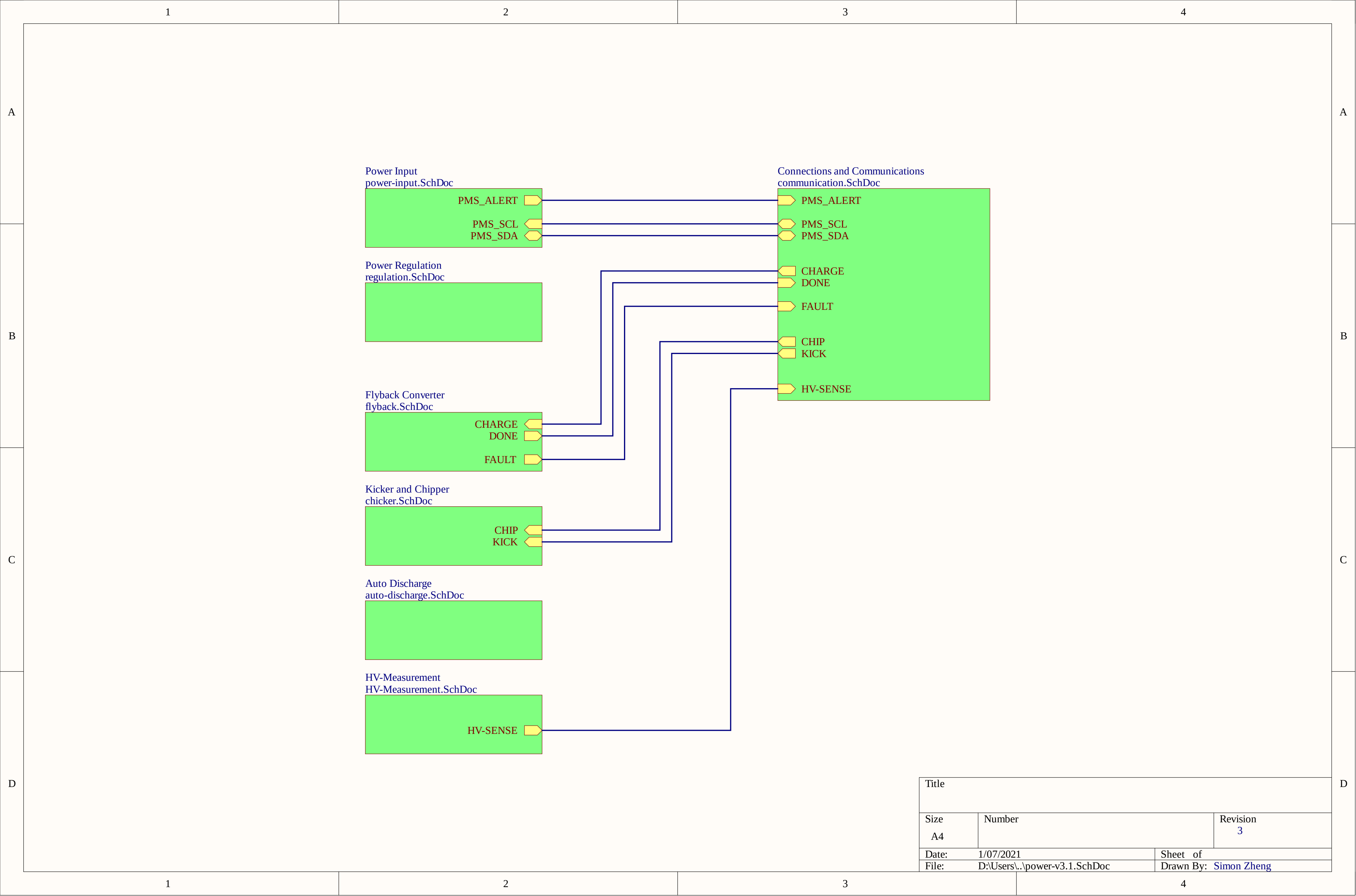
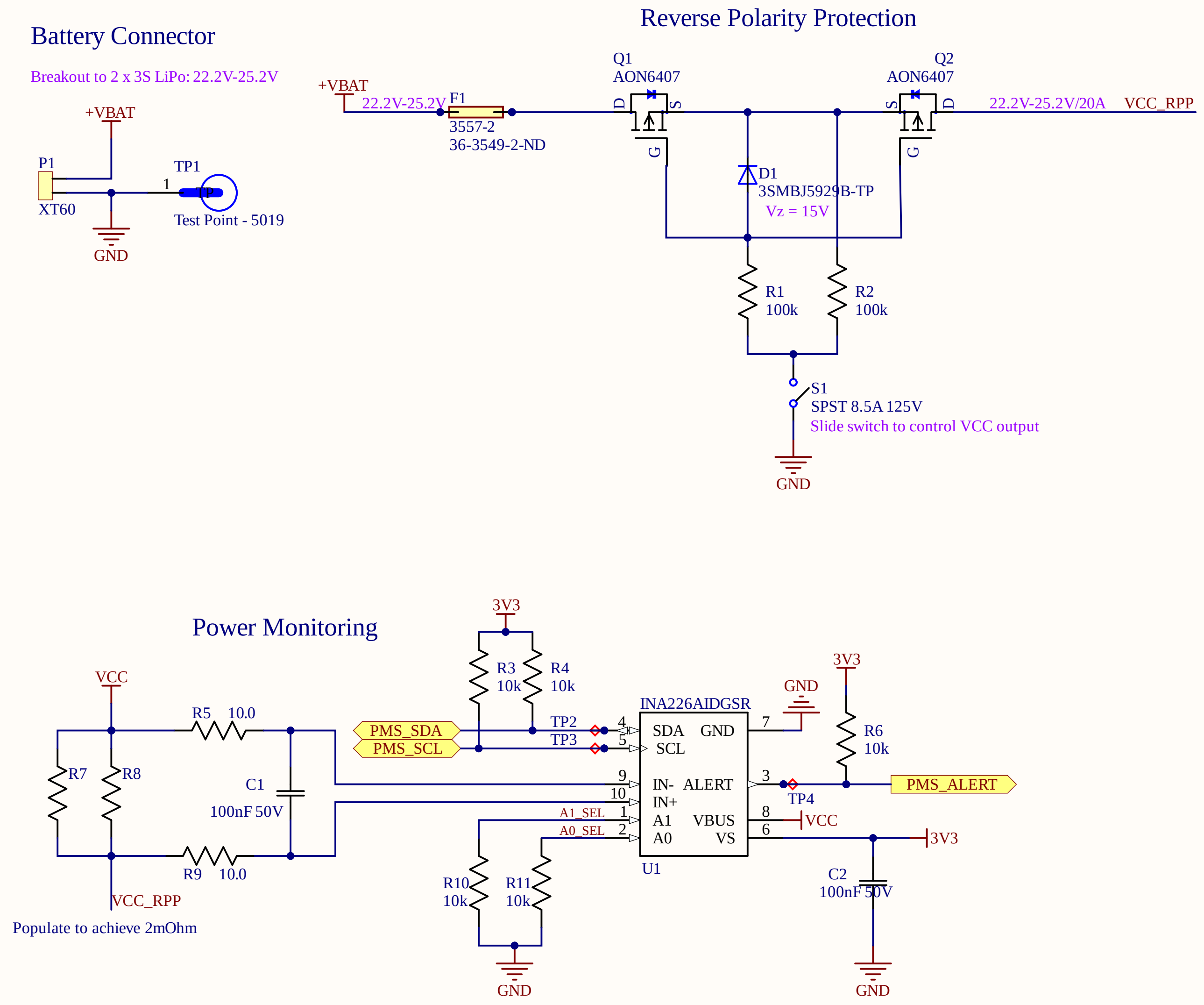


