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01_Revision_History.SchDoc

Revision History

Rev.	Rel.	Date	Author	Description	Page(s)
1.1.1	RC00	2013-09-01	XX	- Initial design	

Learning Platform for Switching Regulators

[No Variations]

V1.1

Infineon Technologies AG

IFAG DES SDF SCS EPE

Am Campeon 1-12 - 85579 Neubiberg - Germany

07/2021

Link to Top Level Document

02 Top Level
02_Top_Level.SchDoc

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Title	Learning Platform for Switching Regulators		
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		Adrian Keil	V1.1
Author: Adrian Keil			
Date: 06.07.2021 Time: 14:56:05	SVN Revision: 42faf29516992bf14129c408a844		
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02_Top_Level.SchDoc

Jumper to select which NTC can be read by the Arduino

JP120 — 61300311121 — 1 NTC_Arduino 2 3

U_Safety — Safety.SchDoc
Input_Current, Output_Current, NTC_ext, NTC_int, Shutdown, Vout_Meas, Curr_Out+, Curr_Out-, Sw_Curr+, Sw_Curr-

Ideal Diode - XMC outputs VCC at AREF

At 3.3V: 150mV reduction -> Deal with comparator offset

AREF — R172 4.7k — R173 100k — GND

3V3 — R170 17.8k

U520C — LM339PWR

Q170 — BSS84PH6327XTSA2 — R171 20R — AREF

Avoid that mainboard powers XMC (on 3.3V XMC boards)

MP100 — 0082 3 16
MP101 — 0082 3 16
MP102 — 0082 3 16
MP103 — 0082 3 16

Nominal Input Voltage: 12 - 20 V
Absolute Maximum: -60 V to +60 V

U_PowerSupply — PowerSupply.SchDoc — Vin_VoltReg

Shutdown

U_Input — Input.SchDoc — Vin_Raw, Vin_VoltReg, Vin, Vin_Meas, Curr_In+, Curr_In-

X100 — 575-8
X101 — 575-8
GND

U_PowerStage — PowerStage.SchDoc — Vin, Vout, Buck_Cntrl, Boost_Cntrl, Shutdown, SW_Curr+, SW_Curr-, Curr_Inductor+, Curr_Inductor-

Nominal Output Voltage: 0 - 40 V (shutdown at 45 V, clamping at 50 V)

U_Output — Output.SchDoc — Vout, Cntrl1, Cntrl2, Cntrl3, Out_neg, Vout_Meas, Load1, Load2, Load3

X102 — 575-8
X103 — 575-8

Load resistor connection

If no external NTC should be used, simply leave NTC_ext open

X150 — 61201021621 — Vout, Load1, Load2, Load3, NTC_ext, W100

GND

Do not use Pin 10 for Power!

U_User — User.SchDoc — UserLED1..4, UserBtn1, UserBtn2, UserSw

JP125 — 61300211121 — UserLED1, Cntrl1
JP126 — 61300211121 — UserLED2, Cntrl2
JP127 — 61300211121 — UserLED3, Cntrl3

The pins for the User LEDs can be used to control the load switches as well.

U_CurrentSensors — CurrentSensors.SchDoc — Curr_In+, Curr_In-, Curr_Inductor+, Curr_Inductor-, SW_Curr+, SW_Curr-, Curr_Out+, Curr_Out-, Input_Current, Inductor_Current, Output_Current, SW_Current, Inductor_Overcurr

R103 15mR — Curr_Out+ / Curr_Out-

TP103 — 5011

Control Pinheader

X140 — TSW-112-07-L-S — 61301211121

12V, 3V3, GND, Vin_VoltReg, Input_Current, Output_Current, Inductor_Current, SW_Current, Vout, Buck_Cntrl_Ext, Boost_Cntrl_Ext

Clamp voltage for ADC. Max. 3.5 V

Input_Current — R110 47k — In_Curr_ADC
Output_Current — R111 47k — Out_Curr_ADC
D110 — BAT54-05W — 3V3

TVS diodes clamp voltage a bit too late

Vin_Meas, Vout_Meas — D111 — BAT54-05W — 3V3

SW_Current — R131 1.3k — SW_Current_ADC
Inductor_Current — R132 1.3k — Inductor_Curr_ADC
Current_Blanking — R130 47k — Q130 BSS816NW — Blanking_NMOS
JP130 — 61300311121

Arduino Pinheader

Special Functions ->

Arduino	XMC1100	XMC4700 (just PWM)
SCK		
MISO		
MOSI		CCU41.OUT2
SS/PWM	SS	CCU41.OUT0
PWM		CCU81.OUT11
PWM	-	
PWM		CCU80.OUT22
PWM	-	CCU81.OUT33
-	PWM	
Int&PWM		CCU40.OUT2
Int		
UART TX		
UART RX		

