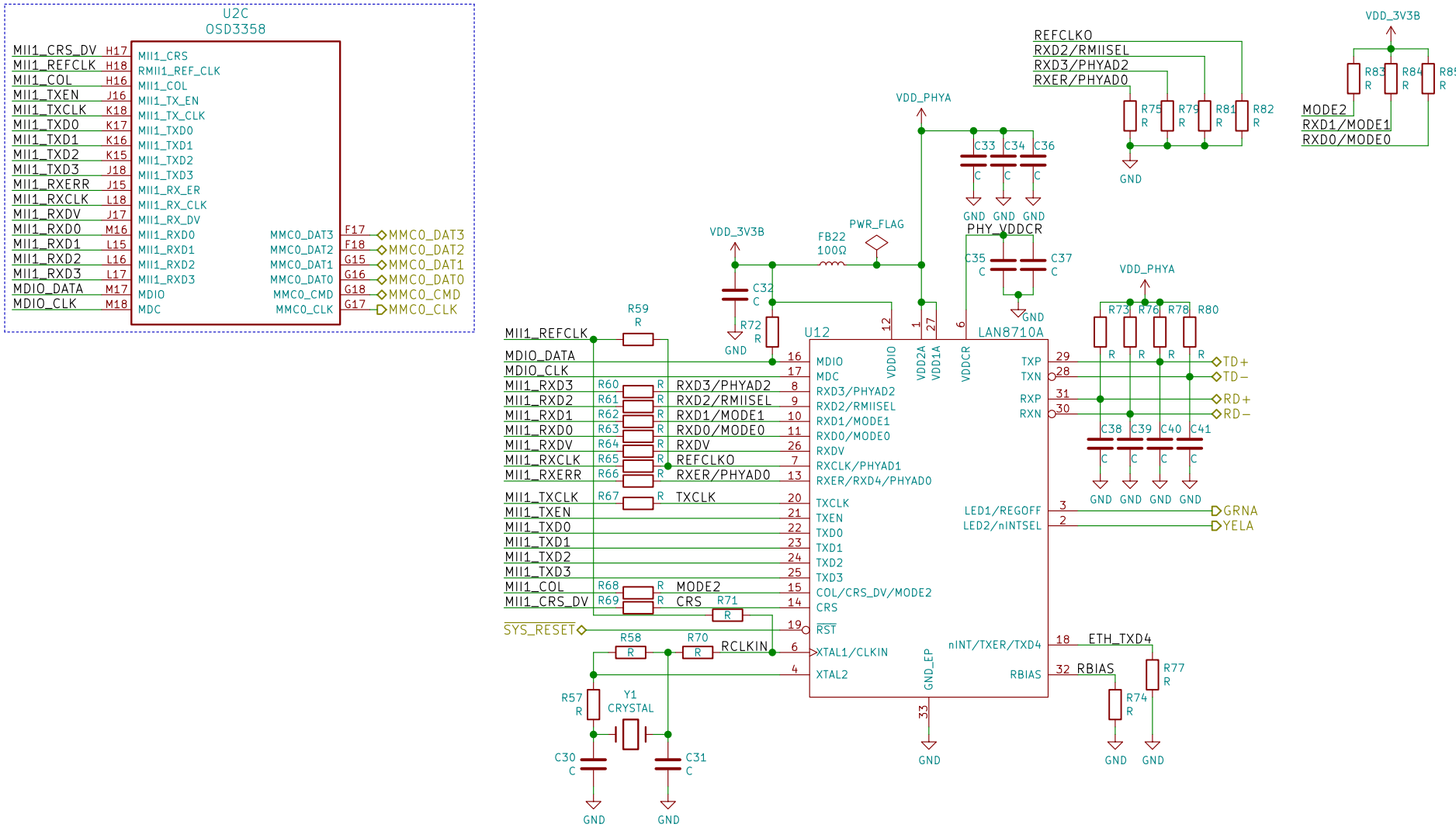
Sheet: /Flash/
File: flash.sch

Title:

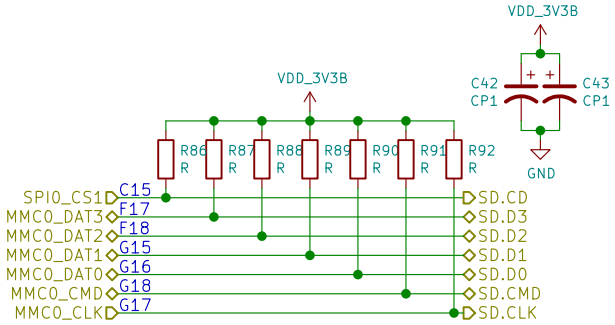
Size: A3	Date:	**Rev:**
KiCad E.D.A. kicad (2016-12-15 revision b13c7e4)-master		Id: 6/26



