psMCU

'Why not?'

Philipp Schilk
2020–2021

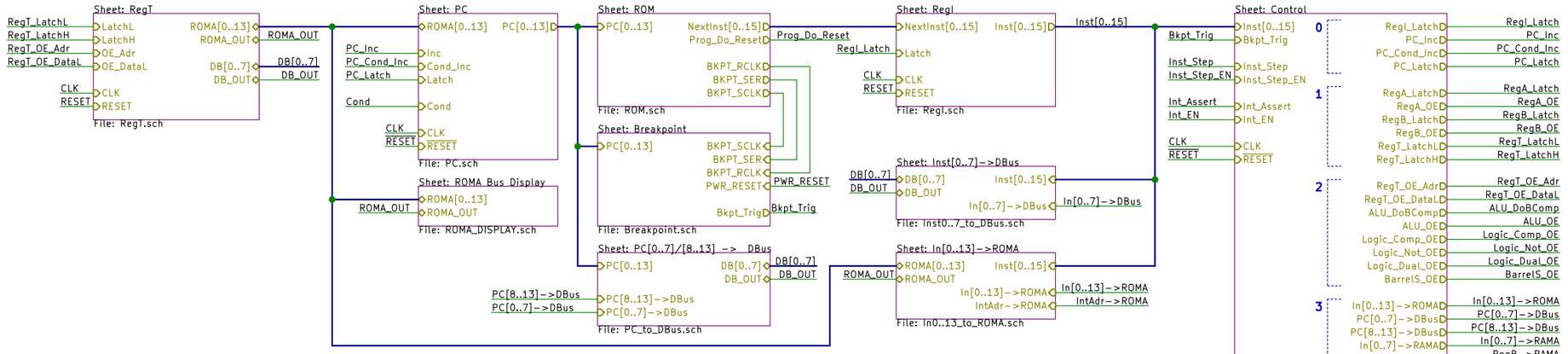
Specs:

- 8bit Processor
- 1MHz Clock
- 8kB Heap RAM,
- 32kB Stack RAM
- 16kB Program ROM
- Interrupts

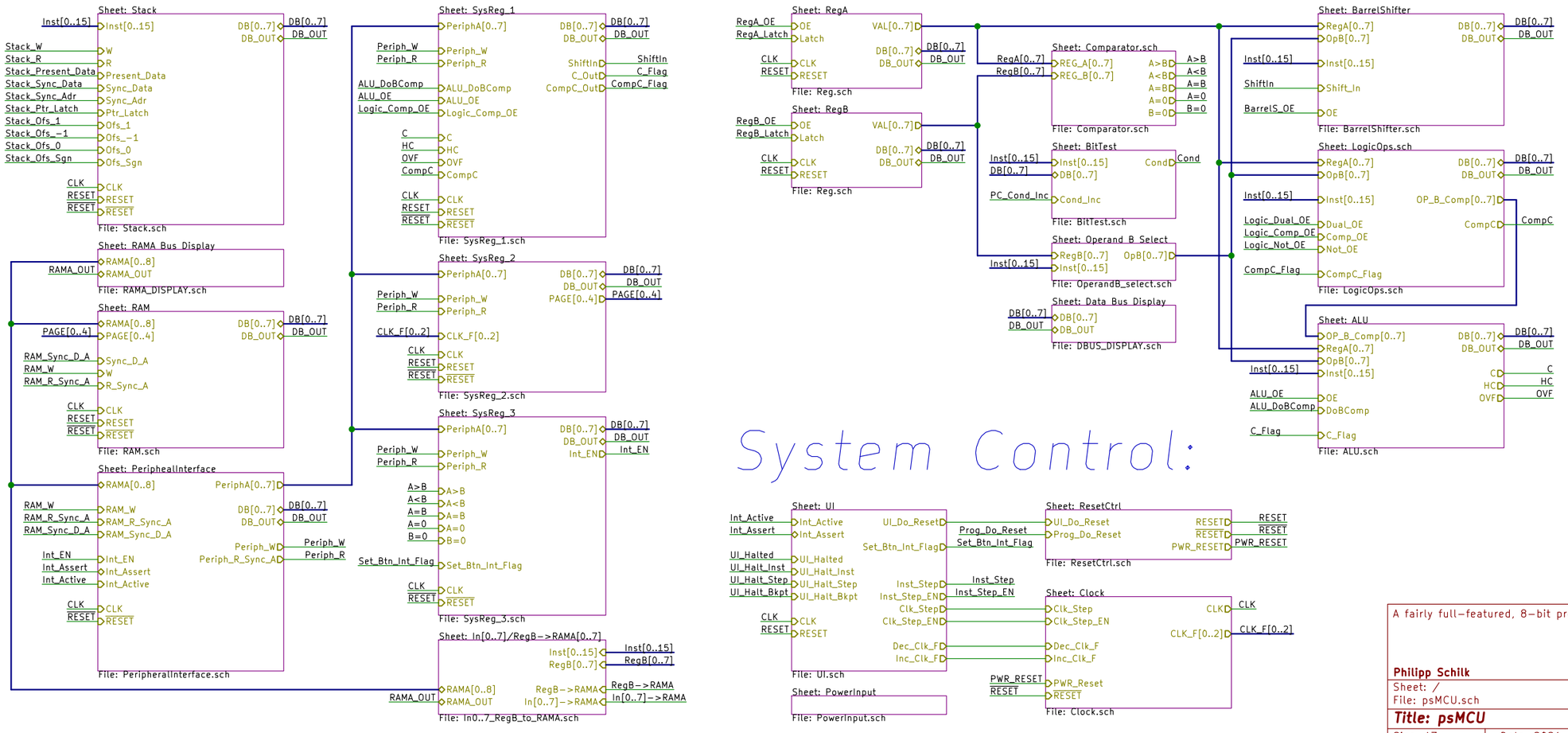
Features:

- 300+ LEDs
- Instruction Stepping
- Clock Stepping
- 1Hz–1MHz Clock
- External remote control
- External USB programmer
- Hardware Call/Return
- Peripheral Ports
- Hardware breakpoint

Central State Machine:



Memory & Peripherals: Data Manipulation:



System Control:

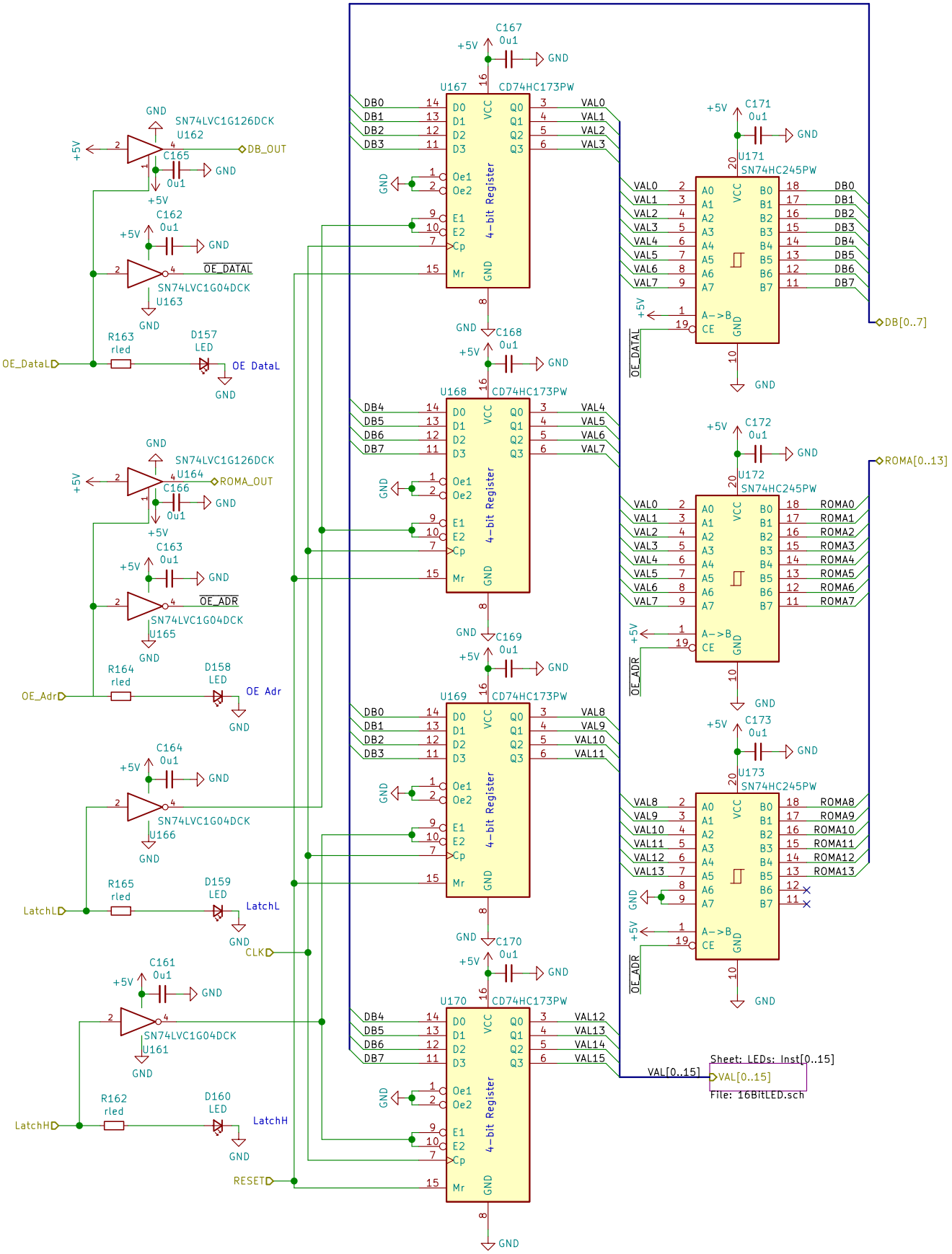
A fairly full–featured, 8–bit processor built entirely from 74–Series logic.

Philipp Schilk

Sheet: /
File: psMCU.sch

Title: psMCU

Size: A3	Date: 2021–05–31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)–1		Id: 1/97



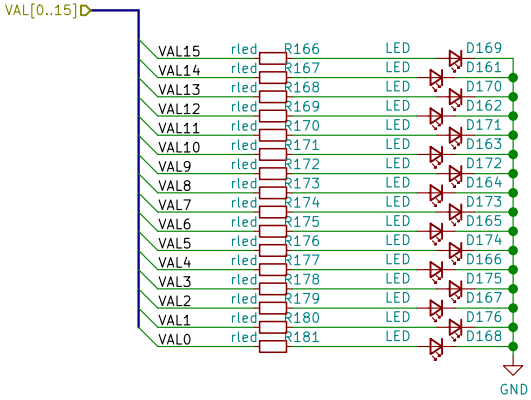
A 16 bit register used during return instructions, to swap register contents, and during a few other instructions. The DBus can be latched into the higher or lower 8 bits. The current content can be read to the ROMA bus, or the lower 8 bits can be read to the DBus.

Philipp Schilk

Sheet: /RegT/
File: RegT.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 2/97



A 16bit binary LED display.

Philipp Schilk

Sheet: /RegT/LEDs: Inst[0..15]/
File: 16BitLED.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 3/97

Interrupts

Sheet: Interrupts
File: Interrupts.sch

Decode

Sheet: Inst_Decode_ROM
File: Inst_Decode_ROM.sch

Sheet: InstDisplay.sch
File: InstDisplay.sch

Sheet: LEDs: InstCode
File: 8BitLED.sch

Sub-Instruction Step Counter

U217 SN74HC161PW

C221 0u1

C220 0u1

U216 SN74LVC1G04DCK

Step Logic

Sheet: STEP_LOGIC
File: STEP_LOGIC.sch

Sheet: Control_Rom0
Sheet: Control_Rom1
Sheet: Control_Rom2
Sheet: Control_Rom3
Sheet: Control_Rom4
Sheet: Control_Rom5
File: Control_Rom.sch
File: Control_Rom5.sch

Sheet: Reg_A_B_Switch
File: Reg_A_B_Switch.sch

R215 rled — D211 LED — Next Inst
R216 rled — D212 LED — Halt

C218 0u1

U214 CD74HC238PW

Sheet: InstStep
File: 8BitLED.sch

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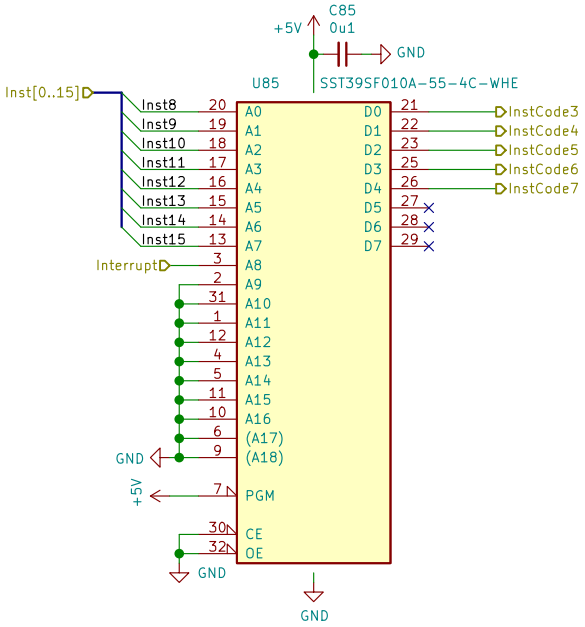
The central state-machine that handles execution. Instructions are decoded, and the individual sub-instruction steps are read from the Microcode ROMs. Also handles interrupts and instruction stepping logic.

Sheet: /Control/
File: Control.sch

Title: psMCU

Size: A3	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 4/97



Decodes the MSBs of an instruction into the actual instruction code for microcode lookup.

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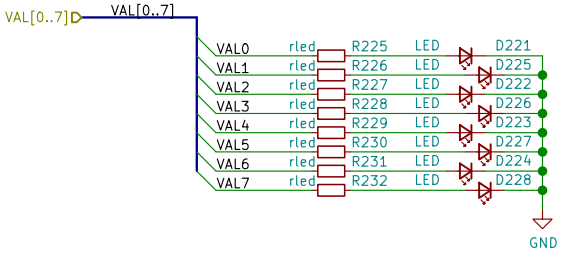
Sheet: /Control/Inst_Decode_ROM/
File: Inst_Decode_ROM.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 5/97



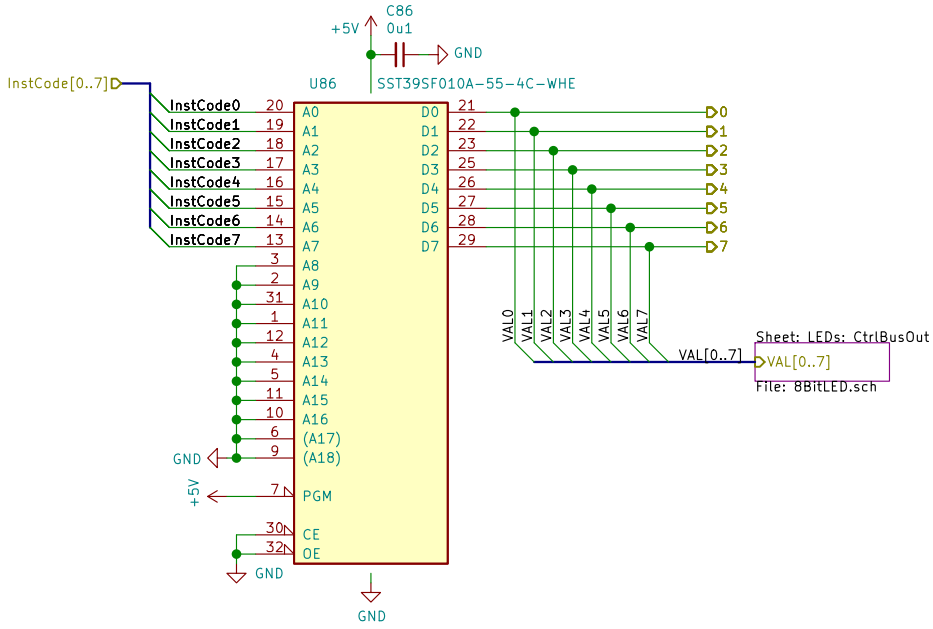
8bit binary LED display.

