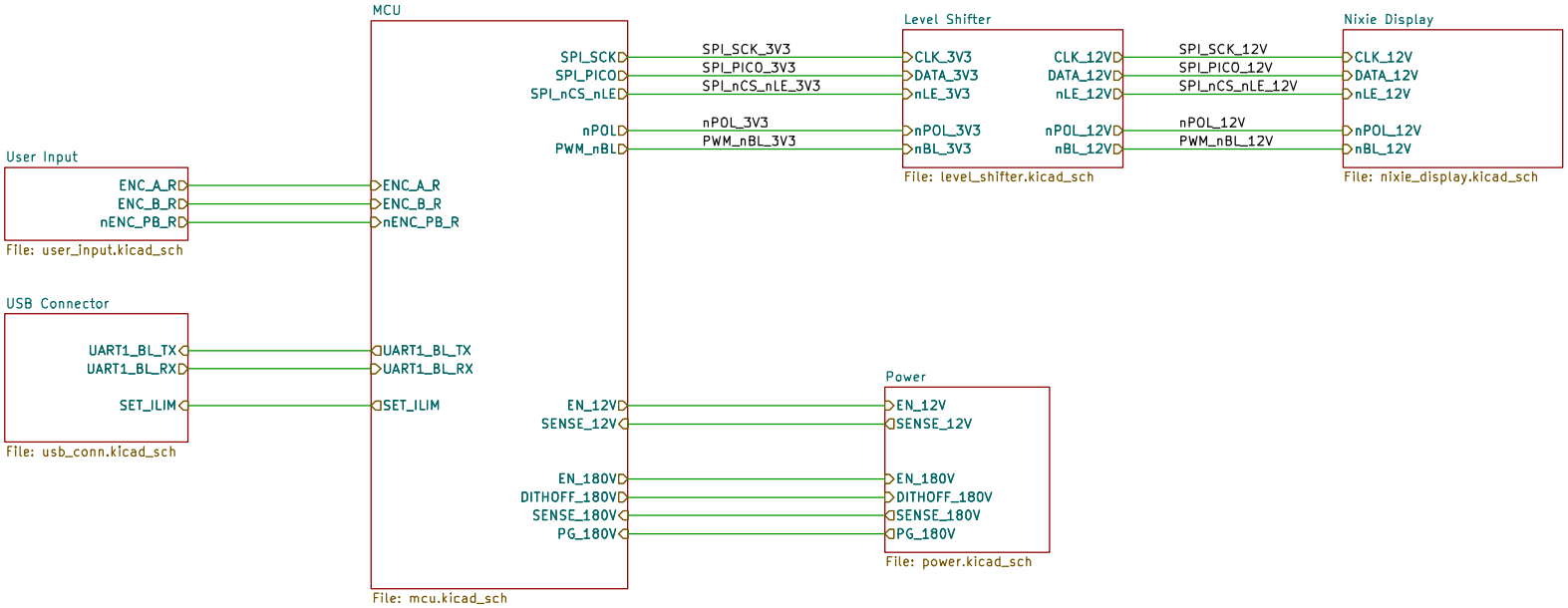

MCU
SPI_SCK
SPI_PICO
SPI_nCS_nLE
nPOL
PWM_nBL
EN_12V
SENSE_12V
EN_180V
DITHOFF_180V
SENSE_180V
PG_180V
ENC_A_R
ENC_B_R
nENC_PB_R
UART1_BL_TX
UART1_BL_RX
SET_ILIM
File: mcu.kicad_sch
SPI_SCK_3V3
SPI_PICO_3V3
SPI_nCS_nLE_3V3
nPOL_3V3
PWM_nBL_3V3
Level Shifter
CLK_3V3
DATA_3V3
nLE_3V3
nPOL_3V3
nBL_3V3
File: level_shifter.kicad_sch
CLK_12V
DATA_12V
nLE_12V
nPOL_12V
nBL_12V
SPI_SCK_12V
SPI_PICO_12V
SPI_nCS_nLE_12V
nPOL_12V
PWM_nBL_12V
Nixie Display
CLK_12V
DATA_12V
nLE_12V
nPOL_12V
nBL_12V
File: nixie_display.kicad_sch
User Input
ENC_A_R
ENC_B_R
nENC_PB_R
File: user_input.kicad_sch
USB Connector
UART1_BL_TX
UART1_BL_RX
SET_ILIM
File: usb_conn.kicad_sch
Power
EN_12V
SENSE_12V
EN_180V
DITHOFF_180V
SENSE_180V
PG_180V
File: power.kicad_sch