X110A — NC, IOREF, RESET, 3V3, 5V, GND, GND, VIN
X110B — A0, A1, A2, A3, A4/SDA, A5/SCL
X110C — A5/SCL, A4/SDA, AREF, GND, D13, D12, D11, D10, D9, D8
X110D — D7, D6, D5, D4, D3, D2, D1, D0

JP111 — 61302021121 — AREF, GND, UserLED4, UserSw, UserLED3, Current_Blanking, Boost_Cntrl_Arduino
JP112 — 61301621121 — UserBtn2, Buck_Cntrl_Arduino, UserLED2, UserLED1, UserBtn1, Inductor_Overcurr
JP110 — 61301221121 — A0, A1, Out_Curr_ADC, Vin_Meas, Vout_Meas, NTC_Arduino

R112 47k — Shutdown — Read-only

S110 — 1301.9314 — Reset

Max. 100mA*0.5V -> 50mW -> +25°C

D112 — BAT54-05W — 12V

JP121 — 61300311121 — In_Curr_ADC, A0, SW_Current_ADC
JP128 — 61300311121 — Inductor_Curr_ADC, A1, UserPoti

E100 E101 E102

For Buck-Boost mode, boost is controlled with inverted buck signal

R124 1.3k — Buck_Cntrl_Inv
Buck_Cntrl — Q124 BSS816NW
JP124 — 61300311121 — Buck_Cntrl_Inv, Boost_Cntrl, Boost_Cntrl_indep
R123 100k — 3V3

3V3 — R160 10k — UserPoti — GND

JP122 — 61300311121 — Buck_Cntrl_Arduino, Buck_Cntrl, Buck_Cntrl_Ext
R122 100k — GND
JP123 — 61300311121 — Boost_Cntrl_Arduino, Boost_Cntrl_indep, Boost_Cntrl_Ext

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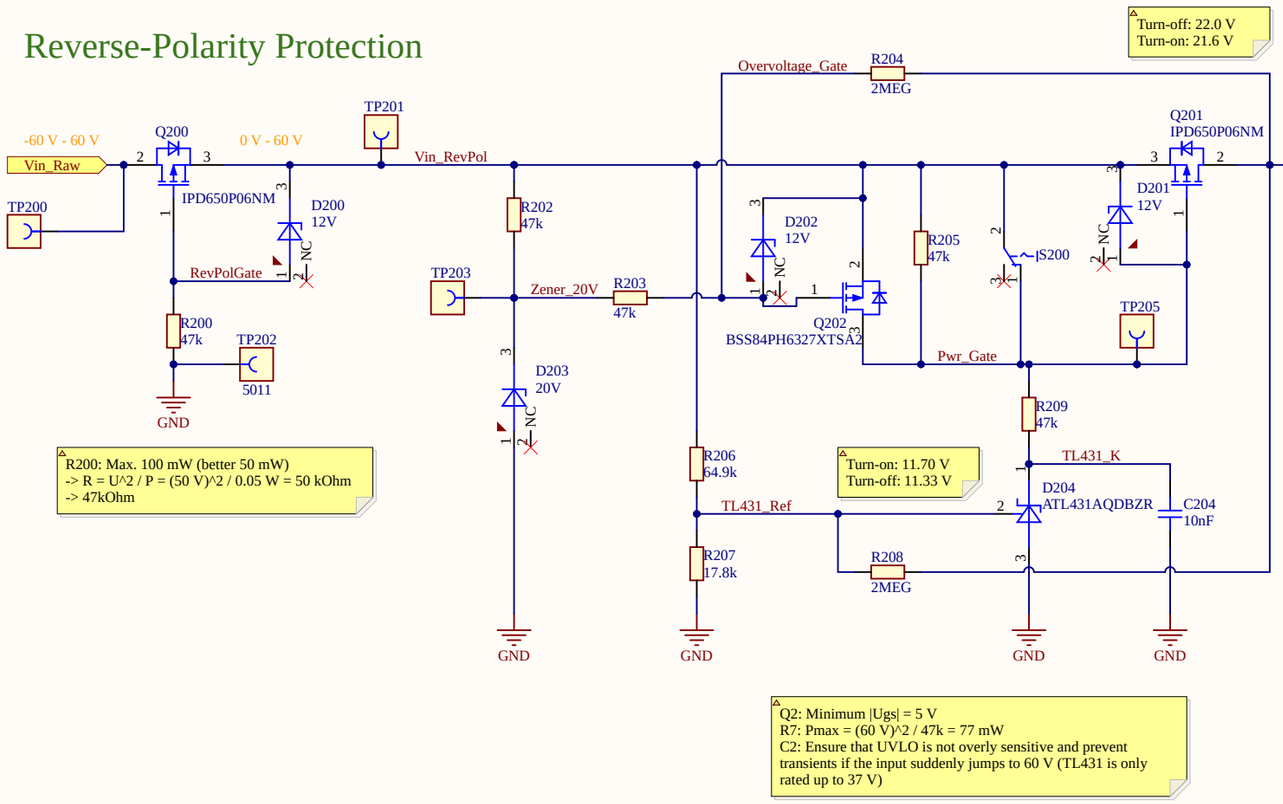
Input.SchDoc