Philipp Schilk

Sheet: /Control/LEDs: InstCode/
File: 8BitLED.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 6/97



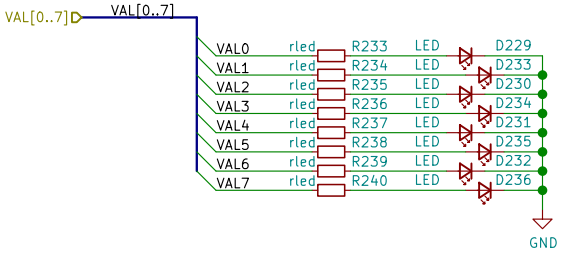
Microcode ROM, stores control signals needed for each sub-step of each instruction.

Philipp Schilk

Sheet: /Control/Control_Rom0/
File: Control_Rom.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 7/97



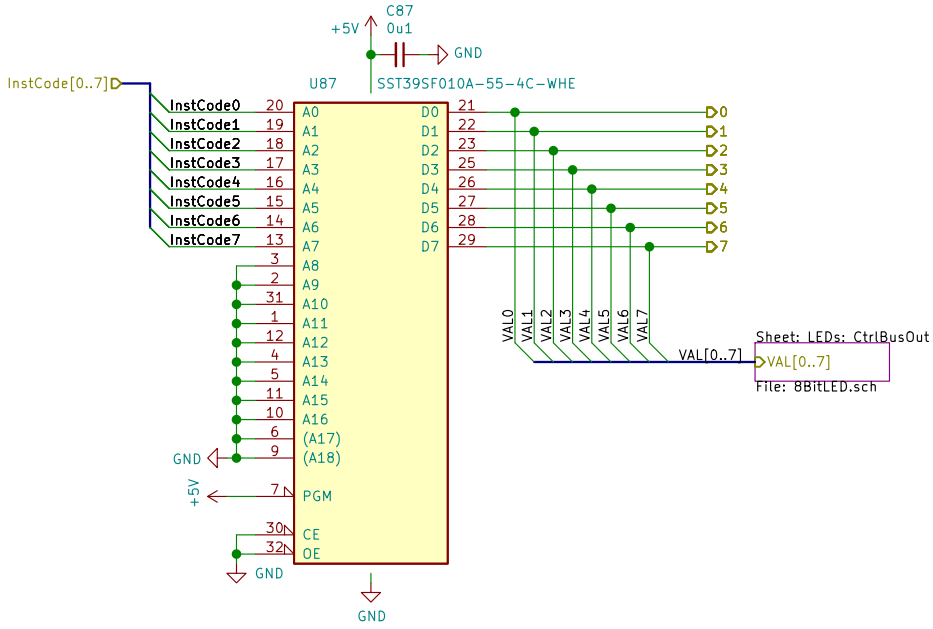
8bit binary LED display.

Philipp Schilk

Sheet: /Control/Control_Rom0/LEDs: CtrlBusOut/
File: 8BitLED.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 8/97



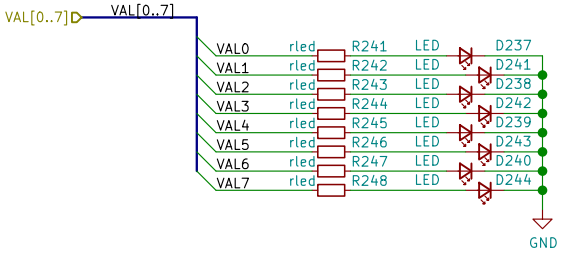
Microcode ROM, stores control signals needed for each sub-step of each instruction.

Philipp Schilk

Sheet: /Control/Control_Rom1/
File: Control_Rom.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 9/97



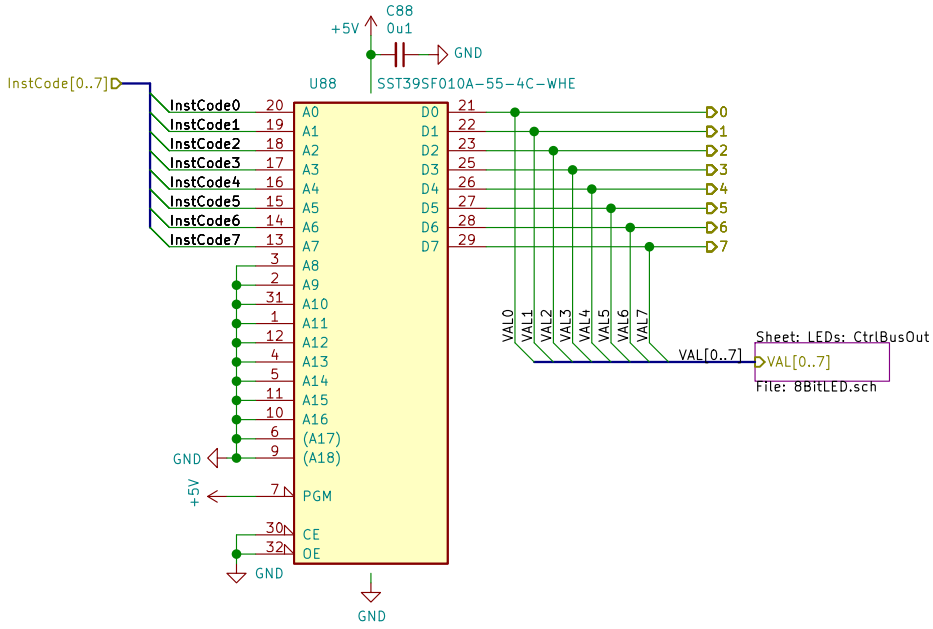
8bit binary LED display.

Philipp Schilk

Sheet: /Control/Control_Rom1/LEDs: CtrlBusOut/
File: 8BitLED.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 10/97



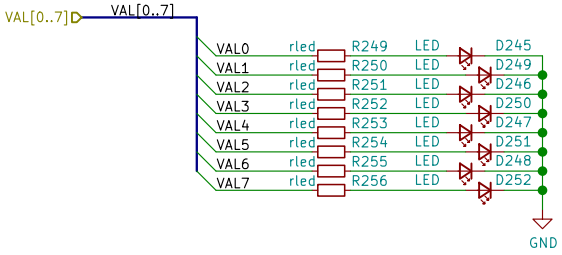
Microcode ROM, stores control signals needed for each sub-step of each instruction.