CLK transitions on falling edge
Transfer of data from the Shift register to the latch occurs when the nLE input is high. (When active low the data is latched and not shown to the output.)
The data in the latch is stored when nLE is low i.e. outputs are Latched (active low)
nBL LOW sets all outputs off - pulled down to ensure all Nixie's off by default.
- Can PWM this to dim the Nixies
nPOL LOW inverts all outputs (keep HI for normal operation)

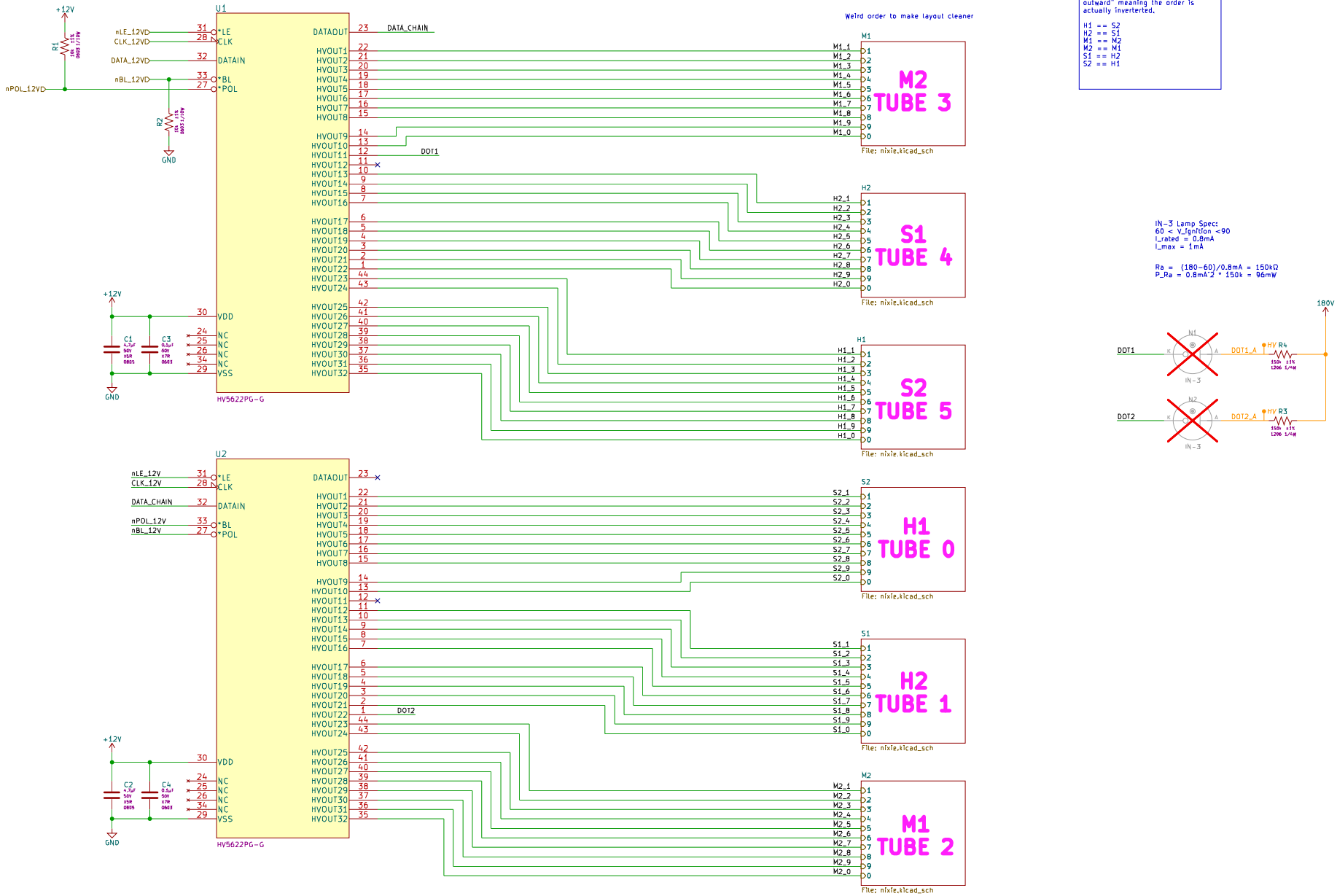
Also realizing I made a booboo with the layout! I put hours on the "left" and seconds on the "right" in layout... but the layout is "looking outward" meaning the order is actually inverterted.