Over-Voltage Protection and UVLO

Reverse-Polarity Protection



Voltage Measurement

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Author: Adrian Keil
Date: 06.07.2021 Time: 14:56:06 SVN Revision: 3e2b9839db8d6a8c0ad15c9805c9
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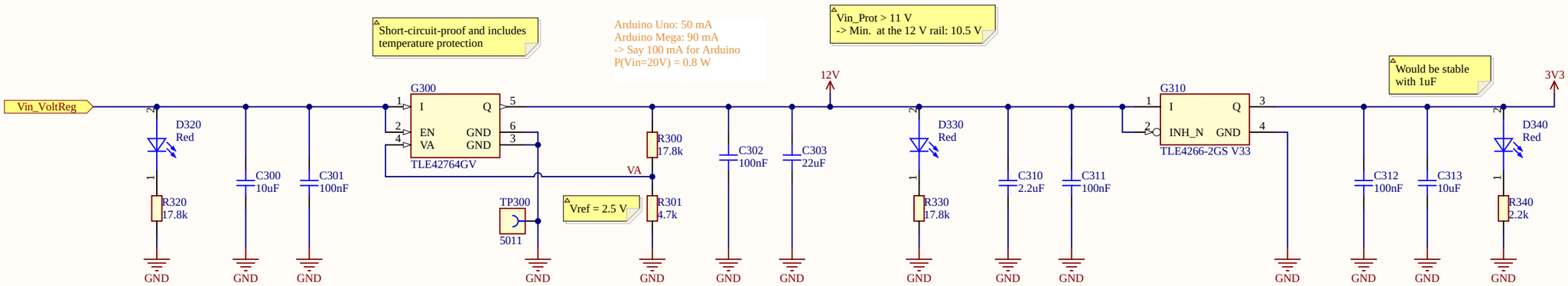
PowerSupply.SchDoc



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Size: A3	Document Name: PowerSupply.SchDoc	Rel. Adrian Keil	Rev. V1.1
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PowerStage.SchDoc

Shutdown

Buck_Cntrl

R404 4.7k

Buck_IN

D404 BAS70-04

3V3

If just Arduino is powered and Buck_Cntrl=3.3V: I=(3.3V-0.3V)/4.7k=0.63mA

BAS70: 2pF, 0.1uA
BAT54: 10pF, 2uA

Place close to gate driver

D405 BAS70-04

R405 4.7k

C405 2.2uF

GND

Buck

Pull-Down Resistors at the gate are not needed (already in the gate-driver)

C410 and C411 are just for the fast switing noise. Additional Input/output capacitors are on the respective sheets

Boost_Cntrl

R434 4.7k

Boost_IN

D434 BAS70-04

Place close to gate driver

D435 BAS70-04

R435 2.2k

C435 2.2uF

Boost

Vin

Vout

I(f=100kHz) = 3mA
(according to simulation)

