6 Digit Nixie Clock "64Bit" - Driver Board

A project started in earnest September 2025

64Bit comes from the fact that this clock is driven with shift registers. Between the 6 nixie digits, and indicators, 64 bits are sent from the microcontroller to the shift registers to create the display output

This is an STM32F446 based project.

The clock time keeping is handled via a Real Time Clock (RTC) communicated with via I2C. The STM32 also has an on-board RTC that can be utilized. Both RTCs have a battery backup via a replaceable 2032 coin cell.

The interface with the clock is via a rotory encoder with a push button. Interfacing with remote capacitive buttons is possible via connectors on the bottom of the Driver Board.

There is a full-color LCD display using driving chip ST7789V2. Communication occurs via SPI.

This clock was designed with safety in mind. There is a dedicated safety circuit that cuts the input and output connections of the high voltage power supply via relays. There are connectors for interfacing external spring pin connections to the cover of the clock, ensuring the high voltage power supply is not on while the lid is off. The safety circuit features dual channels and feedback to the microcontroller. With the spring pin feature, it will provide isolation from the high voltage, even in an event where the microcontroller experiences an error.

The power design of the clock relys on simple components. There are two inputs available to power the clock. A USB-C port and a 12V barrel jack. A boost converter utilizing XL6009 converts (boost) the incoming voltage to 12VDC. Then an LDO creates 5V then another LDO, in series, creates 3.3V. The high voltage power supply typically is set to output 170VDC to 180VDC. It is supplied by a power supply module that sources 12V power.

This driver board interfacese with the display board PCB via right angle board-to-board connectors. Mounted to the back of the display board is an LED board to provide RGB backlighting to each IN-12 Nixie Tubes.

The circuit boards will be mounted to a 3D printed base via brass standoffs. Overtop of the PCBs will be a glass top. The glass top will have sections where copper tape is applied. Spring pins contact the copper tape to pass connections for the safety circuit.