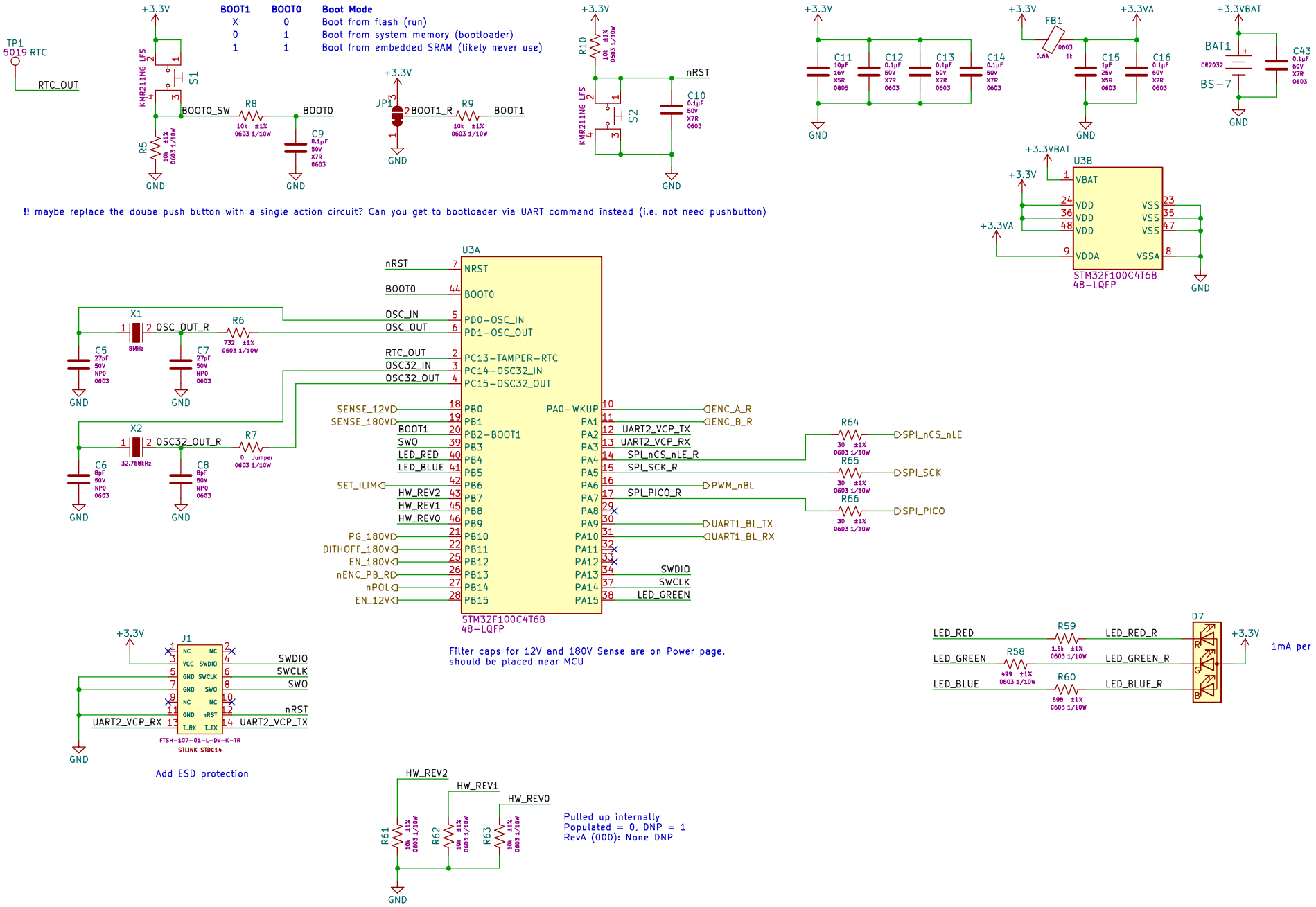
H1 == S2
H2 == S1
M1 == M2
M2 == M1
S1 == H2
S2 == H1