12V

D402 BAS70-04

TP400

VB_Buck

U400 IRS2184SPBF

VCC, VB, IN, HO, VS, SD_N, LO, COM

C403 100nF

C400 100nF

C402 100nF

C404 10uF

Q400

R400 20R

VS_Buck

Curr_Inductor+

Curr_Inductor-

JP421

R420 15mR

L420 27uH

L421 15uH

Q401

R401 20R

H-Bridge_neg

R421 15mR

SW_Curr+

SW_Curr-

TP421 5011

VS_Buck

TP401

R402 2.2k

R403 2.2k

Pmax=45mW each

TP430

VB_Boost

D432 BAS70-04

D433 15V

C432 100nF

U430 IRS2184SPBF

C434 10uF

Q430

R430 20R

VS_Boost

Q431

R431 20R

TP431

C430 100nF

C433 100nF

Boost_IN

Shutdown

Charge Pump to VS_Buck + 12 V

R411 47k

Out_555_Buck

TP412

U410 ICM7555IBAZ

VDD, GND, TH, OUT, CV, RESET_N, TRIGGER_N, DC

VS_Buck

In_555_Buck

C412 1nF

C411 10nF

D411 BAS70-04

D410 15V

C410 100nF

Neg_555_Buck

R410 1.3k

TP411

Charge Pump to VS_Boost + 12 V

TP442

Out_555_Boost

R441 47k

U440 ICM7555IBAZ

VDD, GND, OUT, TH, RESET_N, CV, DC, TRIGGER_N

Vcc_555_Boost

In_555_Boost

D442 BAS70-04

D443 BAS70-04

D441 BAS70-04

C441 10nF

C442 1nF

C440 100nF

D440 15V

Neg_555_Boost

R440 1.3k

TP441

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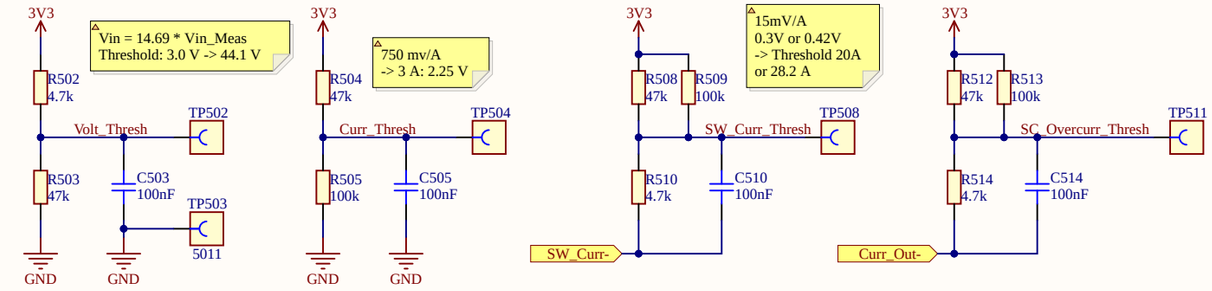
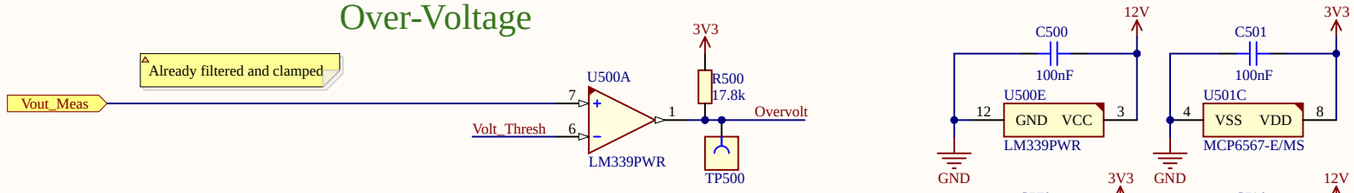
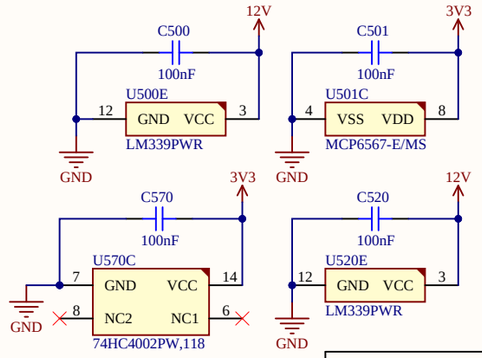
Safety.SchDoc