Power Input
power-input.SchDoc
PMS_ALERT
PMS_SCL
PMS_SDA
Power Regulation
regulation.SchDoc
Flyback Converter
flyback.SchDoc
CHARGE
DONE
FAULT
Kicker and Chipper
chicker.SchDoc
CHIP
KICK
Auto Discharge
auto-discharge.SchDoc
HV-Measurement
HV-Measurement.SchDoc
HV-SENSE
Connections and Communications
communication.SchDoc
PMS_ALERT
PMS_SCL
PMS_SDA
CHARGE
DONE
FAULT
CHIP
KICK
HV-SENSE
Title
Size
A4
Number
Revision
3
Date: 1/07/2021
Sheet of
File: D:\Users\..\power-v3.1.SchDoc
Drawn By: Simon Zheng

Power Input and Monitoring



****

Reverse Polarity Protection Design Specifications

****

Reverse Polarity

Under the condition that a negative potential is applied across the battery input, current flow will be blocked. This is because the reverse polarity causes the body diode of the MOSFET to be reverse biased. Then, VG = |VBAT| > 0V and so P-Channel MOSFET will be in the cut-off region.

Note: no matter the switch state for the reverse polarity condition, the MOSFETs will remain in cut-off.

S1 Closed

----

the gates of Q1 and Q2 are pulled to ground. This places the P-Channel in ohmic region (e.g. conducting) once fully turned on. The zener diode, D1, clamps VGS < +/- 15V and this ensures that VGS always sits within its safe bounds of VGS < +/- 25V.

****

Power Monitoring Specification

****

The INA226 is a current shunt and power monitor with an I2C interface. The device monitors both a shunt voltage drop and bus supply voltage.

Specifications

- Vin = 0.0V - 36.0V
- Vsupply = 2.7V - 5V

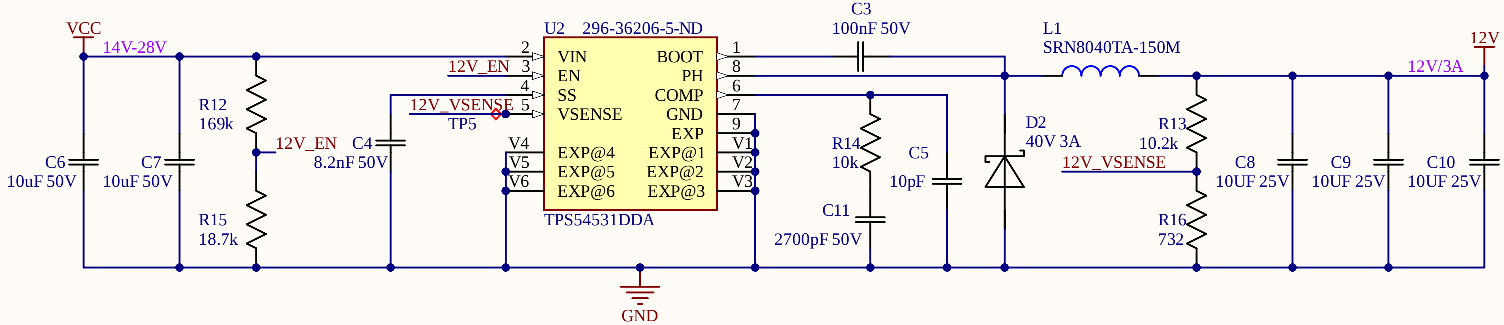
Slave Address

The values of A1 and A0 select the slave address of the device. Both selection inputs are pulled down, mapping to the address 1000000.

Title		
Size: A4	Number	Revision
Date: 1/07/2021		Sheet of
File: D:\Users\..\power-input.SchDoc		Drawn By: Hannah Sawiuk

Voltage Conversion and Regulation

12V DC/DC Converter



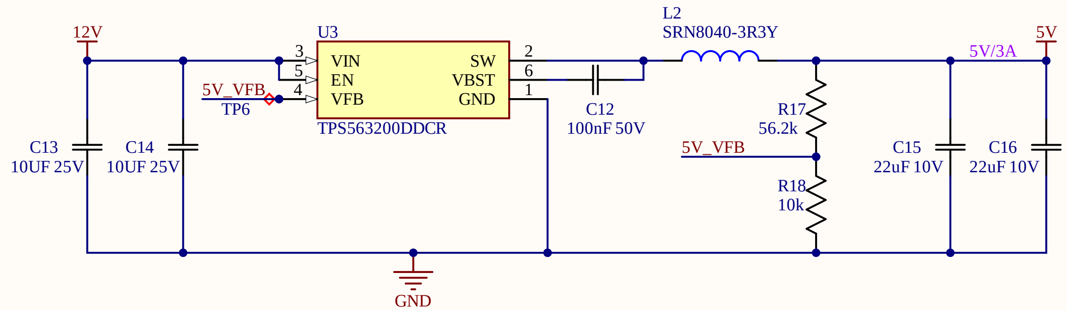
****
12V DC/DC Converter Specifications
****

Designed using Texas Instruments WEBENCH software. The design report, charts, BOMs, simulation exports. and more can be found in doc/12V-dc_dc-converter-design/. The converter takes in the batter/supply voltage and steps it down to 12V.

Specifications

- Vin = 14.0V - 28.0V
- Vout = 12.0V
- Iout = 3.0A
- Vripple = 5%
- Frequency = 570.0 kHz
- Pout = 36.0 W

5V DC/DC Converter



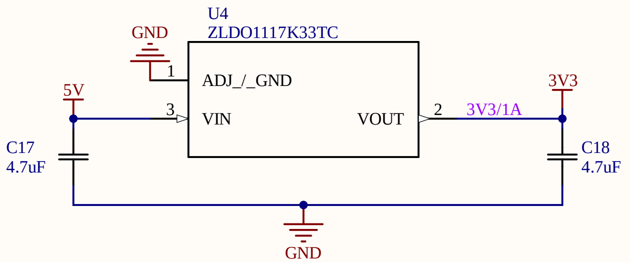
****
5V DC/DC Converter Specifications
****

Designed using Texas Instruments WEBENCH software. The full design report can be found in doc/5V-dc_dc-converter-design/. The converter takes the 12V and steps it down to 5V.

Specifications

- Vin = 11.0V - 13.0V
- Vout = 5.0V
- Iout = 3.0A
- Frequency = 791.515 kHz
- Pout = 15.0 W

3.3V Fixed LDO



****
3.3V LDO
****

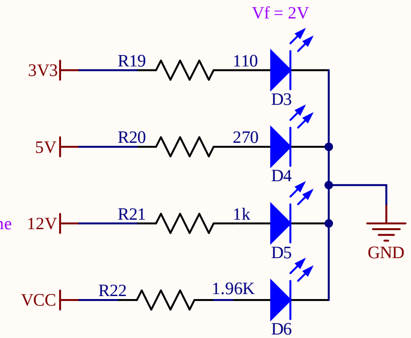
Simple 3.3V fixed LDO for supplying the MCU and various sensors.