Weird order to make layout cleaner

IN-3 Lamp Spec:
60 < V_Ignition <90
I_rated = 0.8mA
I_max = 1mA

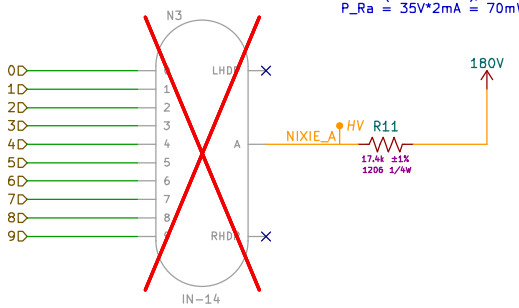
Ra = (180-60)/0.8mA = 150kΩ
P_Ra = 0.8mA^2 * 150k = 96mW




BOOT1 BOOT0 Boot Mode
X 0 Boot from flash (run)
0 1 Boot from system memory (bootloader)
1 1 Boot from embedded SRAM (likely never use)
!! maybe replace the doube push button with a single action circuit? Can you get to bootloader via UART command instead (i.e. not need pushbutton)
U3A
STM32F100C4T6B
48-LQFP
U3B
STM32F100C4T6B
48-LQFP
Filter caps for 12V and 180V Sense are on Power page, should be placed near MCU
Add ESD protection
Pulled up internally
Populated = 0, DNP = 1
RevA (000): None DNP
1mA per

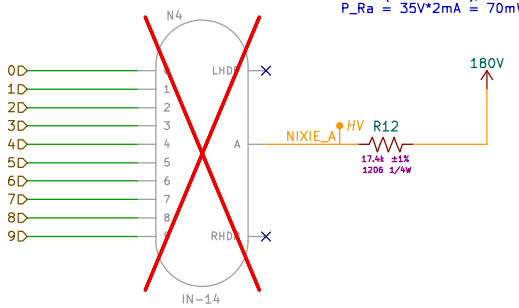
https://threeneurons.wordpress.com/nixie-power-supply/

Vstrike = 170V
Vmax = 200V
170V < Vsupply = 180V < 200V
Vsustain = 145V
I = 2mA (Shift register has 100mA max shift current, so we're good there)
Ra = (180V-145V)/2mA = 17.5k
P_Ra = 35V*2mA = 70mW



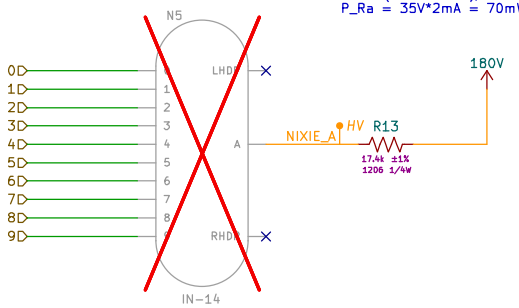
https://threeneurons.wordpress.com/nixie-power-supply/

Vstrike = 170V
Vmax = 200V
170V < Vsupply = 180V < 200V
Vsustain = 145V
I = 2mA (Shift register has 100mA max shift current, so we're good there)
Ra = (180V-145V)/2mA = 17.5k
P_Ra = 35V*2mA = 70mW



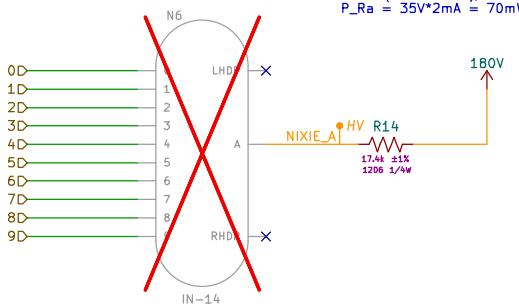
https://threeneurons.wordpress.com/nixie-power-supply/

Vstrike = 170V
Vmax = 200V
170V < Vsupply = 180V < 200V
Vsustain = 145V
I = 2mA (Shift register has 100mA max shift current, so we're good there)
Ra = (180V-145V)/2mA = 17.5k
P_Ra = 35V*2mA = 70mW