Over-Voltage and Over-Current Thesholds

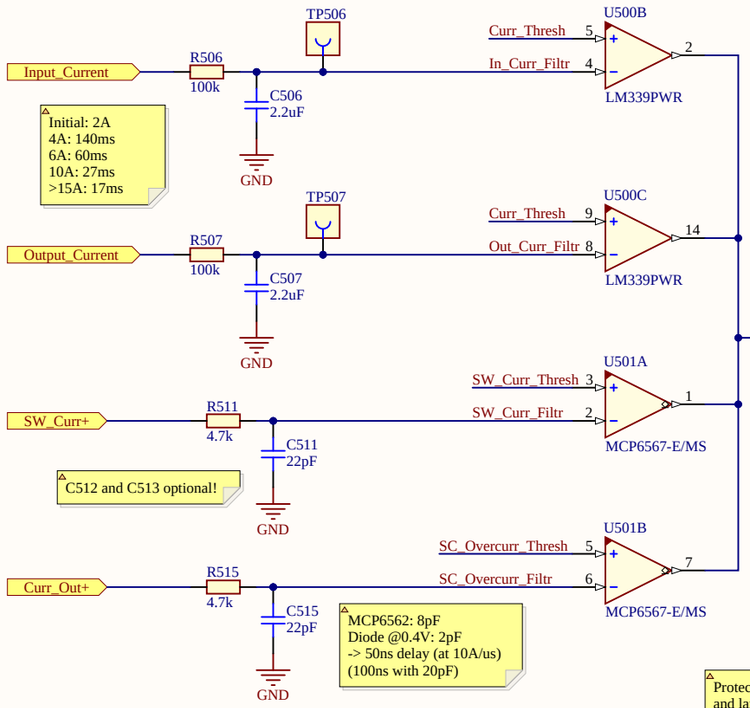


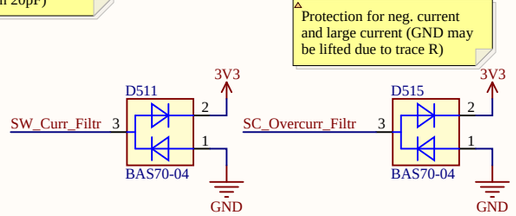
Over-Voltage

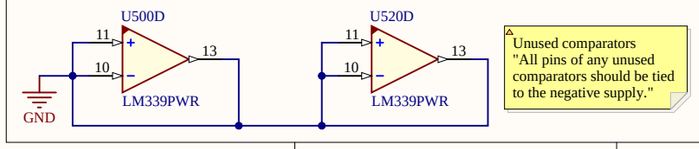




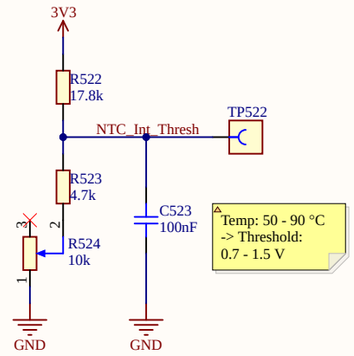
Over-Current

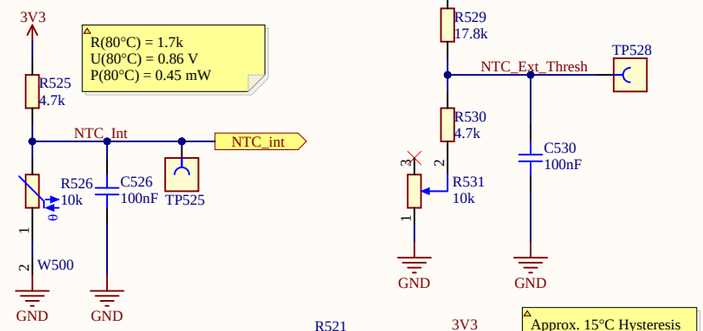


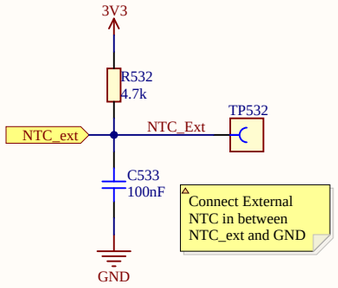


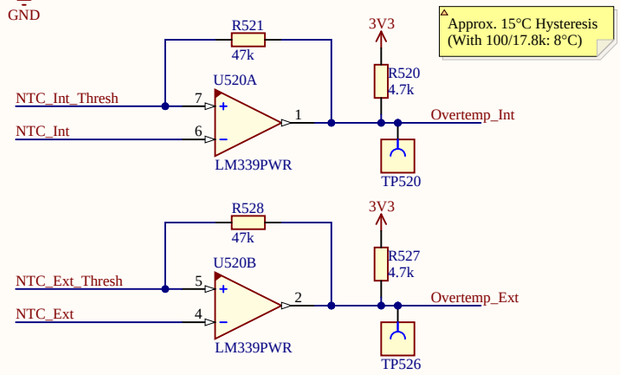


Over-Temperature

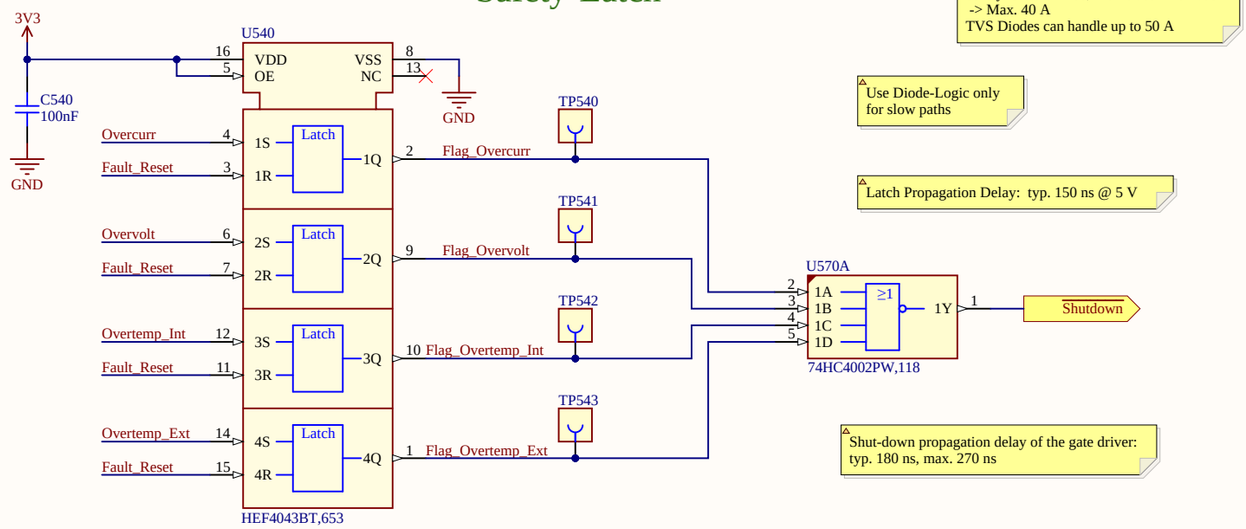




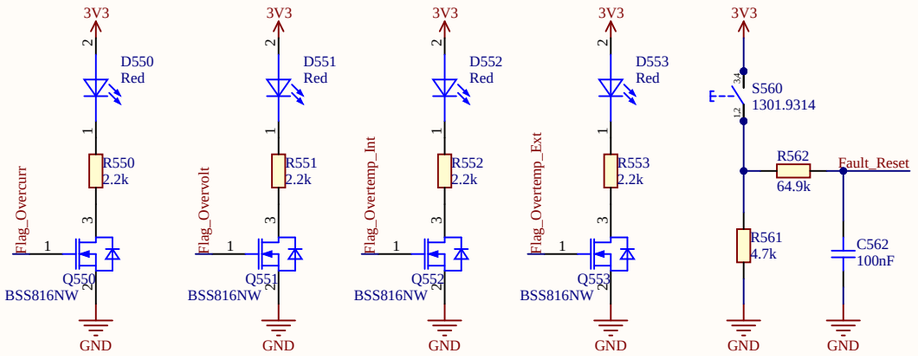




Safety-Latch



Status-LEDs and Reset