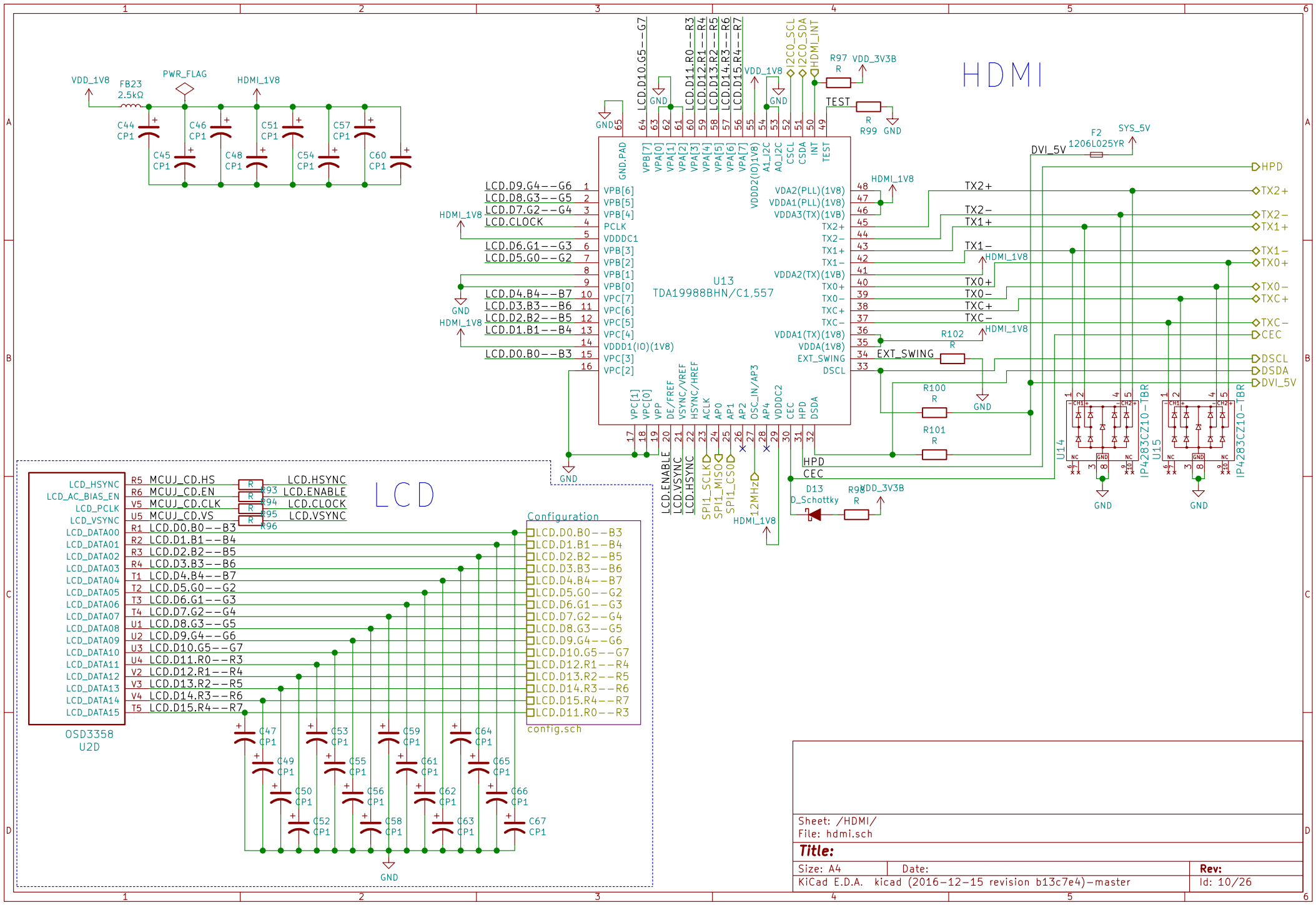
Sheet: /USB/ File: usb.sch		
Title:		
Size: A4	Date:	**Rev:**
KiCad E.D.A. kicad (2016−12−15 revision b13c7e4)−master		Id: 7/26

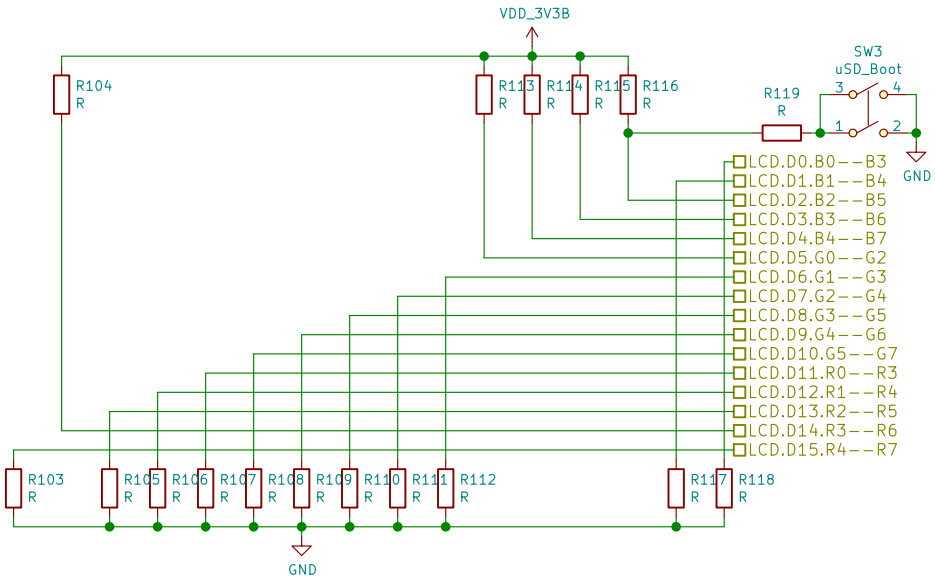


Sheet: /Ethernet/		
File: eth.sch		
Title:		
Size: A4	Date:	**Rev:**
KiCad E.D.A. kicad (2016-12-15 revision b13c7e4)-master		Id: 8/26