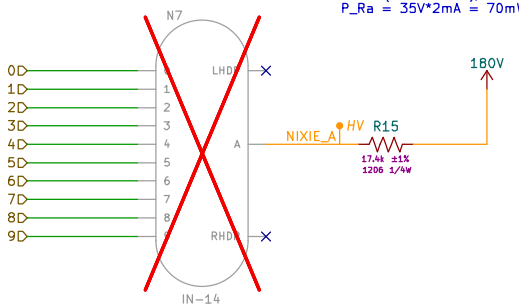
https://threeneurons.wordpress.com/nixie-power-supply/

Vstrike = 170V
Vmax = 200V
170V < Vsupply = 180V < 200V
Vsustain = 145V
I = 2mA (Shift register has 100mA max shift current, so we're good there)
Ra = (180V-145V)/2mA = 17.5k
P_Ra = 35V*2mA = 70mW



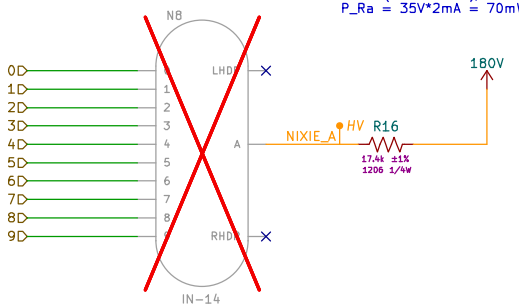
https://threeneurons.wordpress.com/nixie-power-supply/

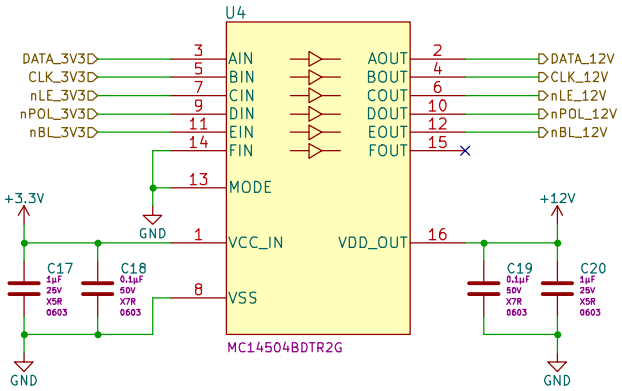
Vstrike = 170V
Vmax = 200V
170V < Vsupply = 180V < 200V
Vsustain = 145V
I = 2mA (Shift register has 100mA max shift current, so we're good there)
Ra = (180V-145V)/2mA = 17.5k
P_Ra = 35V*2mA = 70mW