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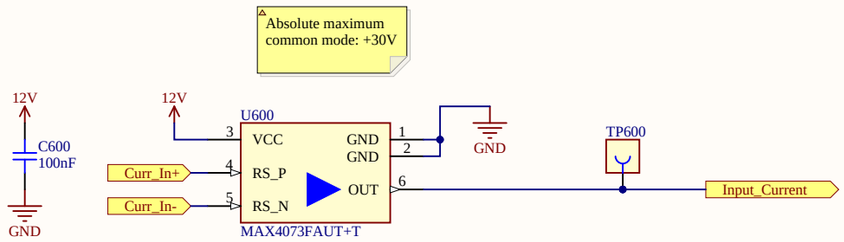
Sheet 6 of 9

CurrentSensors.SchDoc

Input Current

Initial approach of two selectable sense resistors is not worth it (experiment can be easily done in the simulation) and I don't want choices like this in the safety path

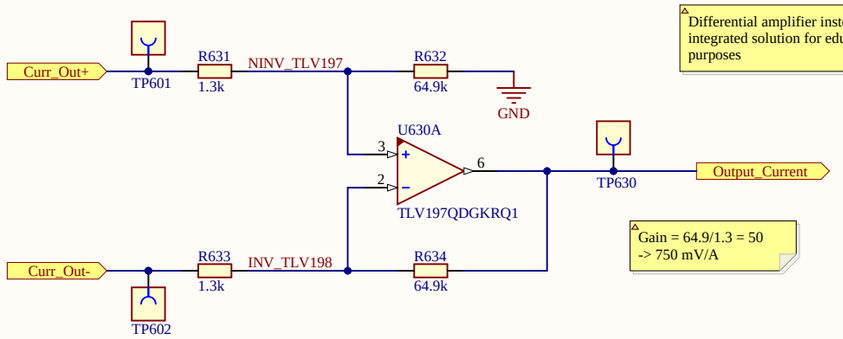


Absolute maximum common mode: +30V

Overall gain = 50 * 15 mV/A = 750 mv/A
I(3.3 V) = 4.4 A

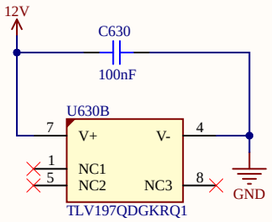
Vout,max > Vcc,min - 1.2 V = 9.3 V
-> 12,4 A