Specifications

- Vin = 1.35V - 18.0V
- Vout = 3.3V
- Iout = 1.0A
- Pout = 3.3W

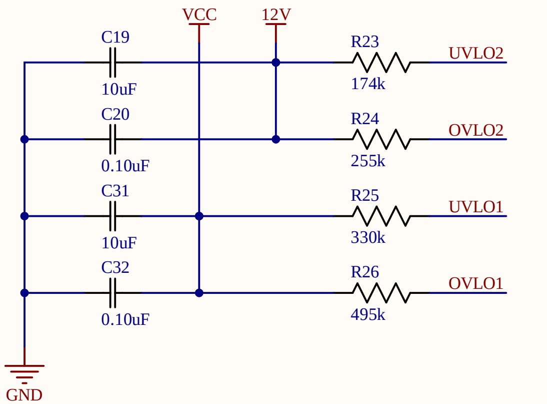
Power LEDs

~10mA to 15mA through each line



Title		
Size A4	Number	Revision
Date: 1/07/2021		Sheet of
File: D:\Users\..\regulation.SchDoc		Drawn By: Hannah Sawiuk

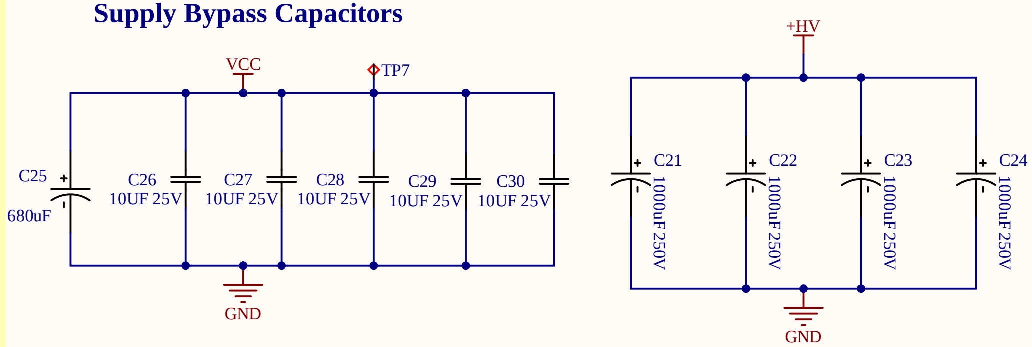
Overvoltage and Undervoltage Pins



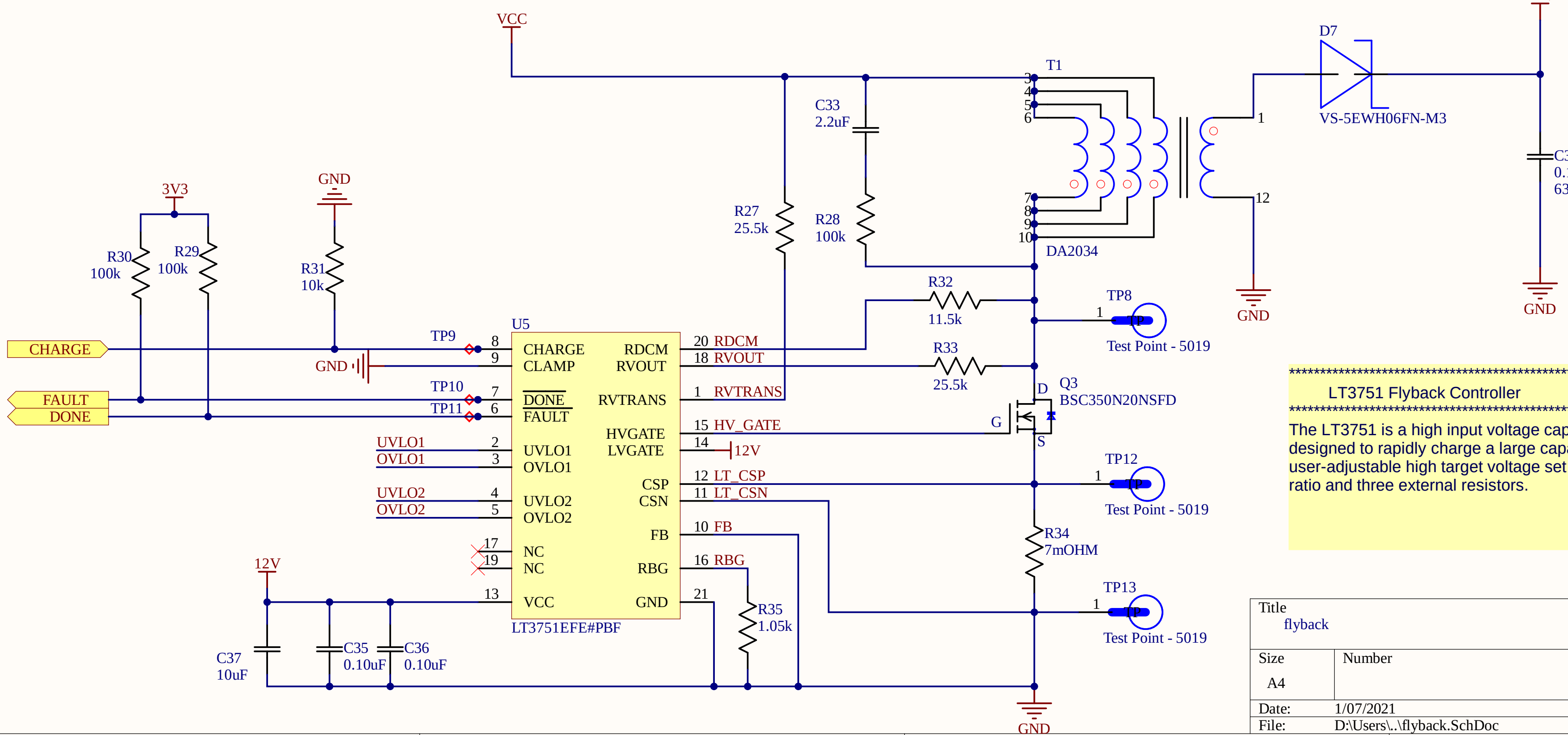

```
****************************************************
        OVLO/UVLO Configuration
****************************************************
The LT3751 provides user-programmable under and
overvoltage lockouts for both VCC and VTRANS.

Note: typical UVLOx/OVLOx pin current = 50uA

12V
--------------------------
VCC_Min = 10V
VCC_Max = 14V
Ruvlo2 = (VCC_MIN-1.225V)/50uA = 175.5k
Rovlo2 = (VCC_MAX-1.225V)/50uA = 255.5k

VCC
--------------------------
VBAT_Min = 18V
VBAT_Max = 26V
Ruvlo1 = (VBAT_MIN-1.225V)/50uA = 335.5k
Rovlo1 = (VBAT_MAX-1.225V)/50uA = 495.5k
```