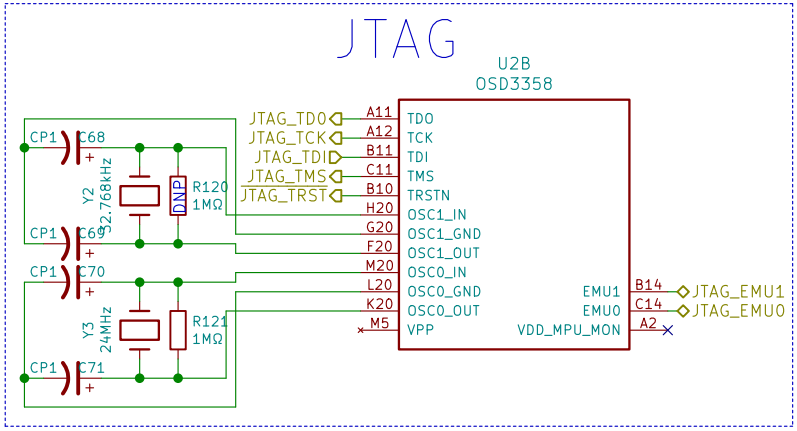


Sheet: /uSD Connector/ File: sd.sch		
Title:		
Size: A4	Date:	**Rev:**
KiCad E.D.A. kicad (2016-12-15 revision b13c7e4)-master		Id: 9/26

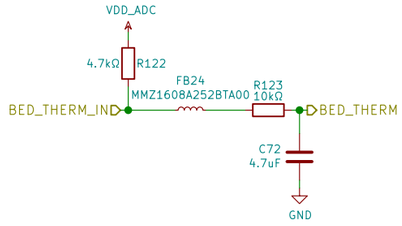

HDMI
LCD
U13
TDA19988BHN/C1,557
OSD3358
U2D
Configuration
config.sch
U14
U15
IP4283CZ10-TBR
Sheet: /HDMI/
File: hdmi.sch
Title:
Size: A4
Date:
Rev:
KiCad E.D.A. kicad (2016-12-15 revision b13c7e4)-master
Id: 10/26

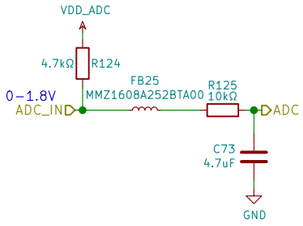


Sheet: /HDMI/Configuration/		
File: config.sch		
Title:		
Size: A4	Date:	**Rev:**
KiCad E.D.A. kicad (2016-12-15 revision b13c7e4)-master		Id: 11/26



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

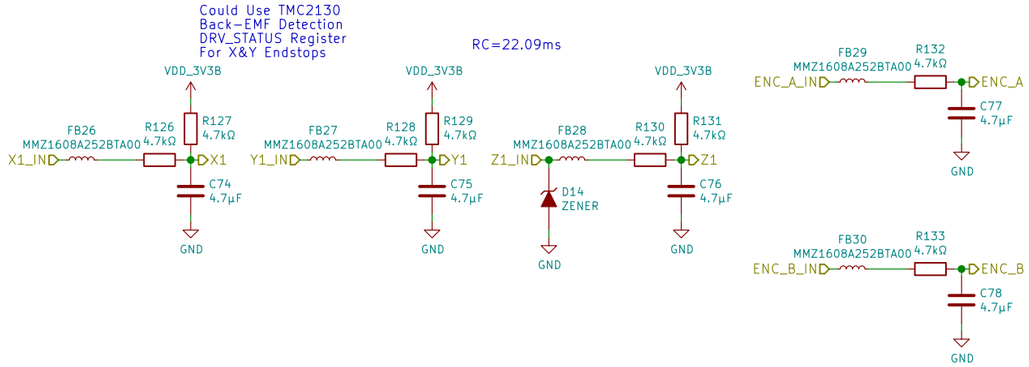




Sheet: /Thermistors / Thermocouples/
File: therm.sch

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 $\overline{EN\_SR}$ 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 EN_SR 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_SS 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 EN_SR HIGH
   - output high-Z, enables all motors
2. Write data
3. Toggle SPI1_SS _|¯|_
4. Bring EN_SR LOW
   - output enabled, disable specific motors/ready to configure

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

SPI1_SCLK
SPI1_MOSI
SPI1_MISO

VDD_3V3B
GND
C79 100nF
C82 100nF

U18 74HC595
U19 74HC595
U20 74HC595

SER
SRCLK
SRCLR
RCLK
G
QA QB QC QD QE QF QG QH $\overline{QH}$

SS_TOOLHEAD0_T
SS_TOOLHEAD0_NVM
SS_TOOLHEAD1_T
SS_TOOLHEAD1_NVM
SS_DOCK0_T
SS_DOCK0_NVM
SS_DOCK1_T
SS_DOCK1_NVM

C80 100nF
C83 100nF
C81 100nF
C84 100nF

X0_SS
X1_SS
Y_SS
Z0_SS
Z1_SS
Z2_SS
E_SS
H_SS

SR_EN
SPI1_SS

74x2G00 U16A
74x2G00 U16B
74LS20 U17A
74LS20 U17B

X_FAULT
X0_FAULT
X1_FAULT
X_SG
X0_SG
X1_SG
Z_FAULT
Z0_FAULT
Z1_FAULT
Z2_FAULT
Z_SG
Z0_SG
Z1_SG
Z2_SG

E Stepper Driver
H Stepper Driver
X0 Stepper Driver
X1 Stepper Driver
Y Stepper Driver
Z0 Stepper Driver
Z1 Stepper Driver
Z2 Stepper Driver

e_stepper.sch
h_stepper.sch
x0_stepper.sch
x1_stepper.sch
y_stepper.sch
z0_stepper.sch
z1_stepper.sch
z2_stepper.sch