Output Current

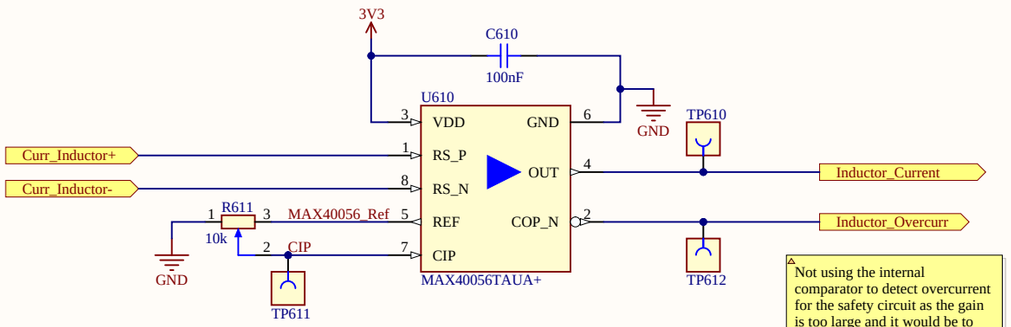


Differential amplifier instead of integrated solution for educational purposes

Gain = 64.9/1.3 = 50
-> 750 mV/A



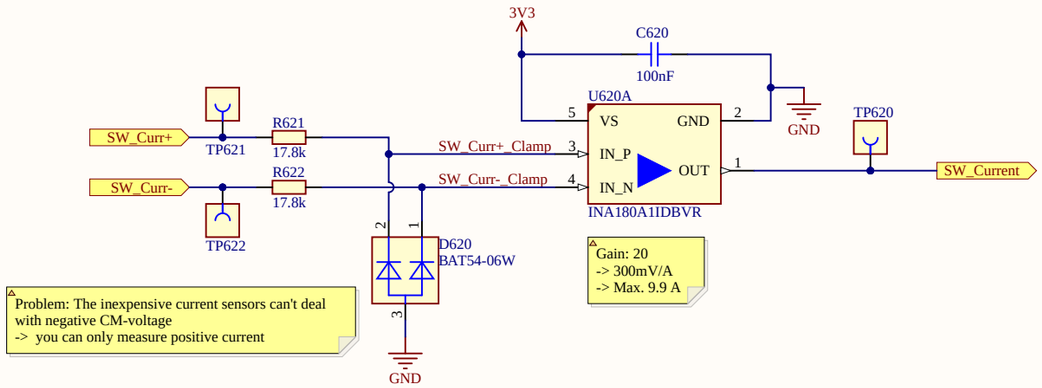
Inductor Current



Overall gain = 20 * 15 mV/A = 300 mv/A
I(1.5 V) = 5 A

Not using the internal comparator to detect overcurrent for the safety circuit as the gain is too large and it would be to sensitive. Can be used for digital regulation though.

Switch Current



Problem: The inexpensive current sensors can't deal with negative CM-voltage
-> you can only measure positive current

Gain: 20
-> 300mV/A
-> Max. 9.9 A

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Author: Adrian Keil			
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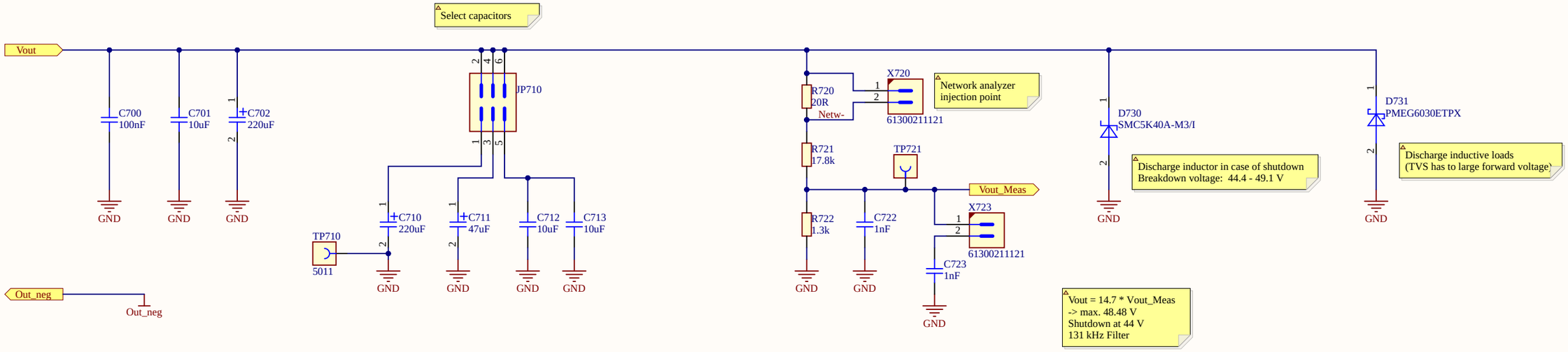
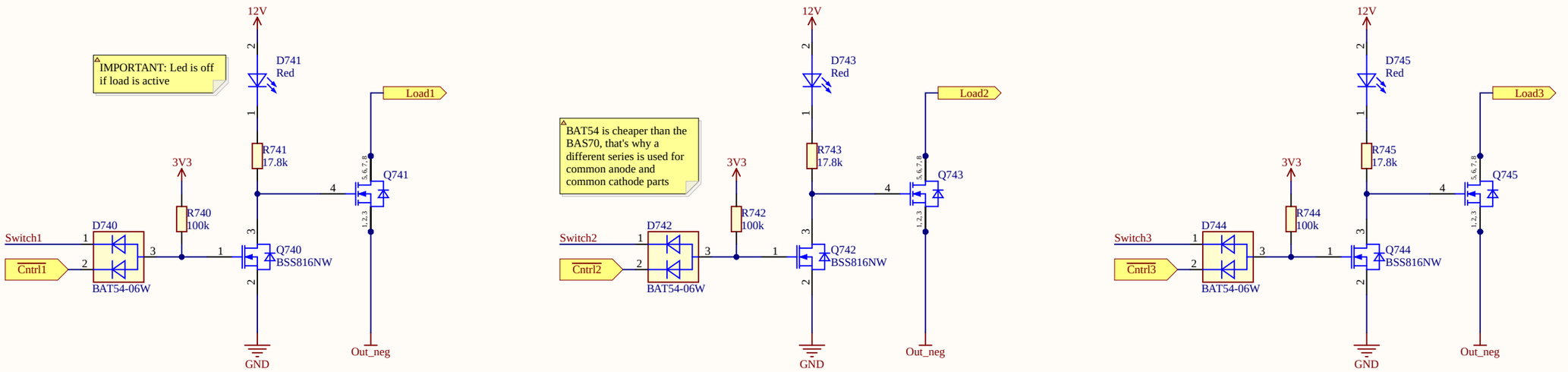
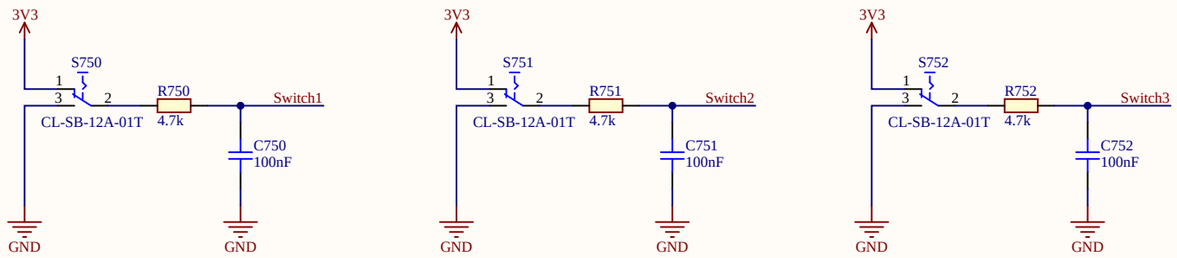
Output.SchDoc