Supply Bypass Capacitors

HV Capacitor Bank



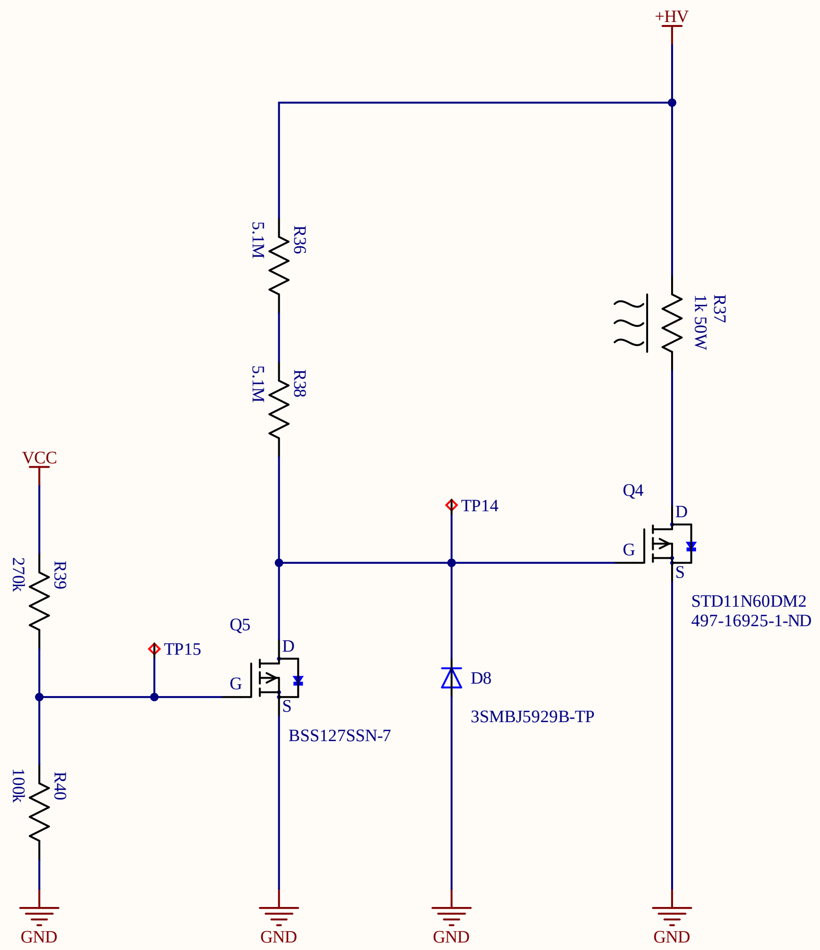
Flyback Controller




```
****************************************************
     LT3751 Flyback Controller
****************************************************
The LT3751 is a high input voltage capable flyback controller
designed to rapidly charge a large capacitor to a
user-adjustable high target voltage set by the transformer turns
ratio and three external resistors.
```

Title: flyback		
Size: A4	Number	Revision
Date: 1/07/2021		Sheet of
File: D:\Users\..\flyback.SchDoc		Drawn By: Graham Whyte

Automatic High Voltage Discharge



****

Auto-Discharge Circuit

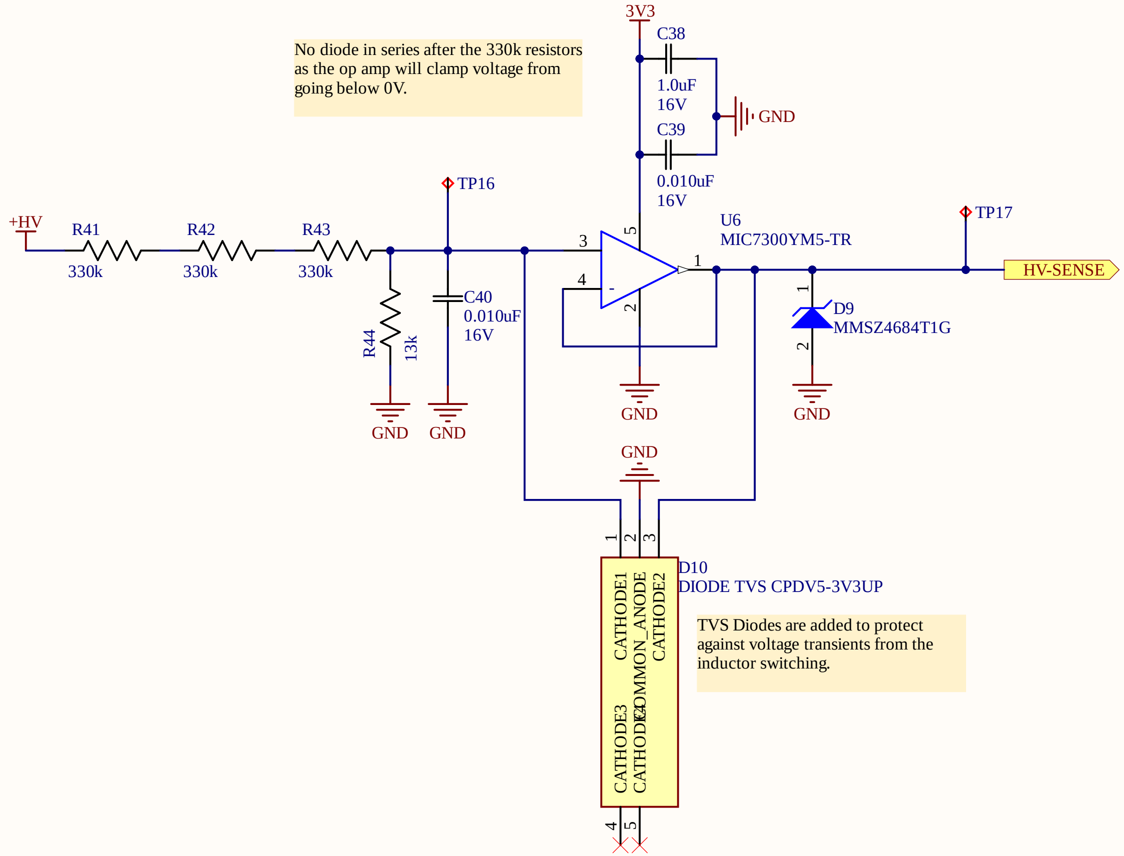
****

When VCC drops such that the divided voltage is below BSS127 Vg_th, the STD11 gate is clamped to <15V, draining the +HV rail.

See the auto-discharge spice simulation for discharge characteristics.