Philipp Schilk

Sheet: /Control/Control_Rom3/
File: Control_Rom.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 11/97



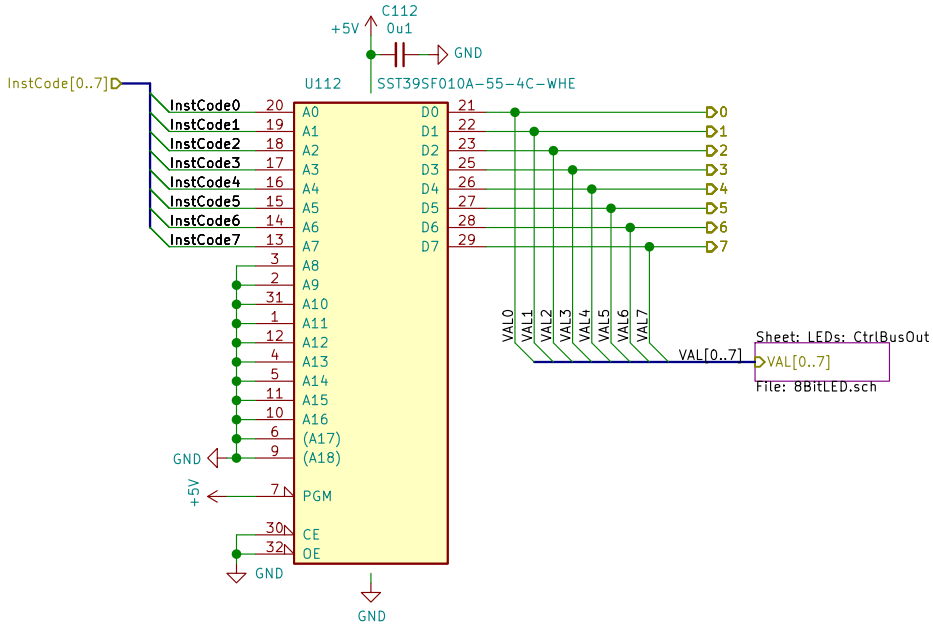
8bit binary LED display.

Philipp Schilk

Sheet: /Control/Control_Rom3/LEDs: CtrlBusOut/
File: 8BitLED.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 12/97



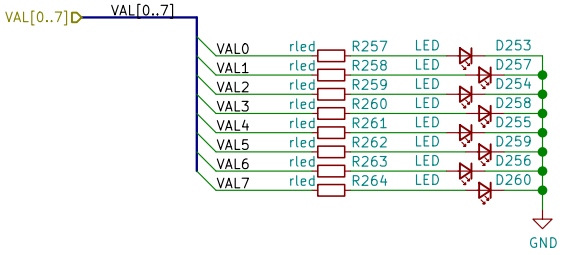
Microcode ROM, stores control signals needed for each sub-step of each instruction.

Philipp Schilk

Sheet: /Control/Control_Rom4/
File: Control_Rom.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 13/97



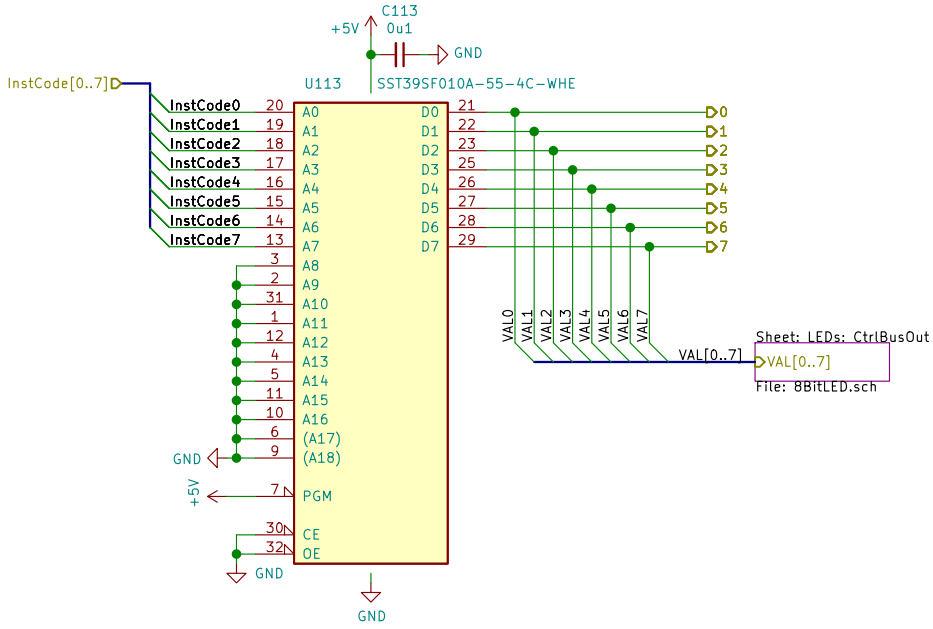
8bit binary LED display.

Philipp Schilk

Sheet: /Control/Control_Rom4/LEDs: CtrlBusOut/
File: 8BitLED.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 14/97



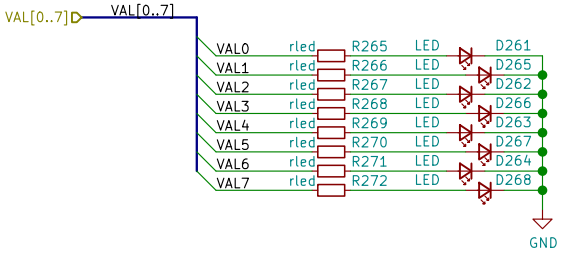
Microcode ROM, stores control signals needed for each sub-step of each instruction.

Philipp Schilk

Sheet: /Control/Control_Rom2/
File: Control_Rom.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 15/97



8bit binary LED display.

Philipp Schilk

Sheet: /Control/Control_Rom2/LEDs: CtrlBusOut/
File: 8BitLED.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 16/97

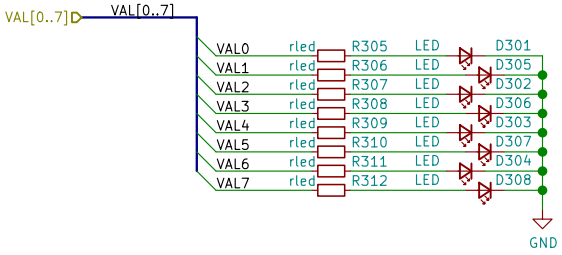
Displays which instruction is currently being executed.

Philipp Schilk

Sheet: /Control/InstDisplay.sch/
File: InstDisplay.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 17/97



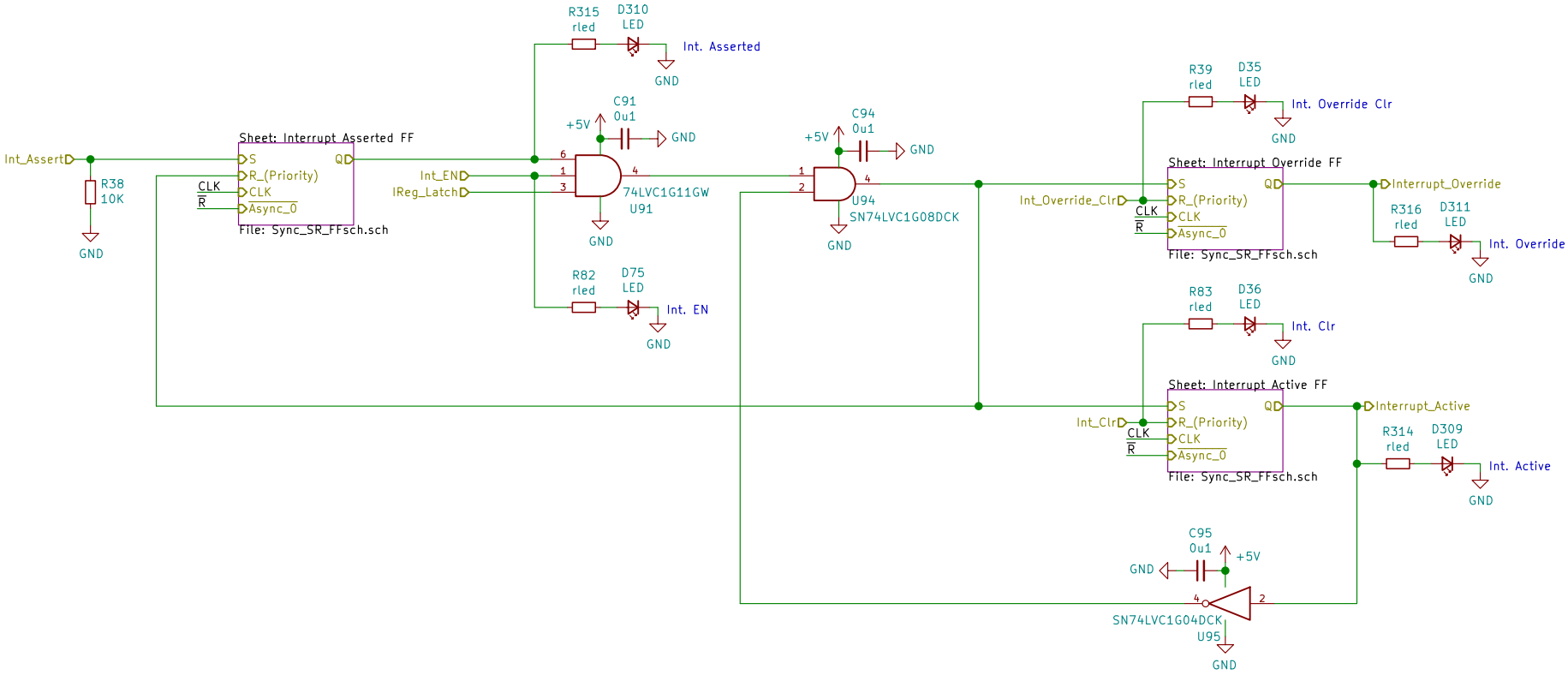
8bit binary LED display.