Sheet: /Stepper Drivers/
File: stepper.sch

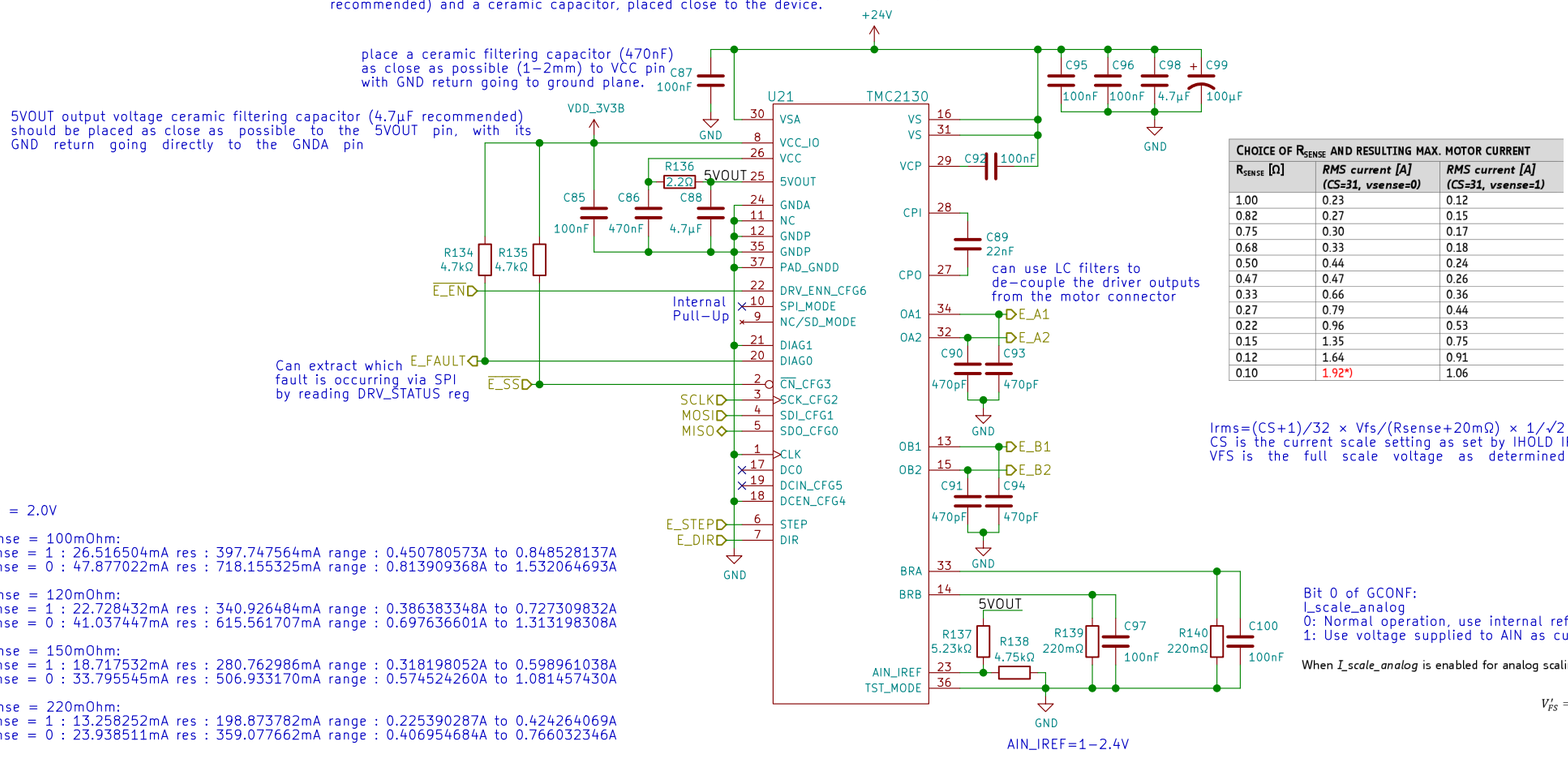
Title:

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

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	-2		+2	%

Vain = 2.379759519V

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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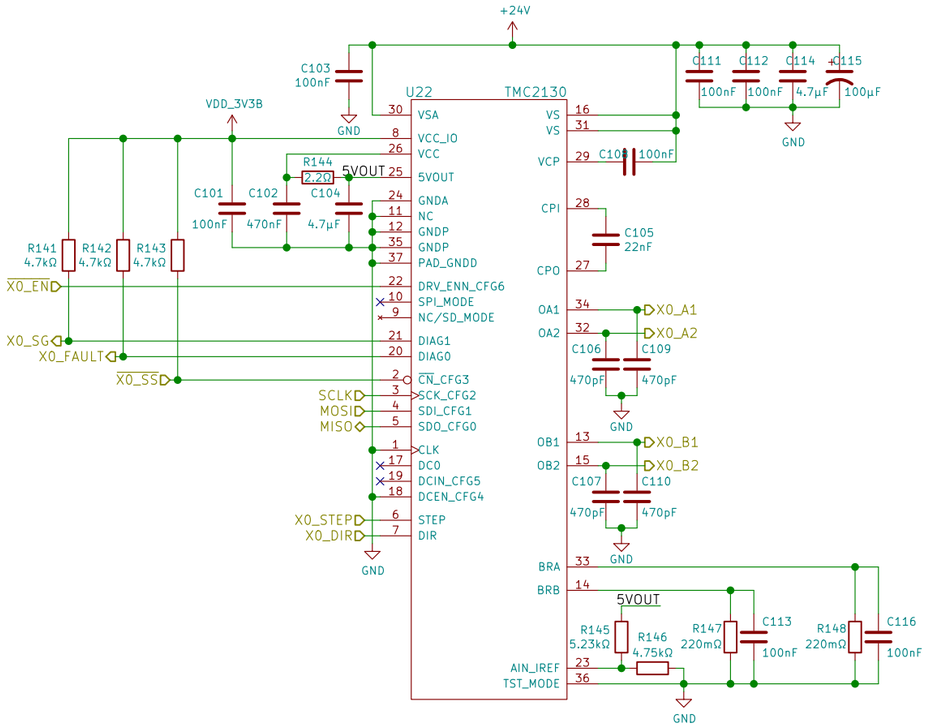

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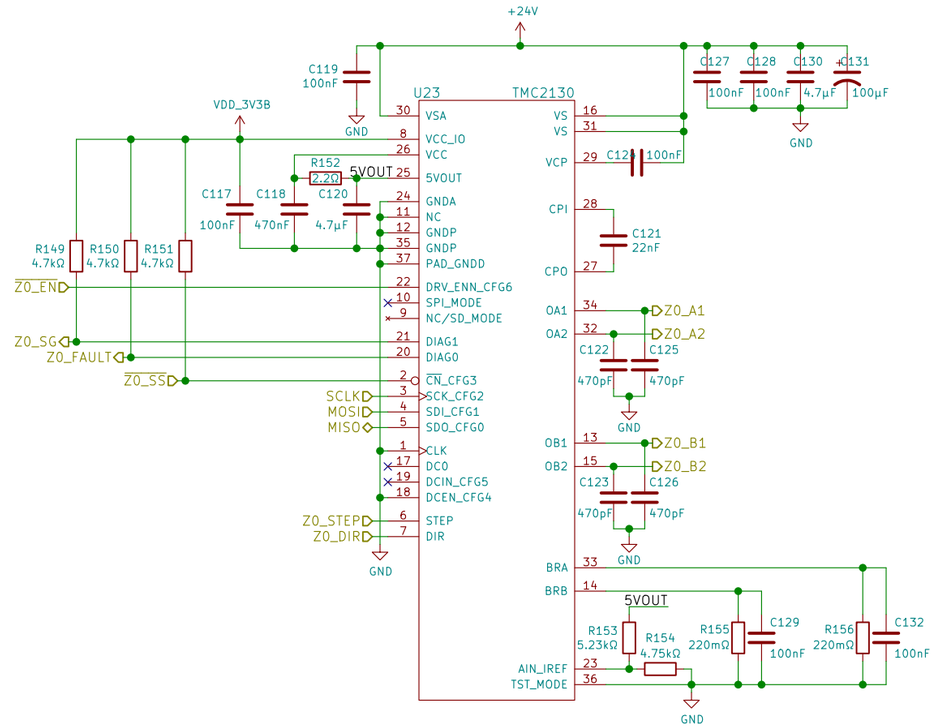

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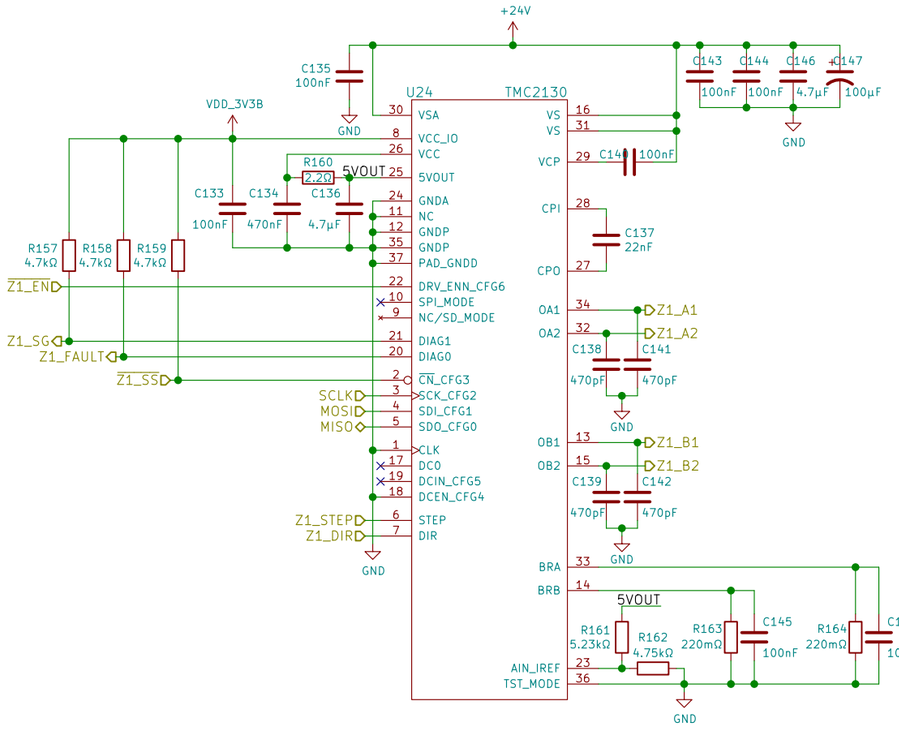