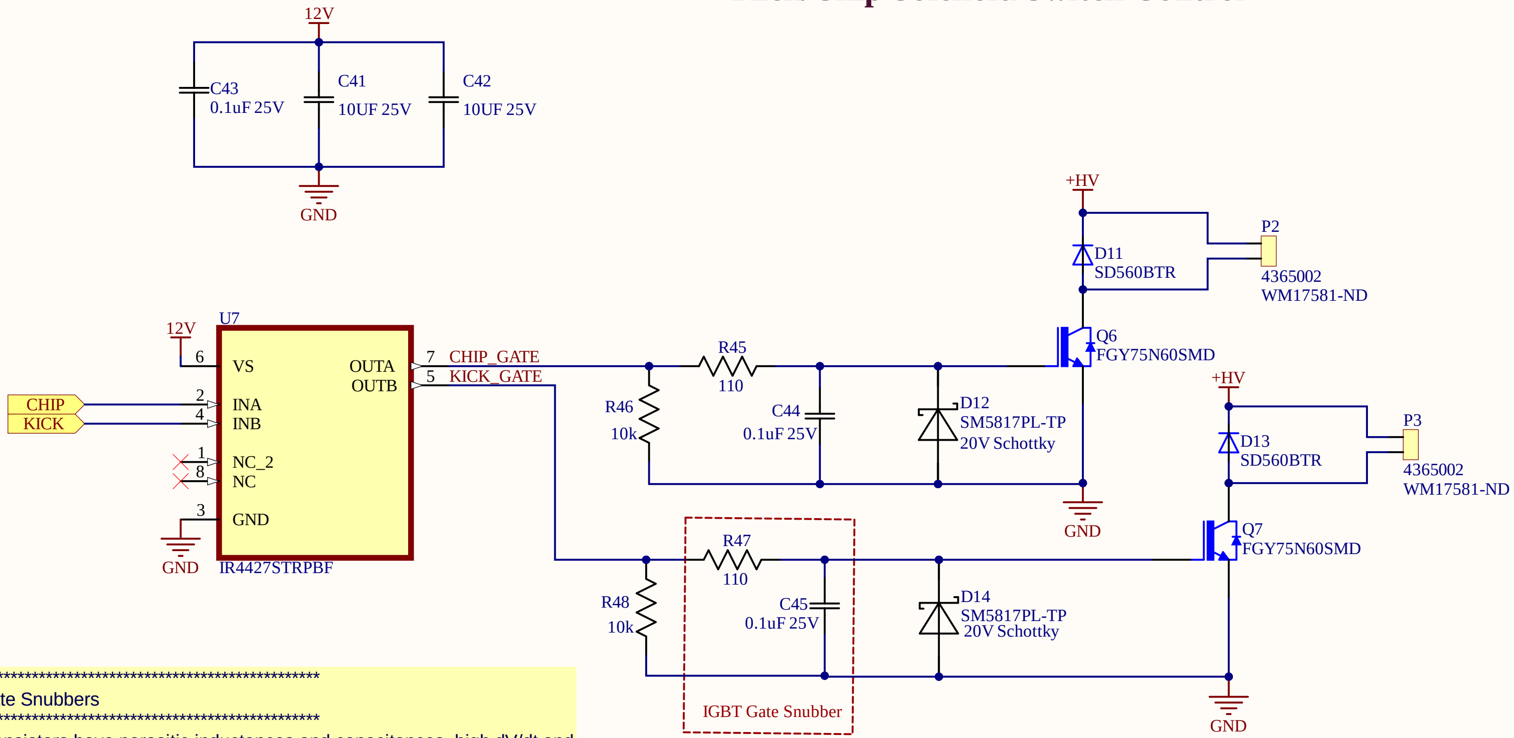
Title			
Size: A	Number		Revision
Date: 1/07/2021		Sheet of	
File: D:\Users\..\auto-discharge.SchDoc		Drawn By: Simon Zheng	

High Voltage Feedback



Title		
Size: A4	Number	Revision
Date: 1/07/2021		Sheet of
File: D:\Users\..\HV-Measurement.SchDoc		Drawn By: Dannon Sturn

Kick/Chip Solenoid Switch Control



****
Gate Snubbers
****
Transistors have parasitic inductances and capacitances, high dV/dt and di/dt, and body-diode reverse recovery can cause unwanted behavior without an appropriately sized gate resistor. To determine the appropriate value for the gate resistor, a 0 ohm resistor is put in as a placeholder and then ringing frequency is measured.

(1) Rg = R(hi or lo) + Rgate + Rg,i
(2) Ls = 1/Ciss(2*pi*f_r)^2
(3) Q = pi*Ls/Rg

Choose quality factor, Q, between 0.5 (critical damping) and 1.0 (underdamped)

See TI's document on "External Gate Resistor Design Guide for Gate Driver"

****
TVS Diodes
****
The IGBT gates are rated for Vge +/- 20V. To ensure transients > 20V do not damage the transistors, TVS diodes with a Reverse Working Voltage (VRWM) <= 20V is used.

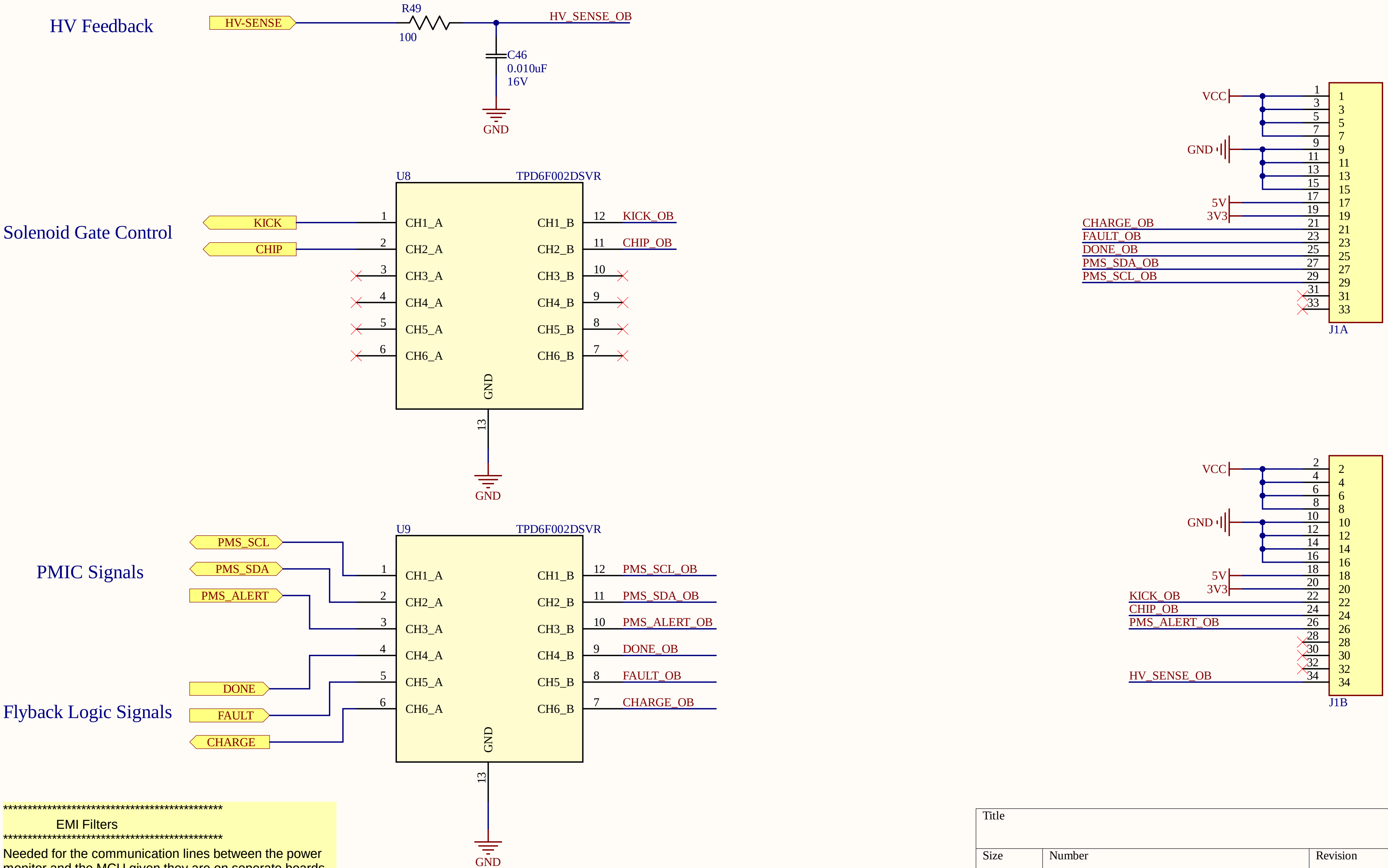
Reverse Working Voltage (VRWM) is the specified voltage at which the device will draw only a very small leakage current.