STM32 MCU

I2C

Interface

Safety Circuit

Power

Connectors

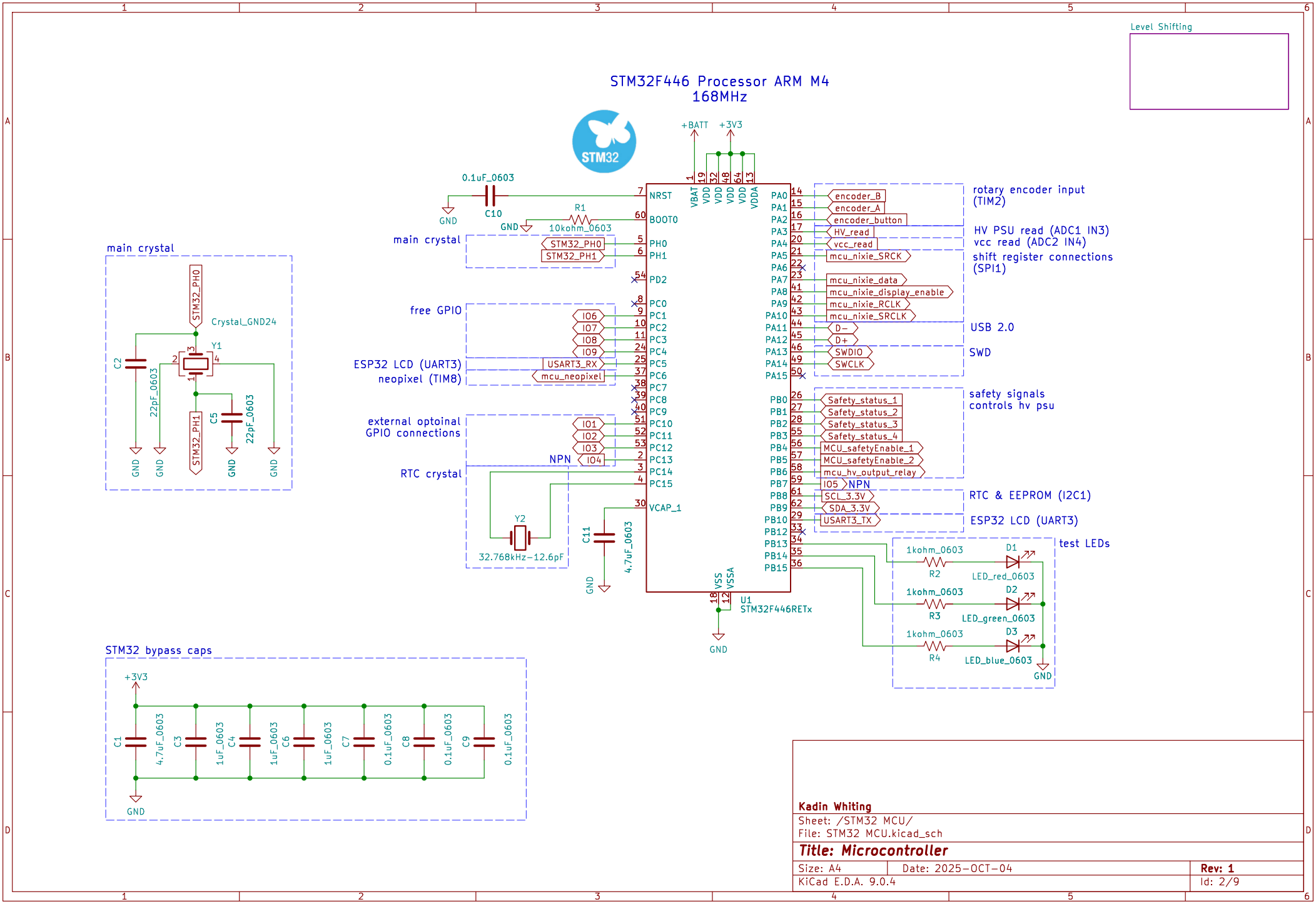
Connectors 2

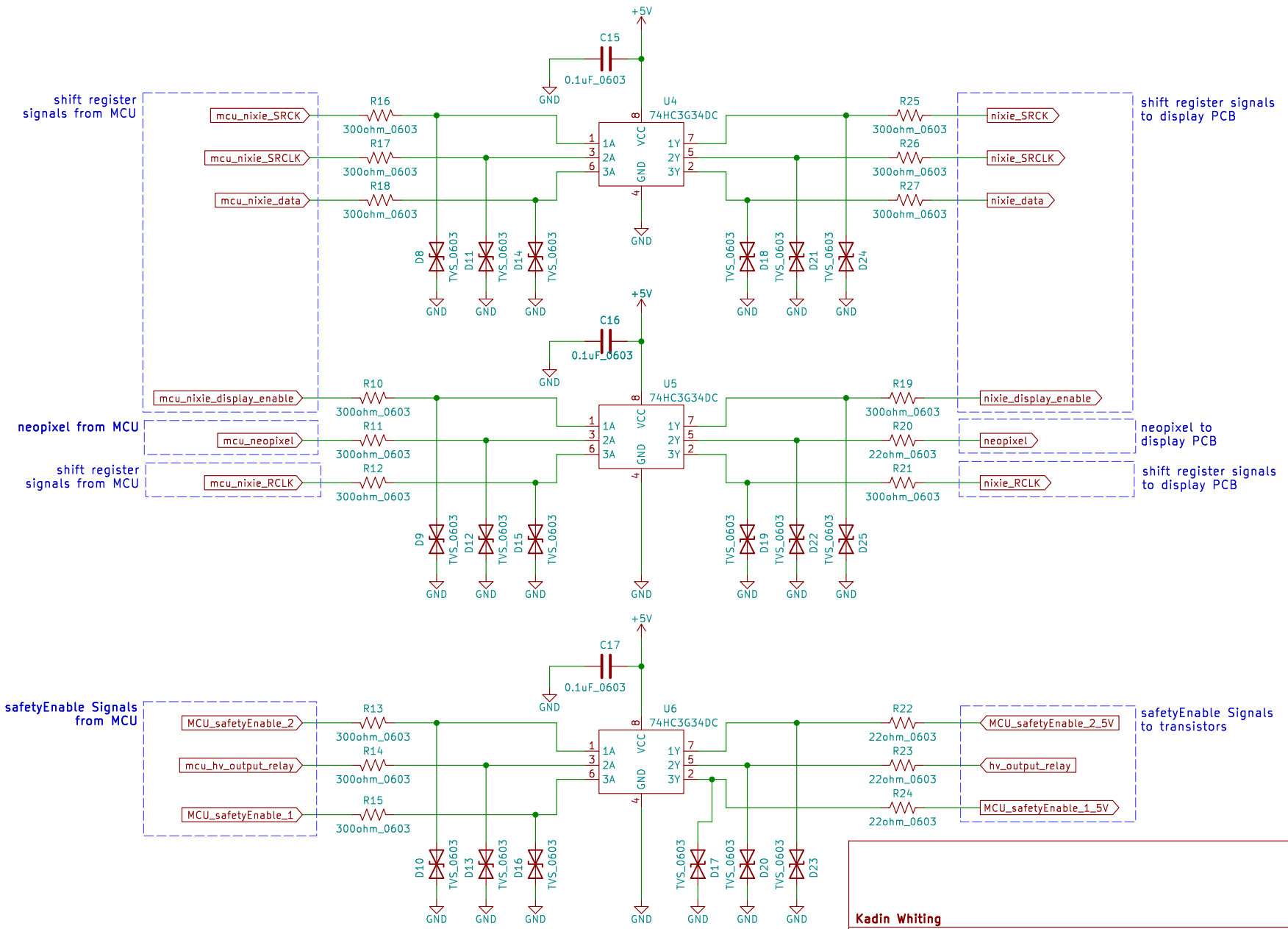
Kadin Whiting

Sheet: /
File: 64 Bit - Main Board.kicad_sch

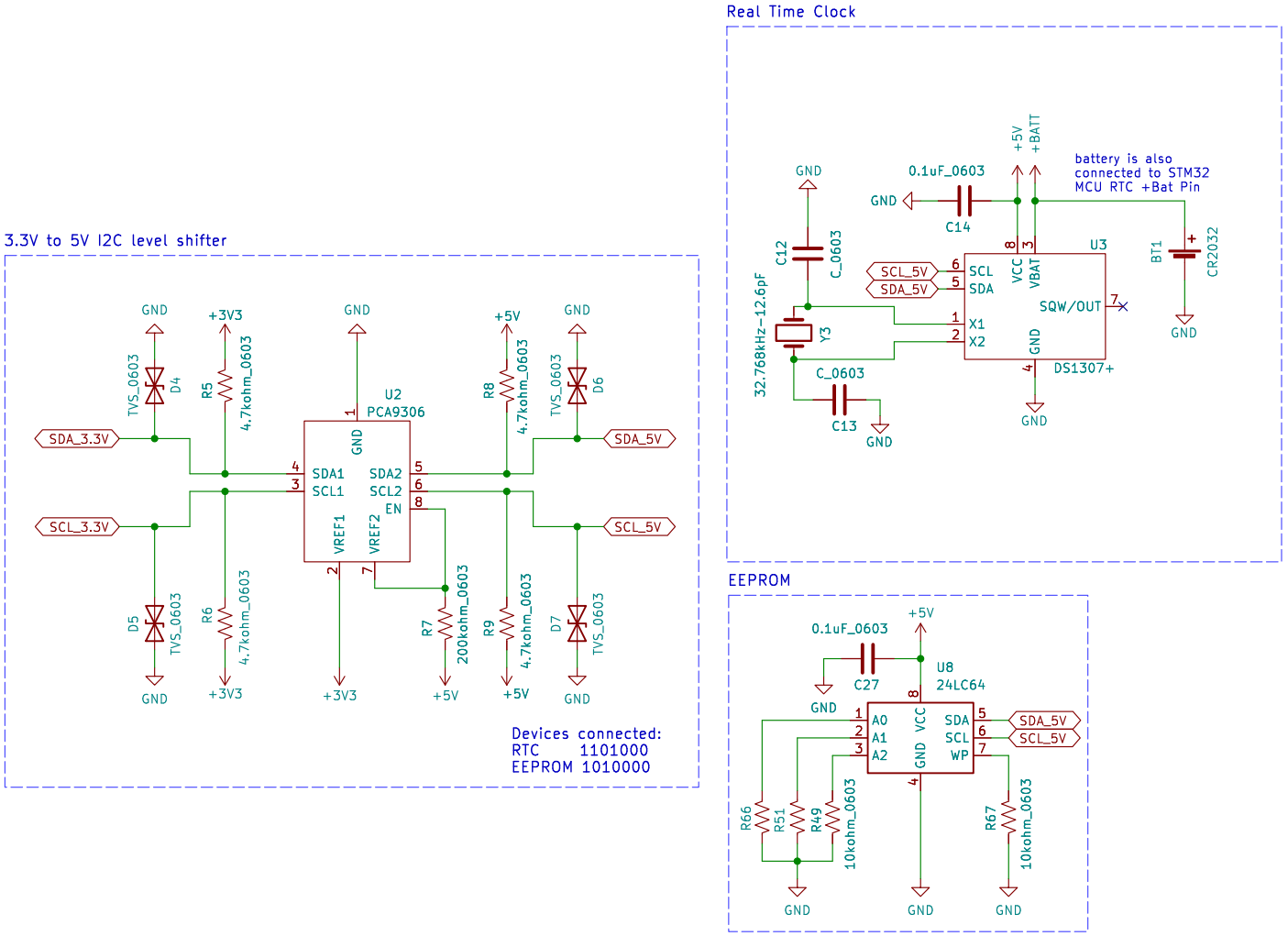
Title: Project Overview

Size: A4	Date: 2025-OCT-04	**Rev: 1**
KiCad E.D.A. 9.0.4		Id: 1/9


Level Shifting
STM32F446 Processor ARM M4
168MHz
STM32
+BATT
+3V3
0.1uF_0603
C10
GND
R1
10kohm_0603
main crystal
STM32_PH0
STM32_PH1
free GPIO
IO6
IO7
IO8
IO9
ESP32 LCD (UART3)
USART3_RX
neopixel (TIM8)
mcu_neopixel
external optoinal
GPIO connections
IO1
IO2
IO3
NPN