Philipp Schilk

Sheet: /Control/InstStep/
File: 8BitLED.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 18/97



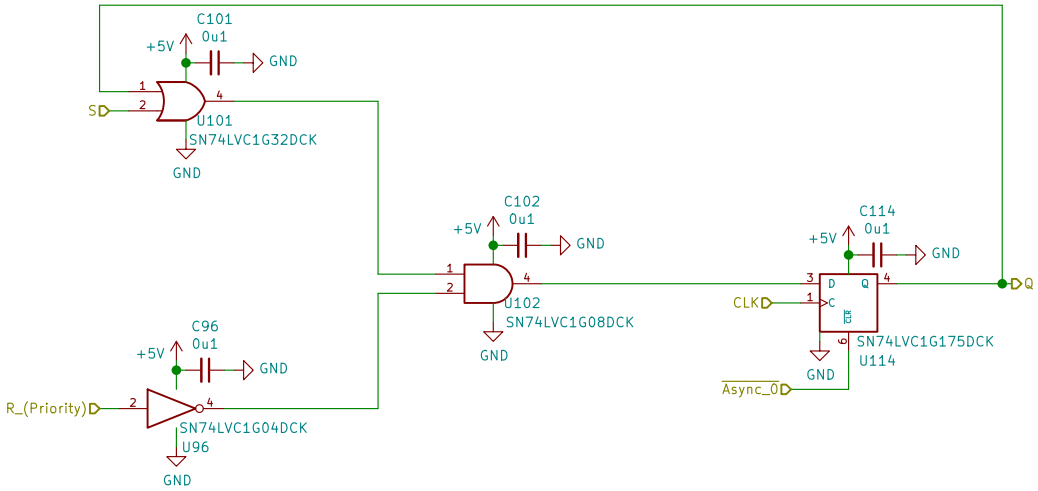
Interrupt logic. Keeps track if an interrupt is currently being served, and forces the state-machine to branch to the interrupt handler if one occurs.

Philipp Schilk

Sheet: /Control/Interrupts/
File: Interrupts.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 19/97



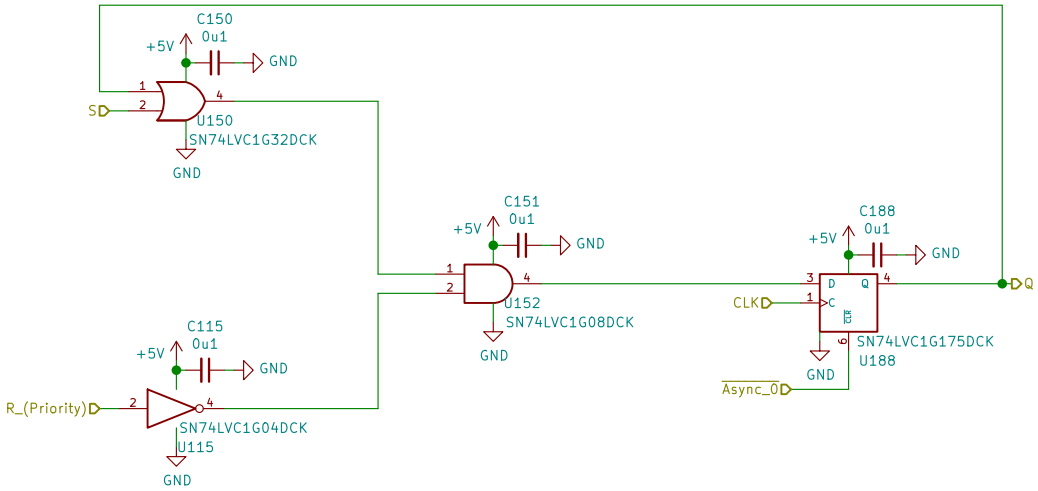
A synchronous RS Flip Flop with async. clear. The reset line has priority: If both R & S are asserted on a rising clock edge, the Flip Flop will be cleared.

Philipp Schilk

Sheet: /Control/Interrupts/Interrupt Asserted FF/
File: Sync_SR_FFsch.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 20/97



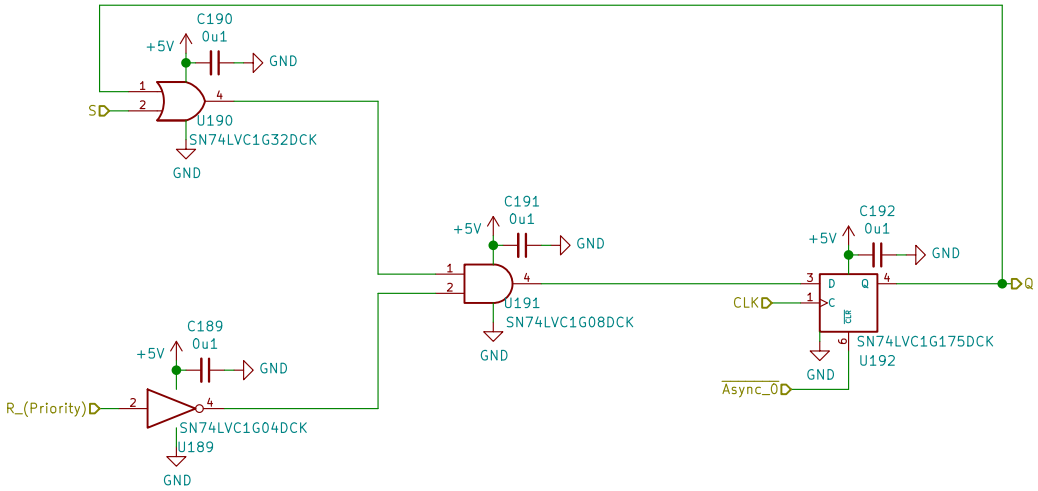
A synchronous RS Flip Flop with async. clear. The reset line has priority: If both R & S are asserted on a rising clock edge, the Flip Flop will be cleared.