****
IGBTs: FGY75N60
****
IGBT Field Stop 600V 150A 750W

Figure 10:
Qg = 200nC @ Vge = 12V, Vcc = 250V

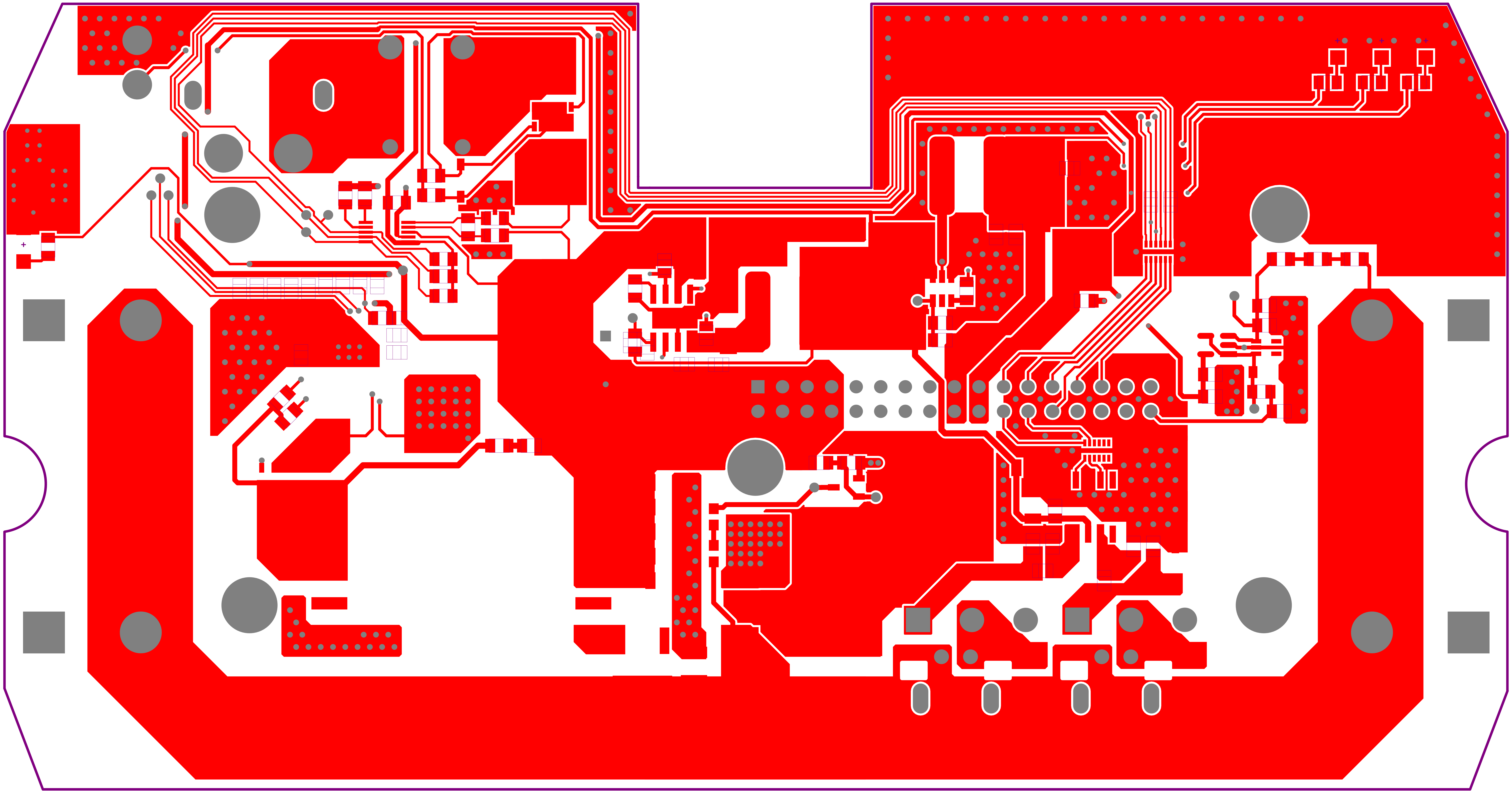
Title		
Size: A4	Number	Revision
Date: 1/07/2021		Sheet of
File: D:\Users\..\chicker.SchDoc		Drawn By: Hannah Sawiuk