IO4
RTC crystal
Y2
32.768kHz-12.6pF
C11
4.7uF_0603
VCAP_1
NRST
BOOT0
PH0
PH1
PD2
PC0
PC1
PC2
PC3
PC4
PC5
PC6
PC7
PC8
PC9
PC10
PC11
PC12
PC13
PC14
PC15
VBAT
VDD
VDDA
VSS
VSSA
U1
STM32F446RETx
PA0
PA1
PA2
PA3
PA4
PA5
PA6
PA7
PA8
PA9
PA10
PA11
PA12
PA13
PA14
PA15
encoder_B
encoder_A
encoder_button
HV_read
vcc_read
mcu_nixie_SRCK
mcu_nixie_data
mcu_nixie_display_enable
mcu_nixie_RCLK
mcu_nixie_SRCLK
D-
D+
SWDIO
SWCLK
rotary encoder input
(TIM2)
HV PSU read (ADC1 IN3)
vcc read (ADC2 IN4)
shift register connections
(SPI1)
USB 2.0
SWD
PB0
PB1
PB2
PB3
PB4
PB5
PB6
PB7
PB8
PB9
PB10
PB12
PB13
PB14
PB15
Safety_status_1
Safety_status_2
Safety_status_3
Safety_status_4
MCU_safetyEnable_1
MCU_safetyEnable_2
mcu_hv_output_relay
IO5
NPN
SCL_3.3V
SDA_3.3V
USART3_TX
safety signals
controls hv psu
RTC & EEPROM (I2C1)
ESP32 LCD (UART3)
test LEDs
1kohm_0603
R2
D1
LED_red_0603
R3
D2
LED_green_0603
R4
D3
LED_blue_0603
main crystal
STM32_PH0
Crystal_GND24
Y1
C2
22pF_0603
STM32_PH1
C5
22pF_0603
STM32 bypass caps
C1
4.7uF_0603
C3
1uF_0603
C4
1uF_0603
C6
1uF_0603
C7
0.1uF_0603
C8
0.1uF_0603
C9
0.1uF_0603
Kadin Whiting
Sheet: /STM32 MCU/
File: STM32 MCU.kicad_sch
Title: Microcontroller
Size: A4
Date: 2025-OCT-04
Rev: 1
KiCad E.D.A. 9.0.4
Id: 2/9