Philipp Schilk

Sheet: /Control/Interrupts/Interrupt Override FF/
File: Sync_SR_FFsch.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 21/97



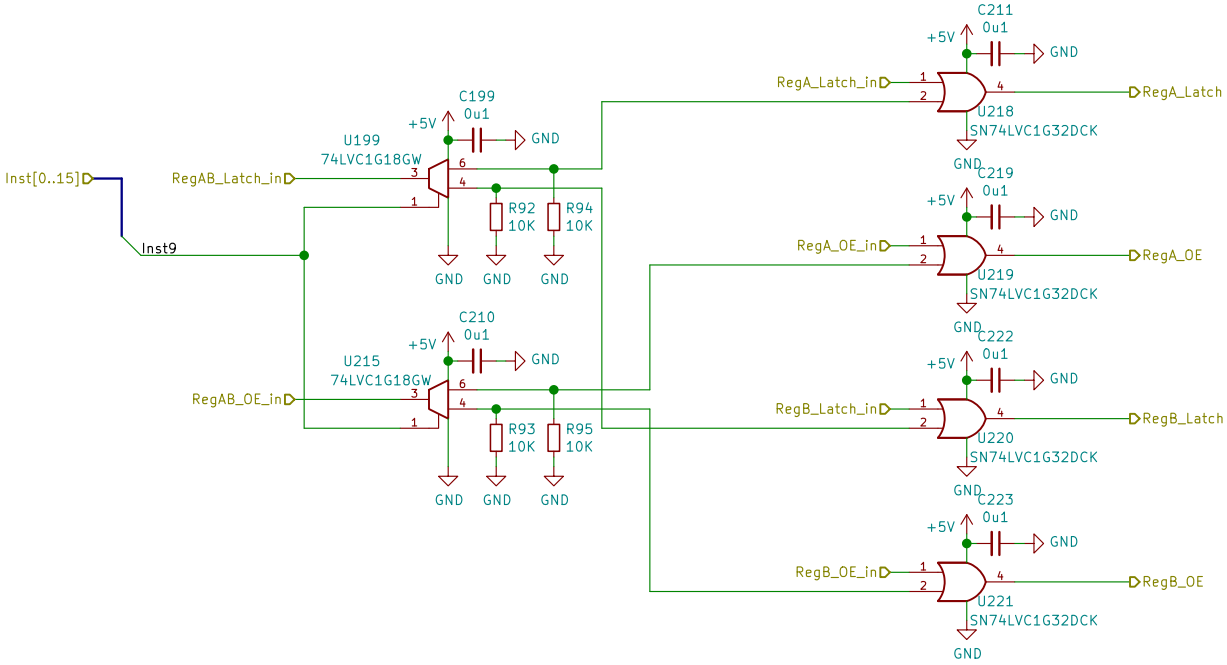
A synchronous RS Flip Flop with async. clear. The reset line has priority: If both R & S are asserted on a rising clock edge, the Flip Flop will be cleared.

Philipp Schilk

Sheet: /Control/Interrupts/Interrupt Active FF/
File: Sync_SR_FFsch.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 22/97



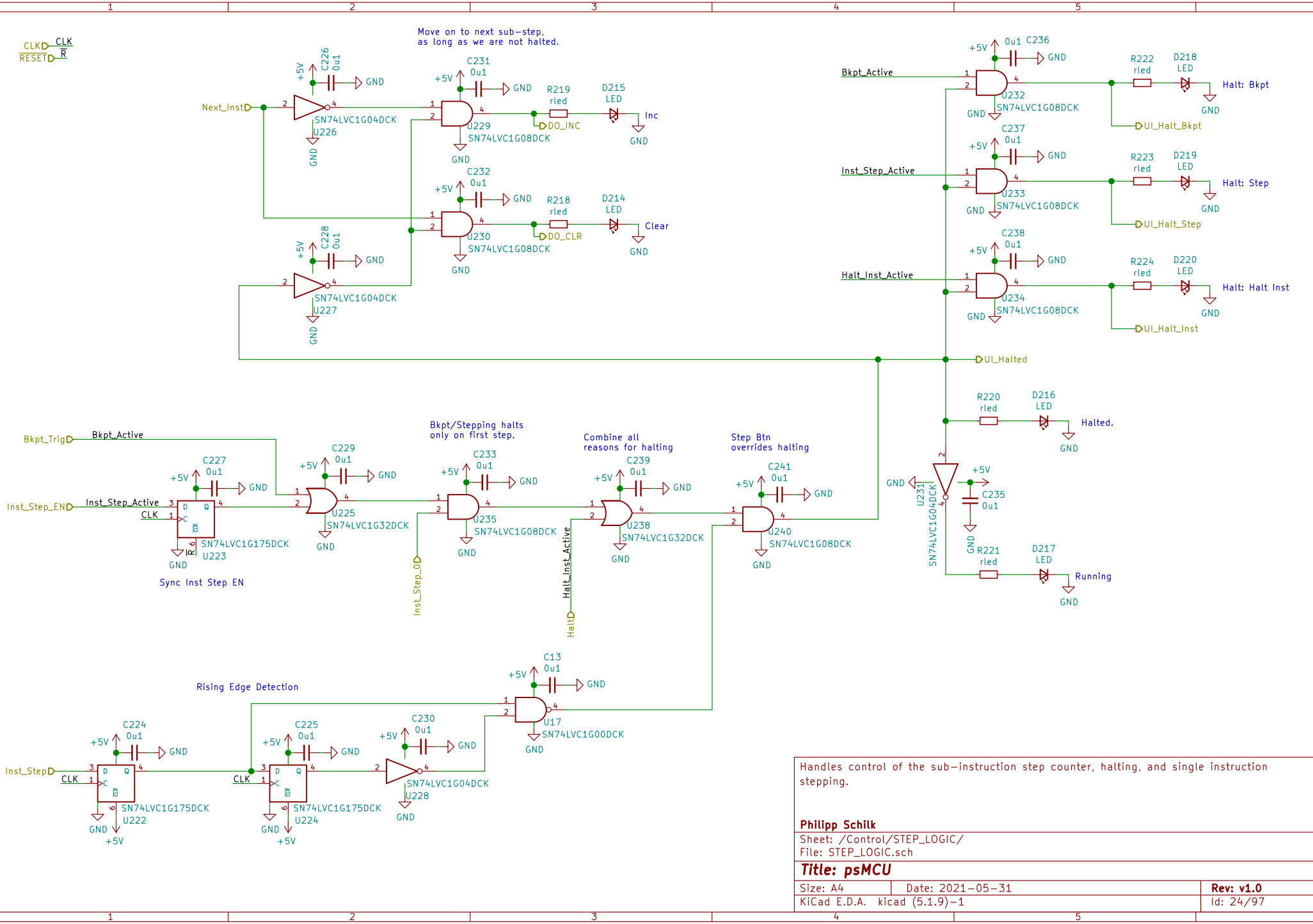
Reroutes Latch/OE signals depending on which register instruciton selects.

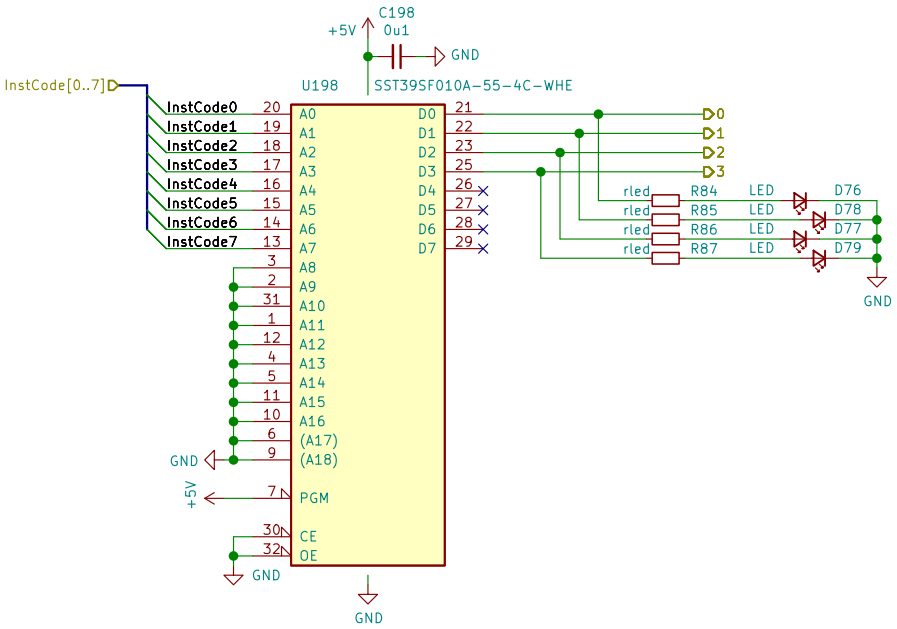
Philipp Schilk

Sheet: /Control/Reg_A_B_Switch/
File: Reg_A_B_Switch.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 23/97