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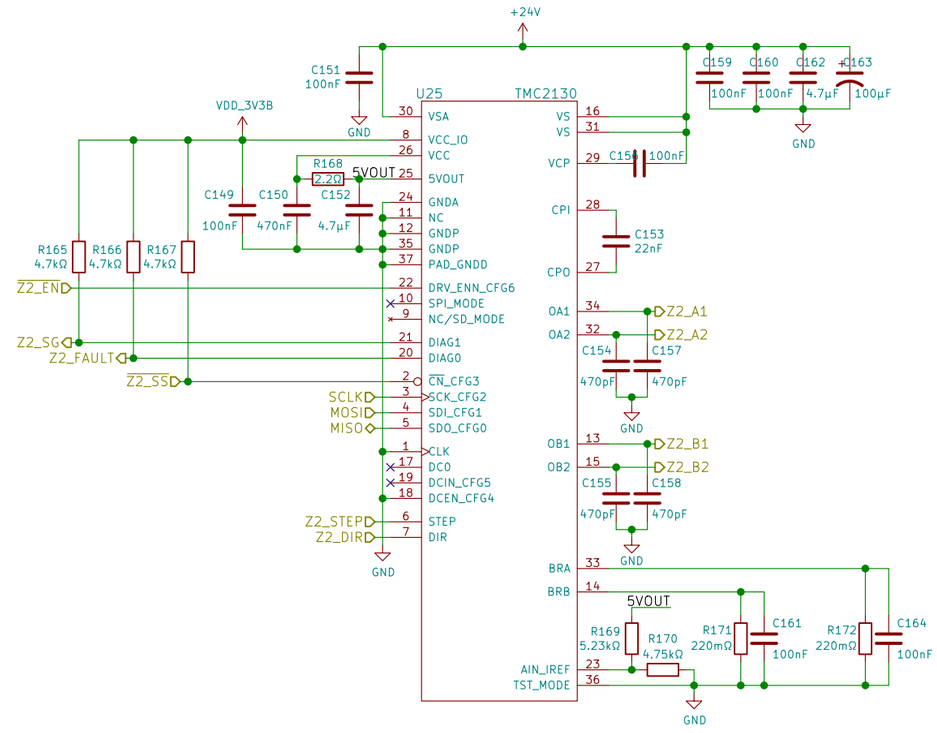

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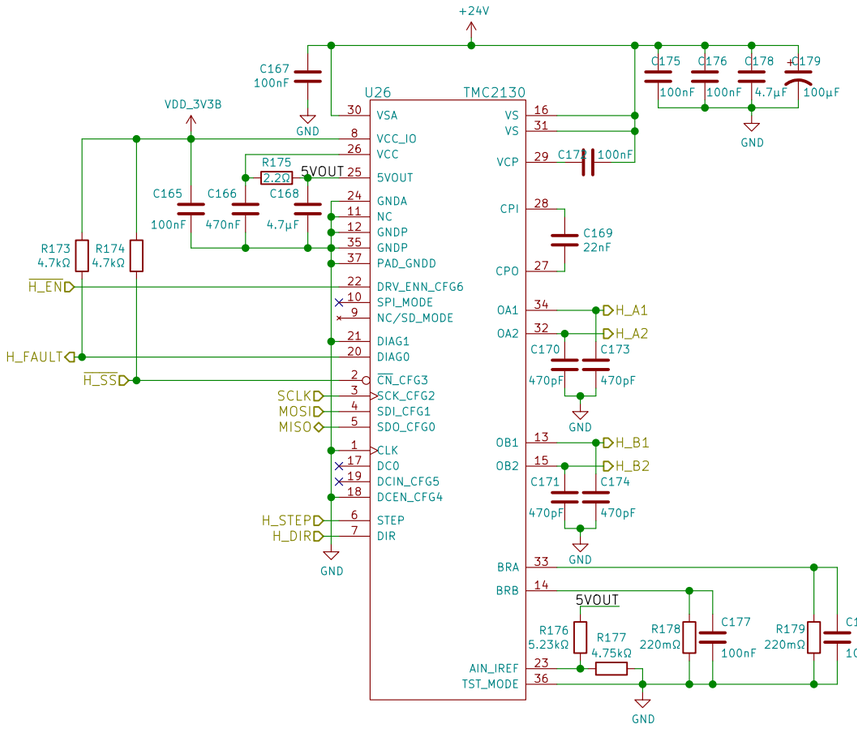