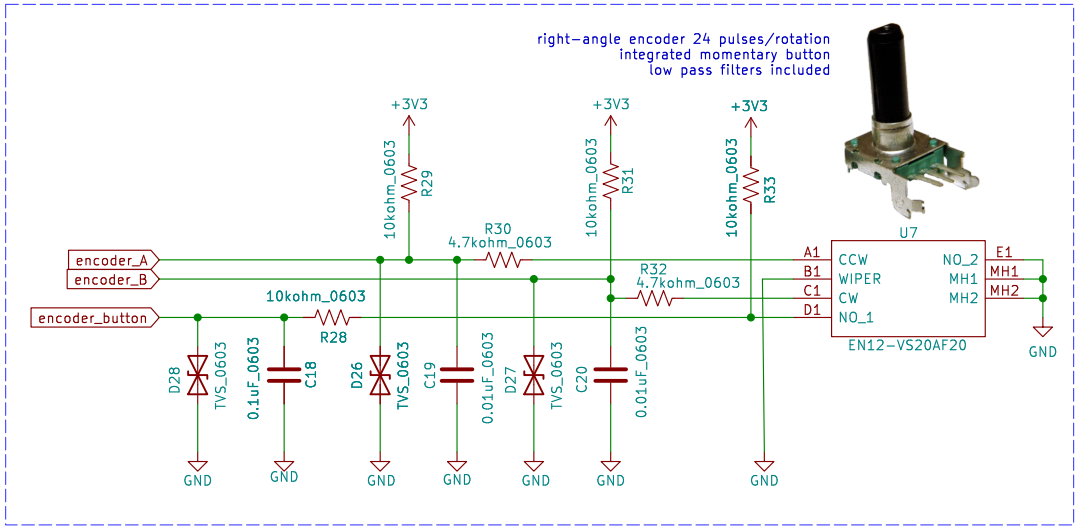
Kadin Whiting		
Sheet: /STM32 MCU/Level Shifting/		
File: Level Shifting.kicad_sch		
Title: 3.3V -> 5.0V Level Shifting		
Size: A4	Date: 2025-OCT-04	**Rev: 1**
KiCad E.D.A. 9.0.4		Id: 4/9



Kadin Whiting	
Sheet: /I2C/	
File: I2C.kicad_sch	
Title: RTC & RTC Level Shifting	
Size: A4	Date: 2025-OCT-04
KiCad E.D.A. 9.0.4	Id: 3/9