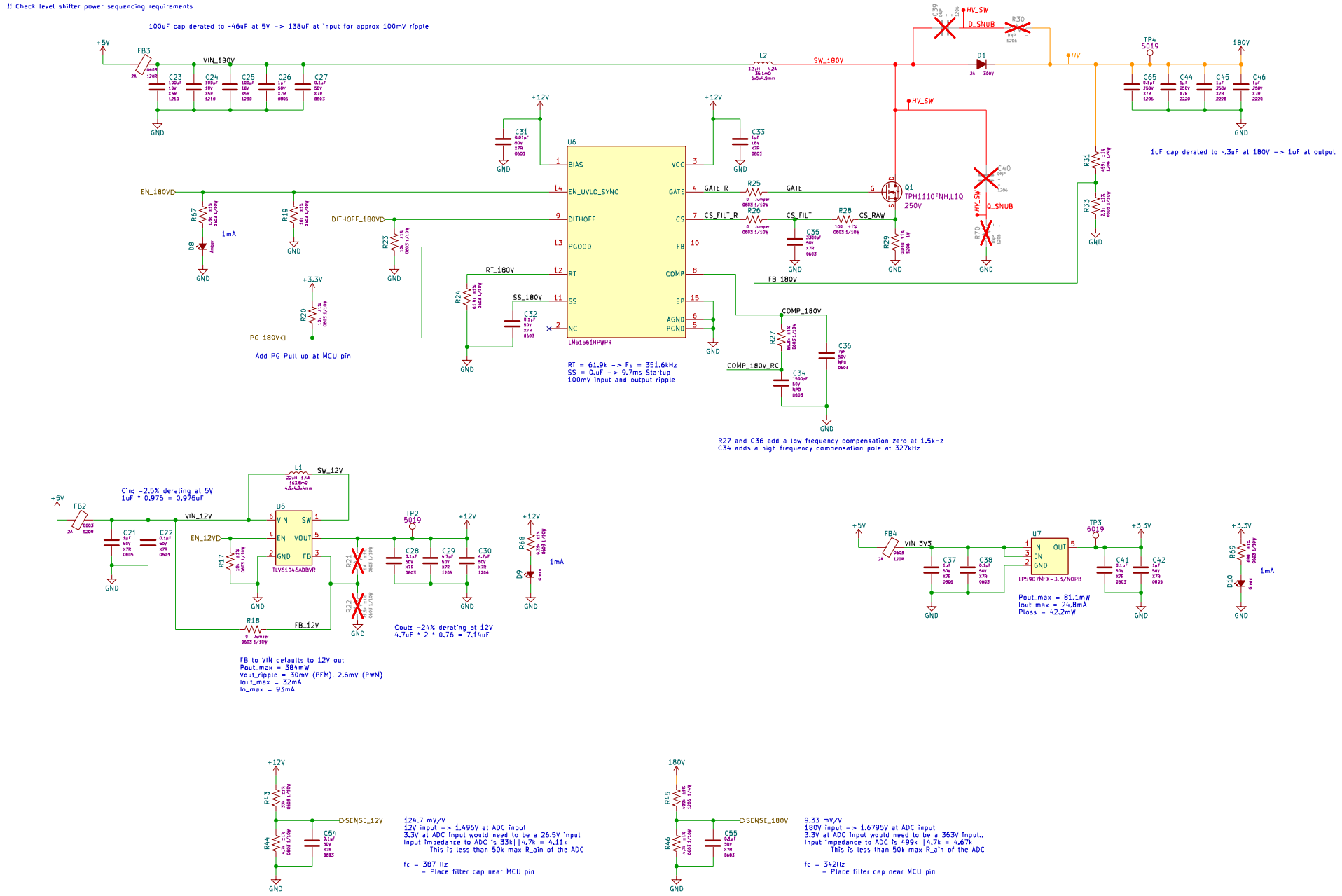


https://threeneurons.wordpress.com/nixie-power-supply/

Vstrike = 170V
Vmax = 200V
170V < Vsupply = 180V < 200V
Vsustain = 145V
I = 2mA (Shift register has 100mA max shift current, so we're good there)
Ra = (180V-145V)/2mA = 17.5k
P_Ra = 35V*2mA = 70mW