CLK
RESET
Move on to next sub-step,
as long as we are not halted.
Next_Inst
SN74LVC1G04DCK
U226
SN74LVC1G08DCK
U229
DO_INC
Inc
U230
DO_CLR
Clear
U227
Bkpt_Active
Inst_Step_Active
Halt_Inst_Active
U232
U233
U234
Halt: Bkpt
Halt: Step
Halt: Halt Inst
UI_Halt_Bkpt
UI_Halt_Step
UI_Halt_Inst
UI_Halted
Halted.
Running
U231
Bkpt_Trig
Inst_Step_EN
SN74LVC1G175DCK
U223
Sync Inst Step EN
SN74LVC1G32DCK
U225
Bkpt/Stepping halts
only on first step.
U235
Inst_Step_0
Combine all
reasons for halting
U238
Halt
Step Btn
overrides halting
U240
Rising Edge Detection
U17
SN74LVC1G00DCK
U222
U224
U228
Handles control of the sub-instruction step counter, halting, and single instruction stepping.
Philipp Schilk
Sheet: /Control/STEP_LOGIC/
File: STEP_LOGIC.sch
Title: psMCU
Size: A4
Date: 2021-05-31
Rev: v1.0
KiCad E.D.A. kicad (5.1.9)-1
Id: 24/97



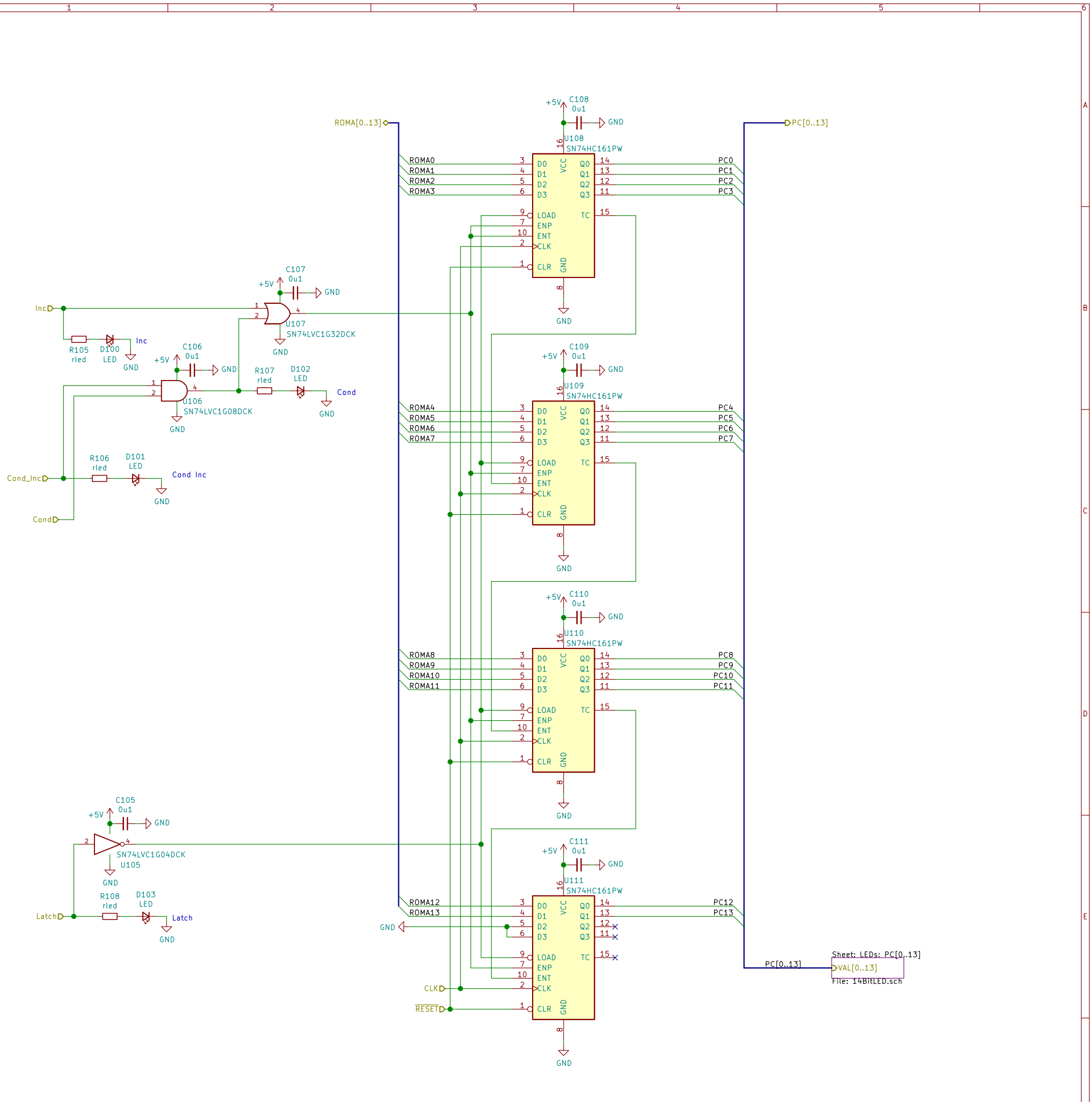
Microcode ROM, stores control signals needed for each sub-step of each instruction.

Philipp Schilk

Sheet: /Control/Control_Rom5/
File: Control_Rom5.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 25/97



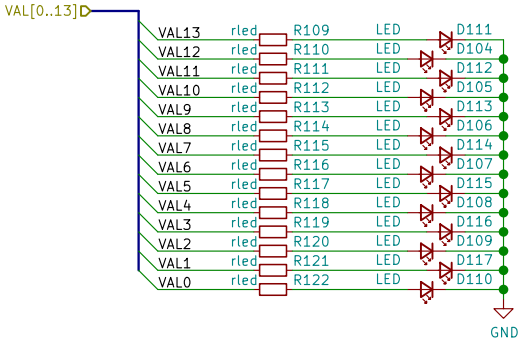
Program Counter. Increment moves to next instruction. Parallel latch enables jumps. Conditional Increment is an increment that is only performed if the bit-test module allows, enabeling conditional bit-test instructions.

Philipp Schilk

Sheet: /PC/
File: PC.sch

Title: psMCU

Size: A3	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 26/97



14bit binary LED display.

Philipp Schilk

Sheet: /PC/LEDs: PC[0..13]/
File: 14BitLED.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 27/97

Disconnect Program Counter
while programming.

Memory

Switch between the 8
program slots.

Slot Select
SW11

Serial Address Interface

Serial Data
Interface (Reading)

Serial Data
Interface (Writing)

Grounding pins 6 and 9
should allow the SST39SF010
to be substituted with a higher
memory version (020,040) in
a pinch.