Output Stages



Output Signal Switches



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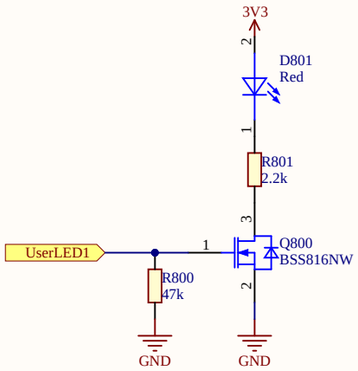
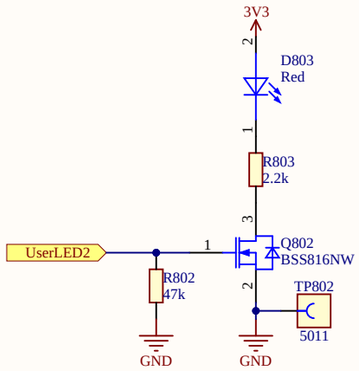
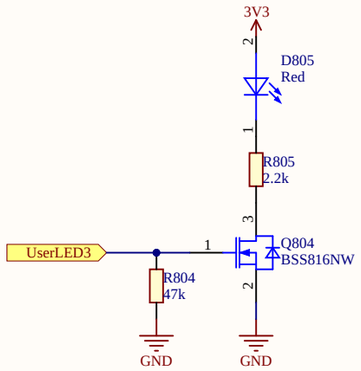
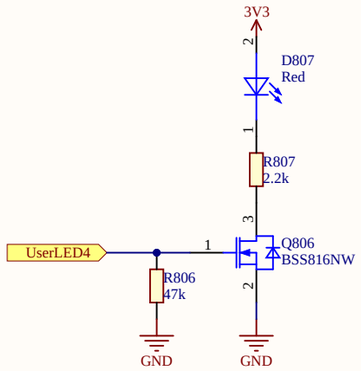
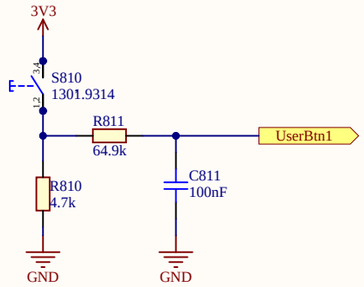
User.SchDoc

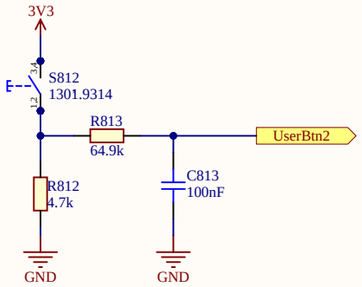


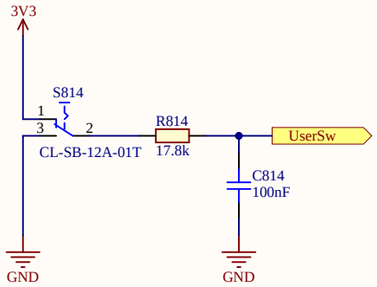












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