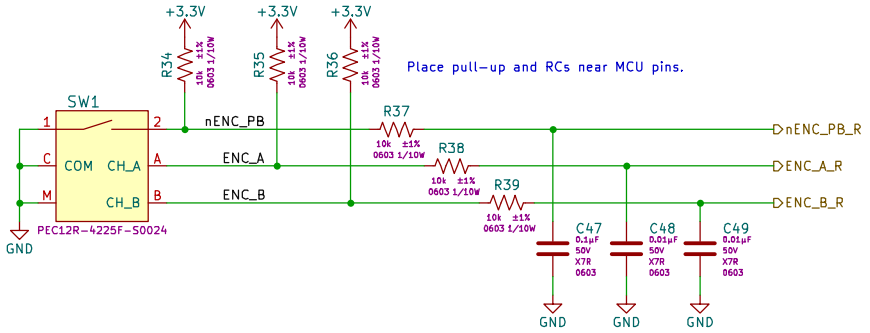


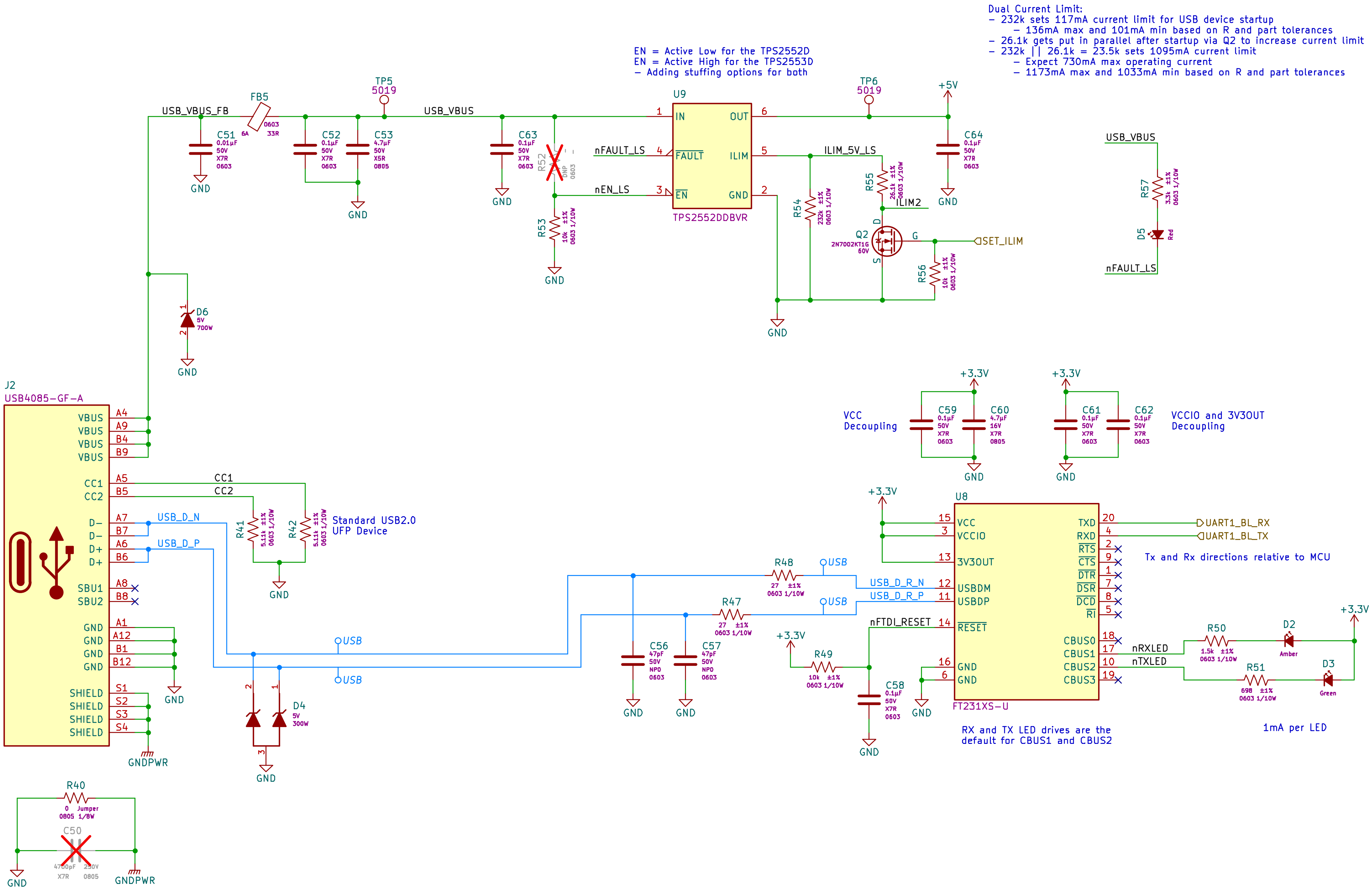

U4
DATA_3V3
CLK_3V3
nLE_3V3
nPOL_3V3
nBL_3V3
3
5
7
9
11
14
AIN
BIN
CIN
DIN
EIN
FIN
13
MODE
1
VCC_IN
8
VSS
AOUT
BOUT
COUT
DOUT
EOUT
FOUT
2
4
6
10
12
15
16
VDD_OUT
DATA_12V
CLK_12V
nLE_12V
nPOL_12V
nBL_12V
+3.3V
+12V
GND
GND
GND
C17
1µF
25V
X5R
0603
C18
0.1µF
50V
X7R
0603
C19
0.1µF
50V
X7R
0603
C20
1µF
25V
X5R
0603
MC14504BDTR2G