Rev: 1

rotary encoder with push button



Kadin Whiting		
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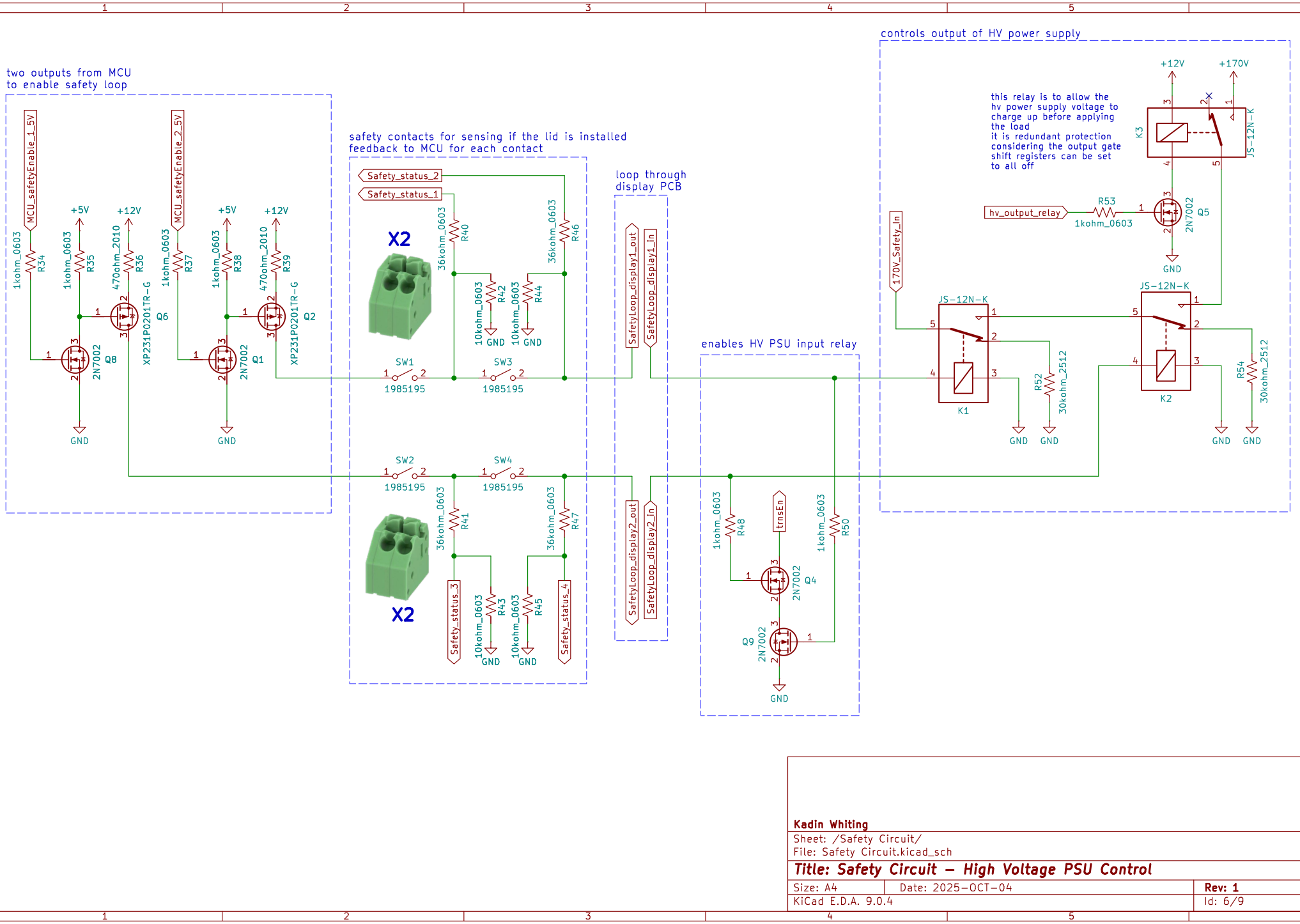
File: Interface.kicad_sch		
Title: Interface – Rotary Encoder		
Size: A4	Date: 2025-OCT-04	**Rev: 1**
KiCad E.D.A. 9.0.4		Id: 5/9



Kadin Whiting	
Sheet: /Safety Circuit/	
File: Safety Circuit.kicad_sch	
Title: Safety Circuit – High Voltage PSU Control	
Size: A4	Date: 2025-OCT-04
KiCad E.D.A. 9.0.4	Id: 6/9

Rev: 1

power selection and power switch

+5V_USB
12V_Jack
SW5
L102011MS02Q
SW6
power_switch
LDO to step to 5V
for relay coil
VR5
AZ1117CH2-5.0TRG1
C28
10uF_1210
C29
22uF_1210
PR30-5V-450-1A-E
K4
MCU reading
input voltage
vcc_read
C31
0.1uF_0603
R56
10kohm_0603
R75
22ohm_0603
R57
36kohm_0603
GND

12V Power Module

VR1
BasicBoostConverter
IN+
IN-
OUT+
OUT-
+12V

5V LDO

VR3
AZ1117CH2-5.0TRG1
C21
10uF_1210
C22
22uF_1210
+5V

3.3V LDO

VR4
AZ1117CH2-3.3TRG1
C23
10uF_1210
C24
22uF_1210
+3V3

3.3V LDO – external devices

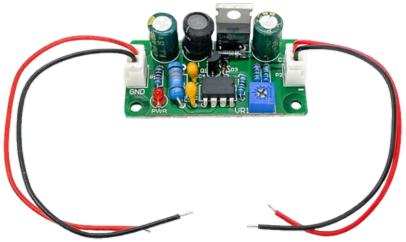
VR6
AZ1117CH2-3.3TRG1
C32
10uF_1210
C33
22uF_1210
+12V
+3V3_2