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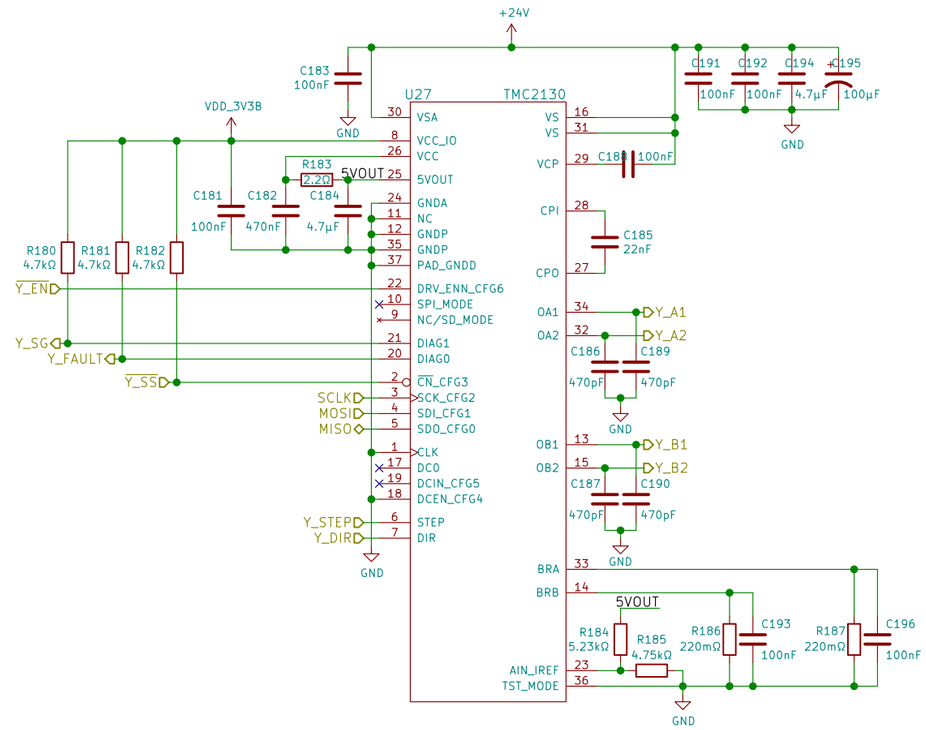

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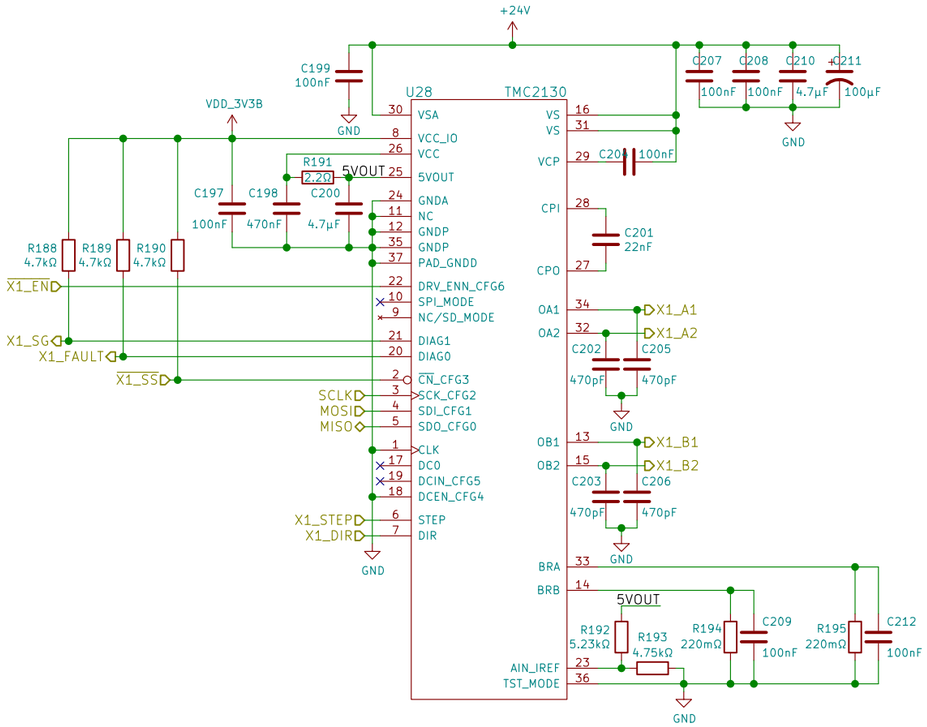

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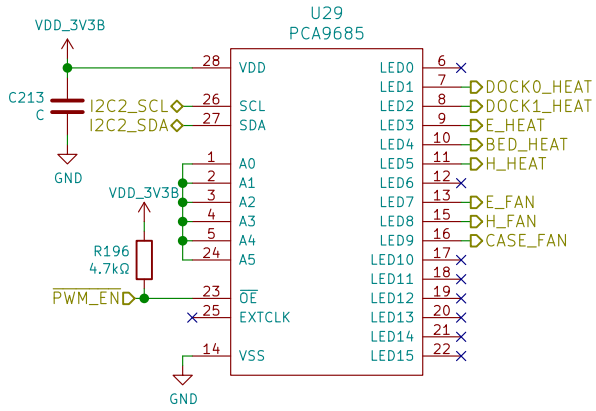