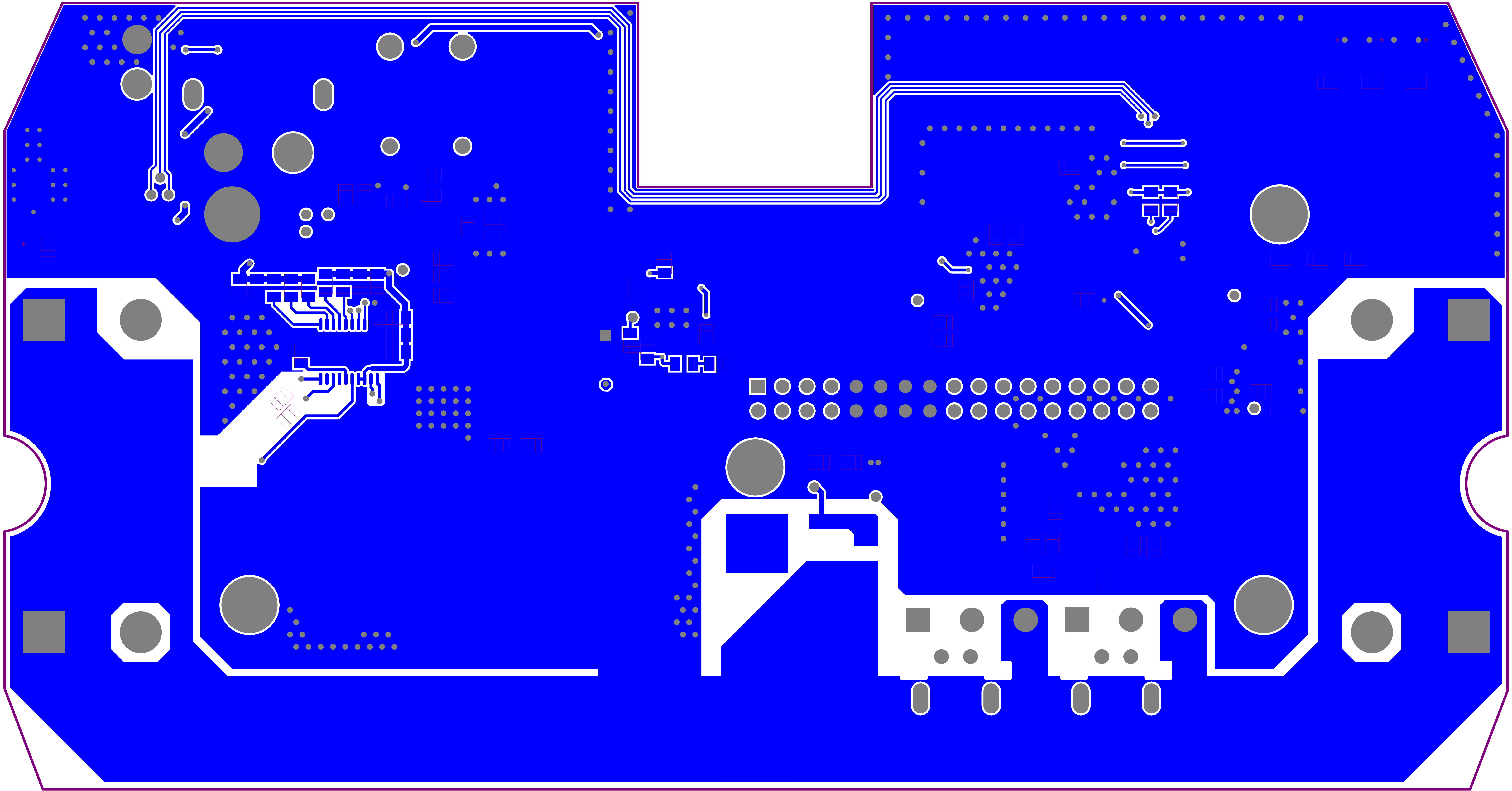
Interboard Signals/Rails

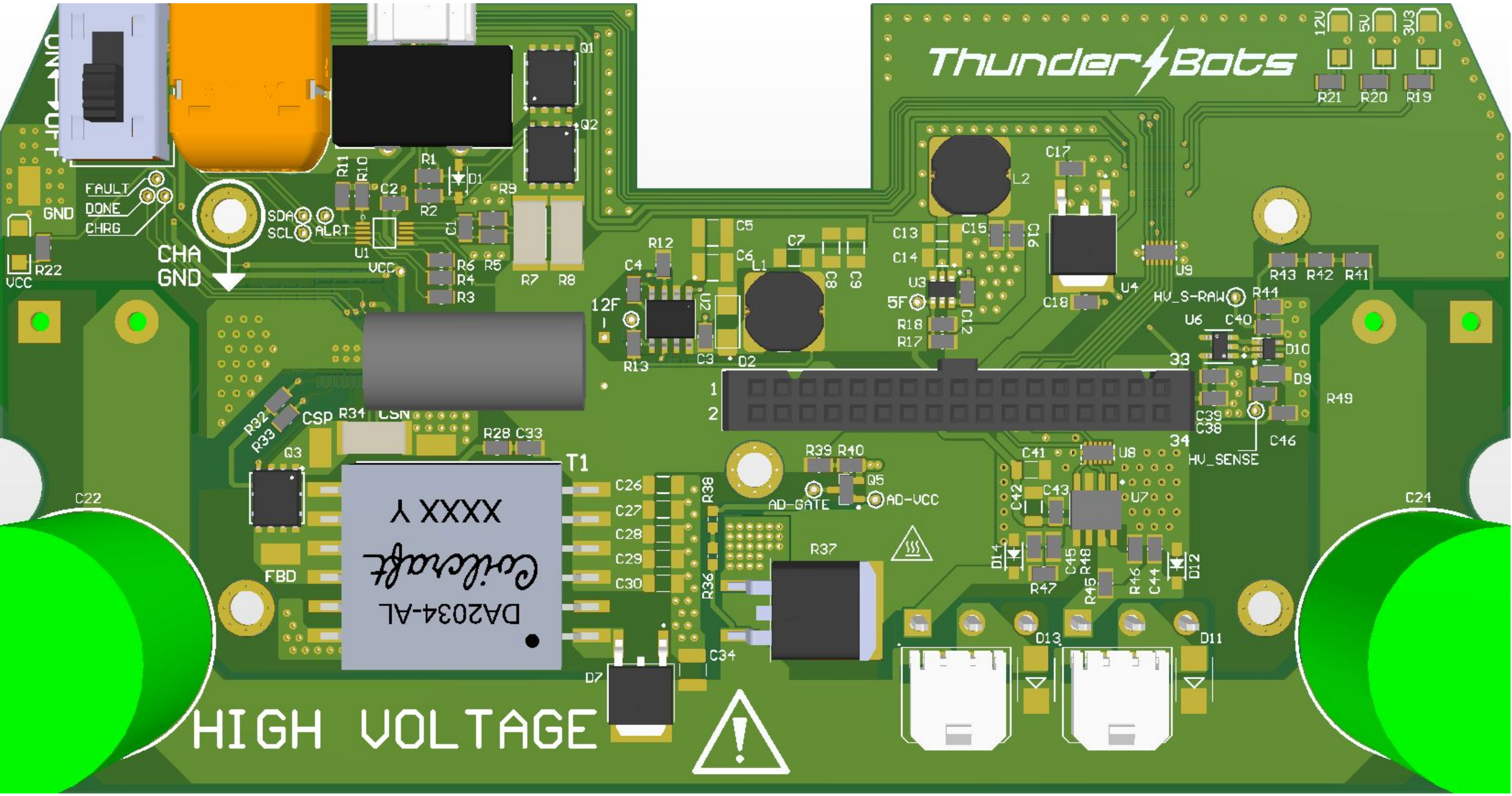


****
EMI Filters
****
Needed for the communication lines between the power monitor and the MCU given they are on seperate boards,

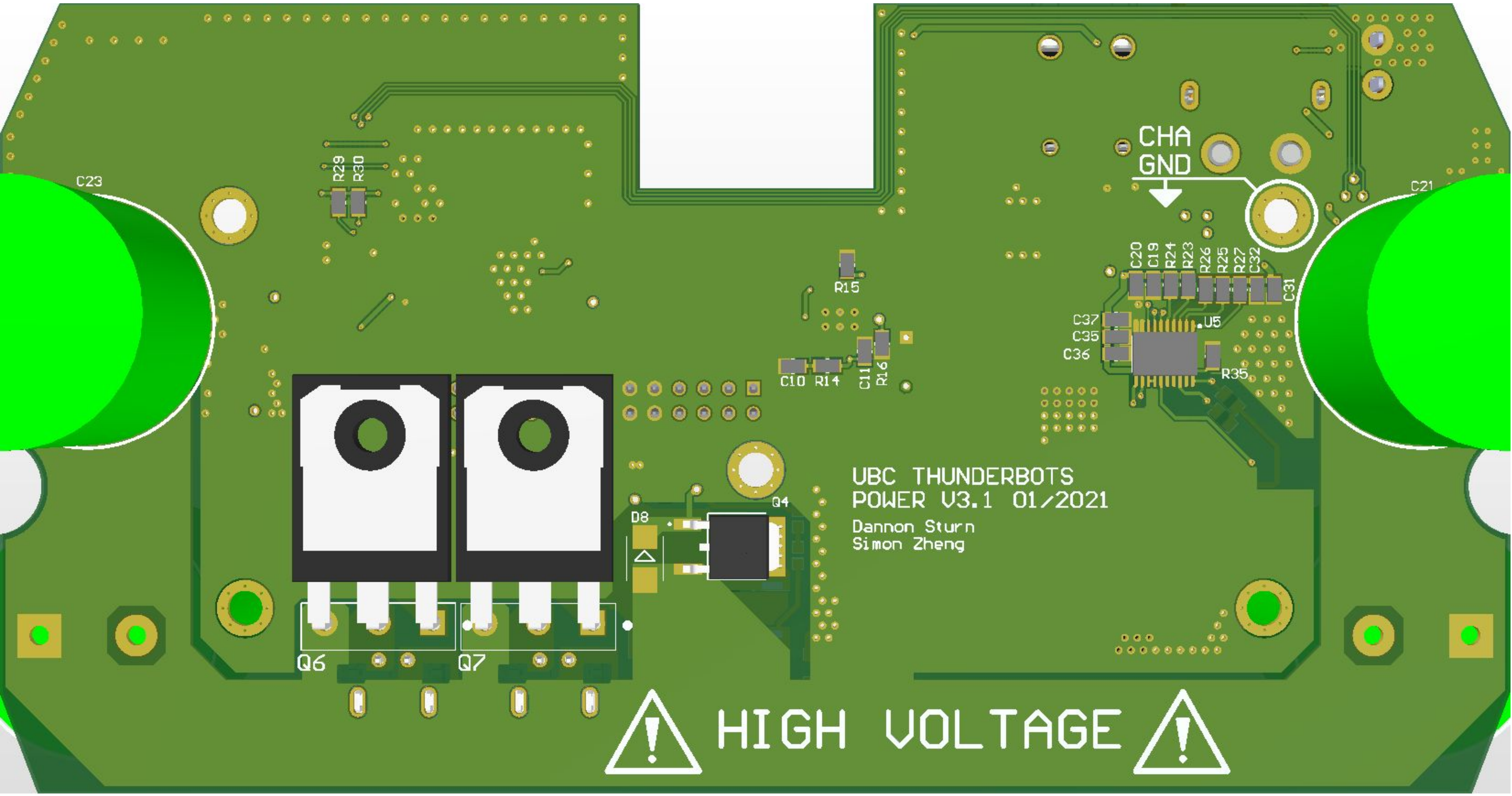
Title		
Size A4	Number	Revision
Date: 1/07/2021		Sheet of
File: D:\Users\..\communication.SchDoc		Drawn By: Simon Zheng