Controlled by safety circuit

+5V
+12V
XP231P0201TR-G
Q10
R58
15kohm_0603
R59
1kohm_0603
trnsEn
K5

high voltage power supply

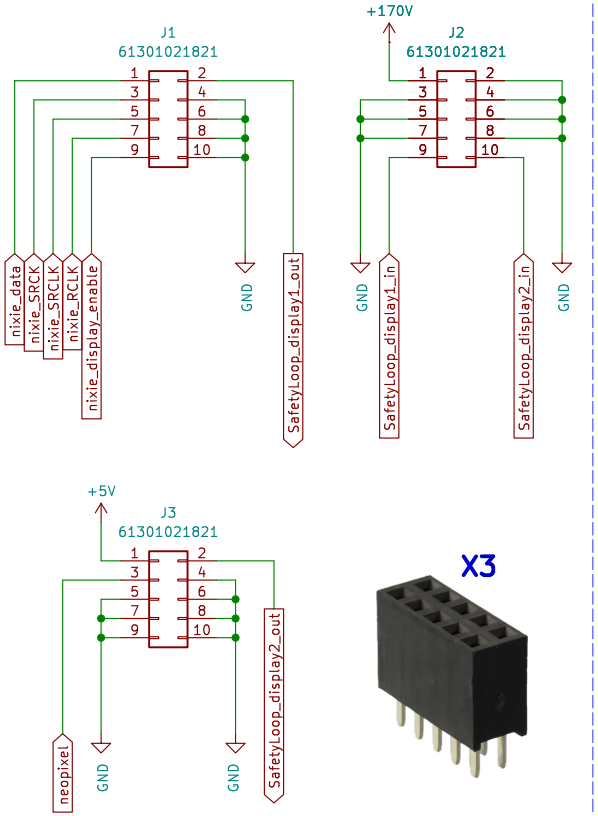
C26
C25
860010578017
PR30-12V-450-1A-E
MCU reading
hv psu voltage
HV_read
240kohm_0603
R73
R72
R55
R60
R74
22ohm_0603
R61
15kohm_0603
C30
0.1uF_0603
VR2
HV_Power Supply
IN+
IN-
OUT+
OUT-
stndoff
170V_Safety_In
sent to safety circuit



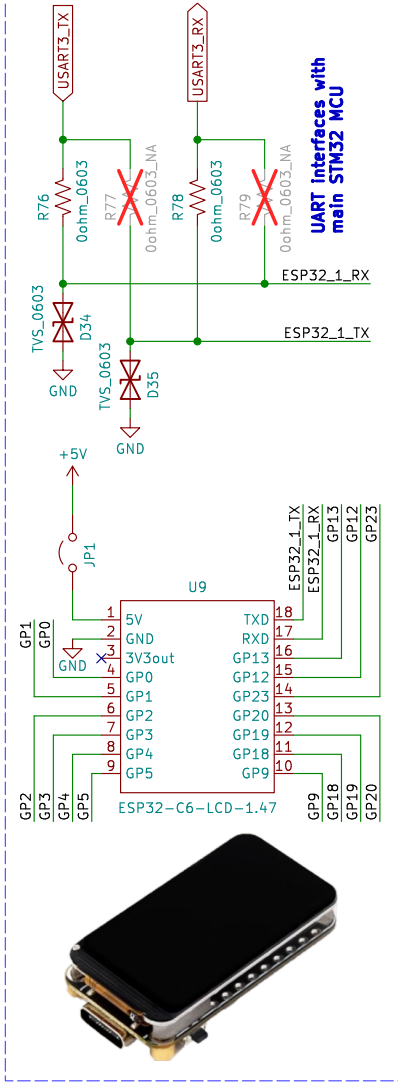
Kadin Whiting		
Sheet: /Power/		
File: Power.kicad_sch		
Title: Power		
Size: A4	Date: 2025-OCT-04	**Rev: 1**
KiCad E.D.A. 9.0.4		Id: 7/9

USB-C (2.0 Device Only)