!! Check level shifter power sequencing requirements
100uF cap derated to ~46uF at 5V -> 138uF at input for approx 100mV ripple
+5V
FB3
VIN_180V
C23
C24
C25
C26
C27
GND
L2
SW_180V
HV_SW
D_SNUB
R30
D1
HV
TP4
5019
180V
C65
C44
C45
C46
1uF cap derated to ~.3uF at 180V -> 1uF at output
U6
BIAS
VCC
EN_UVLO_SYNC
GATE
DITHOFF
CS
PGOOD
FB
RT
COMP
SS
EP
NC
AGND
PGND
LM51561HPWPR
+12V
C31
C33
EN_180VD
GATE_R
R25
GATE
Q1
TPH1110FNH,L1Q
250V
R67
1mA
D8
R19
DITHOFF_180VD
R23
R26
CS_FILT_R
CS_FILT
R28
CS_RAW
C35
R29
C40
Q_SNUB
R70
R31
R33
+3.3V
R20
PG_180VD
Add PG Pull up at MCU pin
RT_180V
R24
SS_180V
C32
FB_180V
COMP_180V
R27
C36
COMP_180V_RC
C34
R27 and C36 add a low frequency compensation zero at 1.5kHz
C34 adds a high frequency compensation pole at 327kHz
RT = 61.9k -> Fs = 351.6kHz
SS = 0.uF -> 9.7ms Startup
100mV input and output ripple
L1
SW_12V
Cin: -2.5% derating at 5V
1uF * 0.975 = 0.975uF
FB2
VIN_12V
EN_12VD
U5
VIN
SW
EN
VOUT
GND
FB
TLV61D046ADBVR
C21
C22
R17
R21
R22
TP2
5019
C28
C29
C30
R68
D9
1mA
R18
FB_12V
Cout: -24% derating at 12V
4.7uF * 2 * 0.76 = 7.14uF
FB to VIN defaults to 12V out
Pout_max = 384mW
Vout_ripple = 30mV (PFM), 2.6mV (PWM)
Iout_max = 32mA
In_max = 93mA
FB4
VIN_3V3
U7
IN
OUT
EN
LP5907MFX-3.3/NOPB
C37
C38
TP3
5019
C41
C42
Pout_max = 81.1mW
Iout_max = 24.8mA
Ploss = 42.2mW
R69
D10
1mA
R43
R44
C54
SENSE_12V
124.7 mV/V
12V input -> 1.496V at ADC input
3.3V at ADC input would need to be a 26.5V input
Input impedance to ADC is 33k||4.7k = 4.11k
- This is less than 50k max R_ain of the ADC
fc = 387 Hz
- Place filter cap near MCU pin
R45
R46
C55
SENSE_180V
9.33 mV/V
180V input -> 1.6795V at ADC input
3.3V at ADC input would need to be a 353V input..
Input impedance to ADC is 499k||4.7k = 4.67k
- This is less than 50k max R_ain of the ADC
fc = 342Hz
- Place filter cap near MCU pin

Rotary Encoder w/Pushbutton

Main user input





Dual Current Limit:
- 232k sets 117mA current limit for USB device startup
- 136mA max and 101mA min based on R and part tolerances
- 26.1k gets put in parallel after startup via Q2 to increase current limit
- 232k || 26.1k = 23.5k sets 1095mA current limit
- Expect 730mA max operating current
- 1173mA max and 1033mA min based on R and part tolerances
EN = Active Low for the TPS2552D
EN = Active High for the TPS2553D
- Adding stuffing options for both
USB_VBUS_FB
FB5
TP5
5019
USB_VBUS
U9
TPS2552DDBVR
IN
OUT
FAULT
ILIM
EN
GND
nFAULT_LS
nEN_LS
ILIM_5V_LS
ILIM2
TP6
5019
+5V
C51
C52
C53
C63
C64
R52
R53
R54
R55
R56
Q2
2N7002KT1G
SET_ILIM
R57
D5
USB_VBUS
nFAULT_LS
D6
GND
J2
USB4085-GF-A
VBUS
CC1
CC2
D-
D+
SBU1
SBU2
GND
SHIELD
USB_D_N
USB_D_P
R41
R42
Standard USB2.0
UFP Device
D4
GNDPWR
R40
C50
VCC
Decoupling
C59
C60
C61
C62
VCCIO and 3V3OUT
Decoupling
+3.3V
U8
FT231XS-U
VCC
VCCIO
3V3OUT
USBDM
USBDP
RESET
GND
TXD
RXD
RTS
CTS
DTR
DSR
DCD
RI
CBUS0
CBUS1
CBUS2
CBUS3
UART1_BL_RX
UART1_BL_TX
Tx and Rx directions relative to MCU
R48
R47
USB
USB_D_R_N
USB_D_R_P
C56
C57
nFTDI_RESET
R49
C58
nRXLED
nTXLED
R50
R51
D2
D3
Amber
Green
RX and TX LED drives are the
default for CBUS1 and CBUS2
1mA per LED