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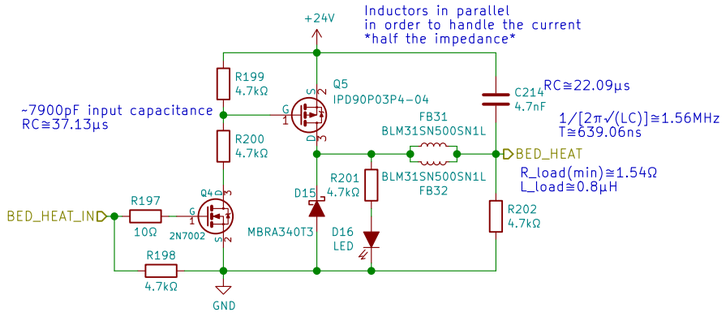
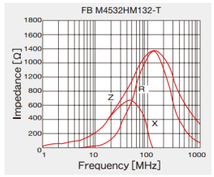
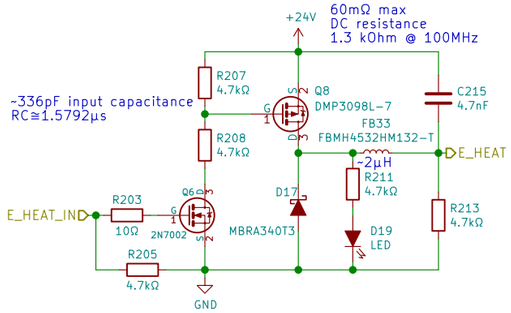
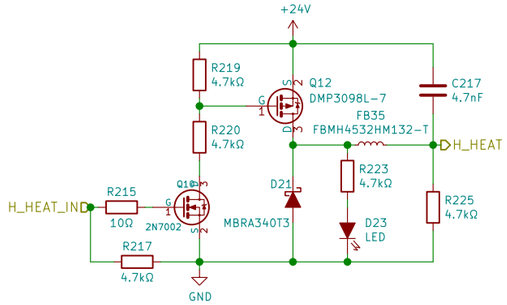
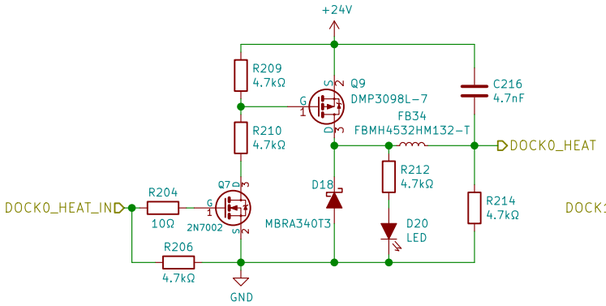
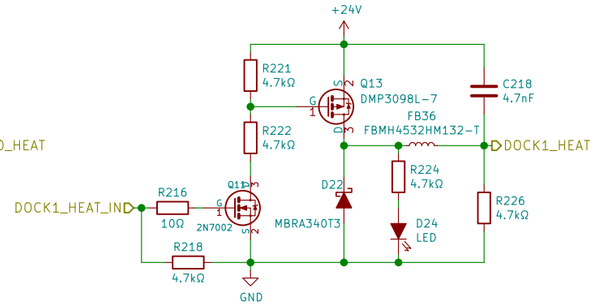








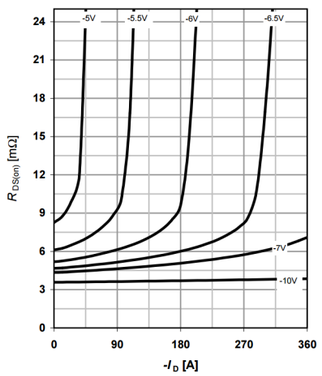




6 Typ. drain-source on-state resistance

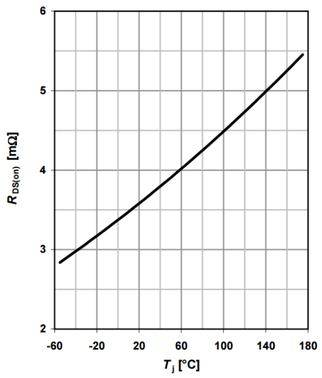
$R_{DS(on)} = (I_D)$; $T_j = 25$ °C

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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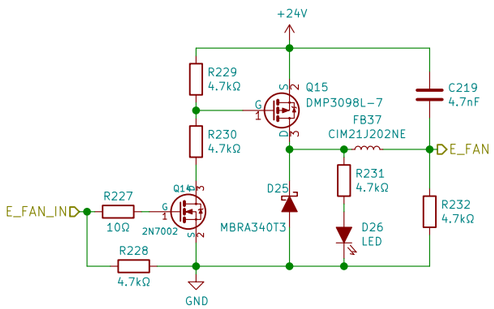

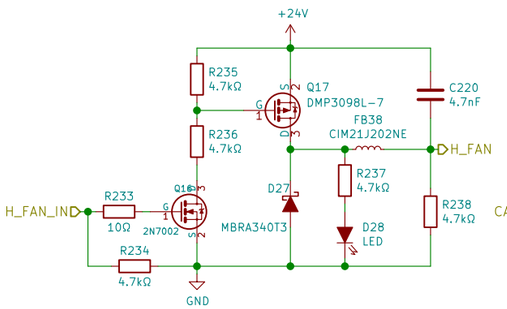

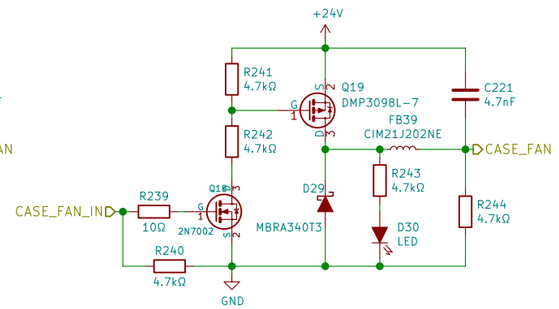

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