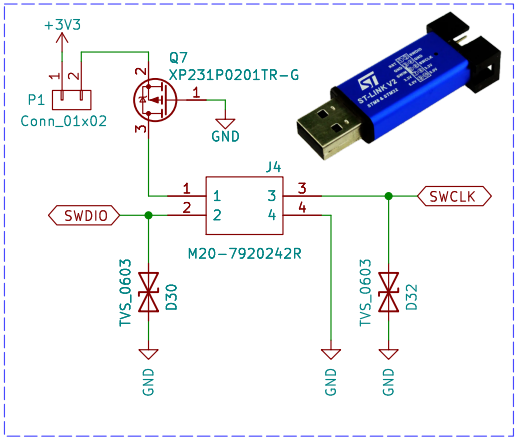
connections to driver board



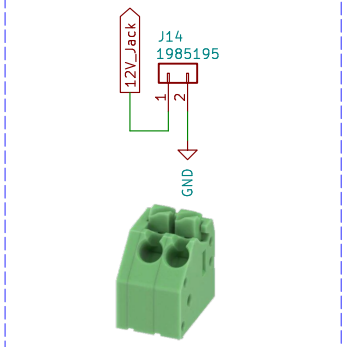
ESP32-C6 1.47" 172×320 LCD



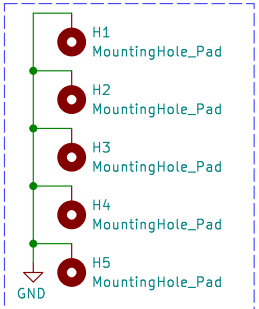
Programming Header



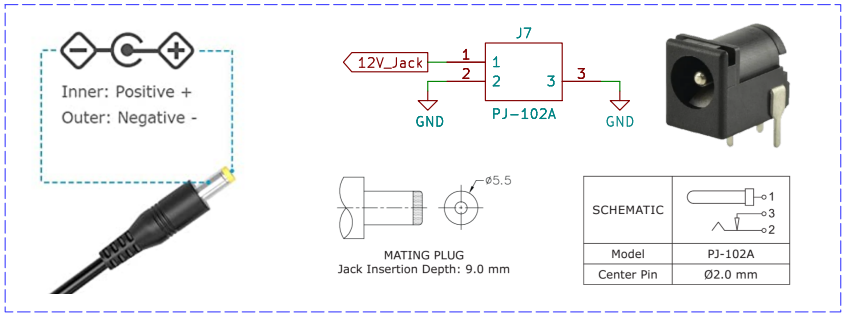
12VDC backup input



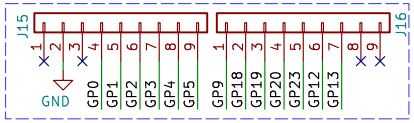
M3 mounting holes



12VDC power input



ESP32 Breakout Connections



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Sheet: /Connectors/
File: Connectors.kicad_sch

Title: Connectors

Size: A4	Date: 2025-OCT-04	**Rev: 1**
KiCad E.D.A. 9.0.4		Id: 8/9

external GPIO optional connections

connections to TTP223 capacitive button modules

NPN or GPIO

5V I2C breakout

free GPIO

+3V3_2

+5V

GND

J8 J9 J10 J11 J12 J6 J13 J17 J18

M20-7920242R

IO1 IO2 IO3 IO4 IO5 IO6 IO7 IO8 IO9

SDA_5V SCL_5V

X9 – Bottom side of PCB

Default x2 NPN outputs for LED filament strips
Resistor configuration possible for GPIO

Q3 Q11 2N7002

0ohm_0603_NA R70 R71

1kohm_0603 R68 R69

ESD protection to signals that leave the PCB placed near connectors

D36 D37 D38 D39 D40 D41 D42 TVS_0603

D43 D44 D45 D46 TVS_0603

power test points

TP1 TP2 TP3 TP4 TP5 TP6

+3V3 +5V +12V +170V +3V3_2

Kadin Whiting		
Sheet: /Connectors 2/		
File: Connectors 2.kicad_sch		
Title: Connectors		
Size: A4	Date: 2025-OCT-04	**Rev: 1**
KiCad E.D.A. 9.0.4		Id: 9/9