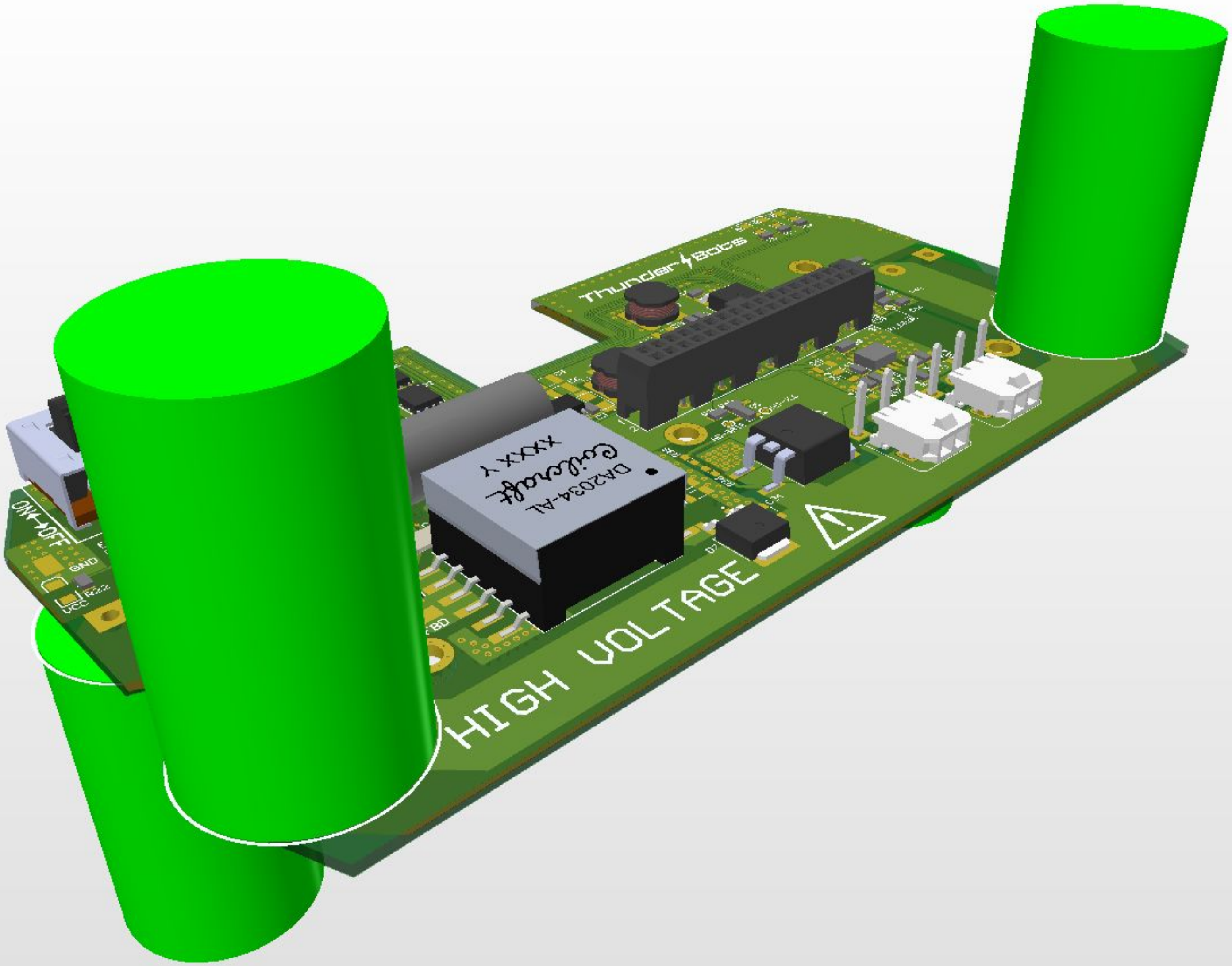






ThunderBots
12V
5V
3V3
R21
R20
R19
FAULT
DONE
CHRG
GND
VCC
R22
CHA
GND
SDA
SCL
ALRT
U1
VCC
R11
R10
C2
R1
R2
D1
R9
C1
R6
R4
R3
R5
R7
R8
Q1
Q2
C5
C6
C7
L1
C8
C9
C4
R12
12F
U2
R13
C3
D2
L2
C17
C13
C15
C16
C14
U3
5F
R18
R17
C12
U4
C18
U9
HV_S-RAW
R43
R42
R41
R44
U6
C40
D10
D9
R49
33
34
1
2
C39
C38
C46
HV_SENSE
CSP
R34
CSN
R32
R33
Q3
R28
C33
T1
Coilcraft
DA2034-AL
C26
C27
C28
C29
C30
R38
R36
FBD
C22
C24
R39
R40
Q5
AD-GATE
AD-VCC
R37
C34
D7
C41
U8
C42
C43
U7
D14
C45
R48
R47
R45
R46
C44
D12
D13
D11
HIGH VOLTAGE


C23
C21
R29
R30
CHA
GND
R15
C20
C19
R24
R23
R26
R25
R27
C32
C31
C37
C35
C36
U5
R35
C10
R14
C11
R16
UBC THUNDERBOTS
POWER V3.1 01/2021
Dannon Sturn
Simon Zheng
Q4
D8
Q6
Q7
HIGH VOLTAGE



Thunder Bots
DA2034-AL
Coilcraft
XXXX Y
HIGH VOLTAGE
ON OFF
GND
VCC