Programmer Connector

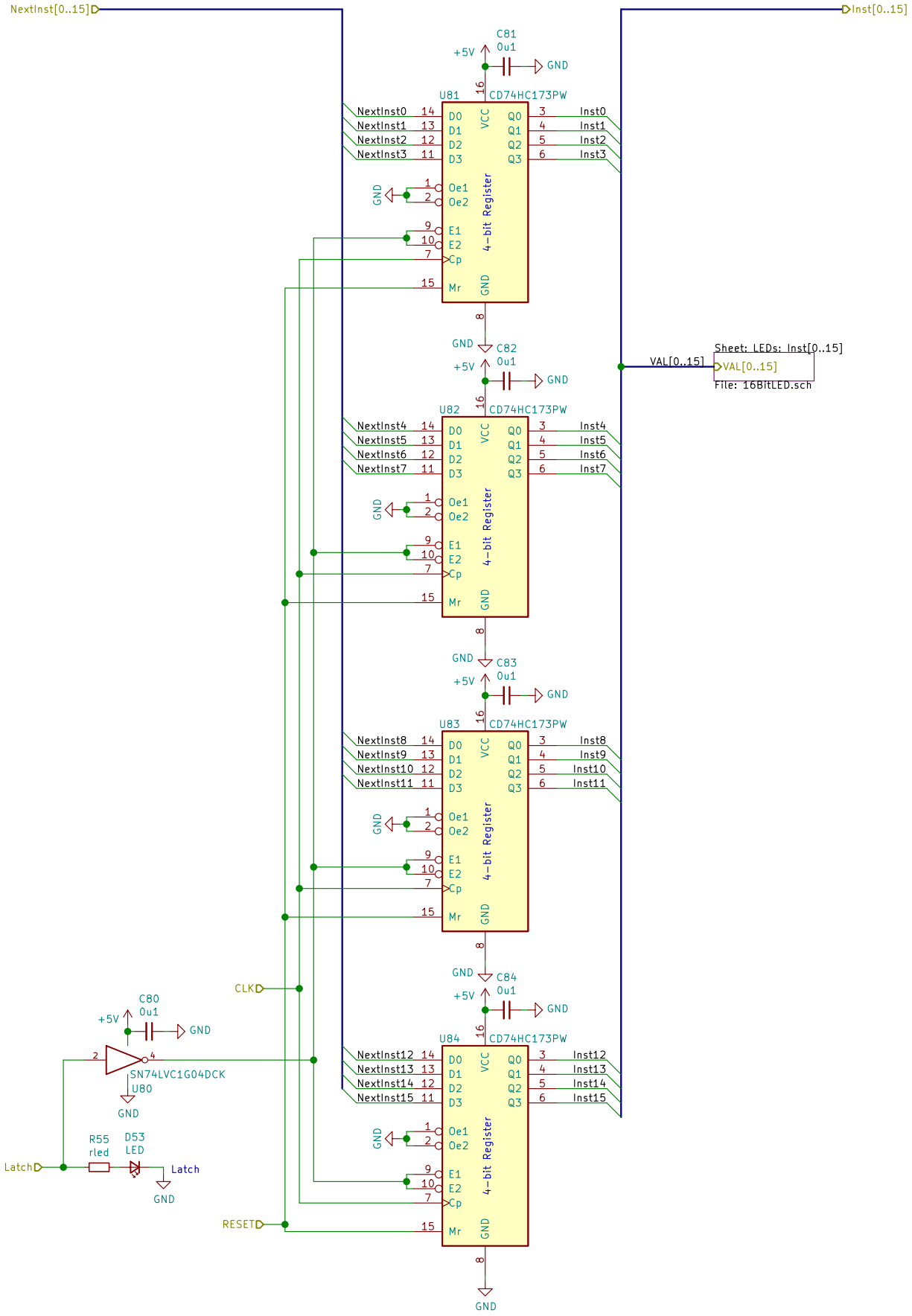
ROM that stores the 16-bit instructions and programming interface. During normal operation the current instruction is read out based on the program counter. The external programmer can reroute the IO of the ROM ICs to allow programming and reading. To reduce pin count, programming is done serially with shift registers.

Philipp Schilk

Sheet: /ROM/
File: ROM.sch

Title: psMCU

Size: A3	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 28/97



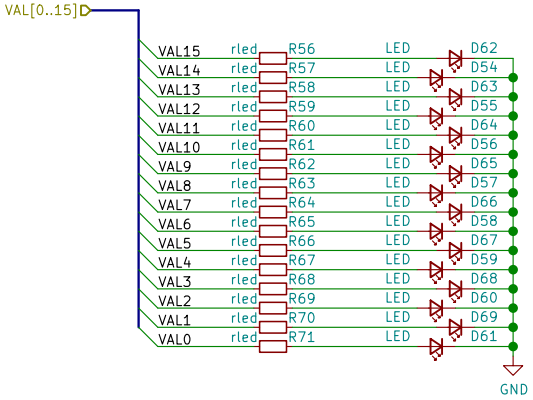
16Bit register that stores the instruction currently being executed.

Philipp Schilk

Sheet: /Regl/
File: Regl.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 29/97



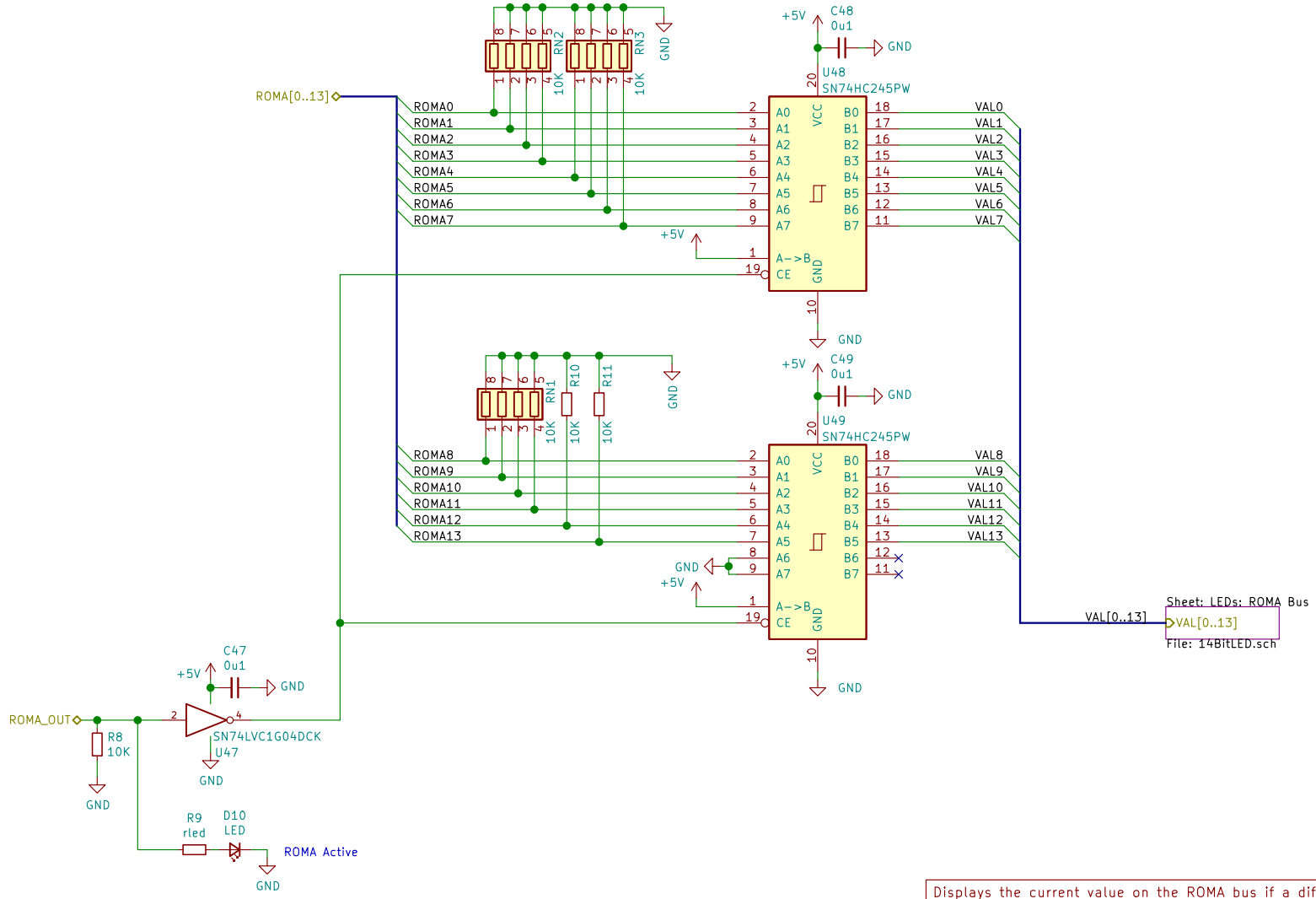
A 16bit binary LED display.

Philipp Schilk

Sheet: /Regl/LEDs: Inst[0..15]/
File: 16BitLED.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 30/97



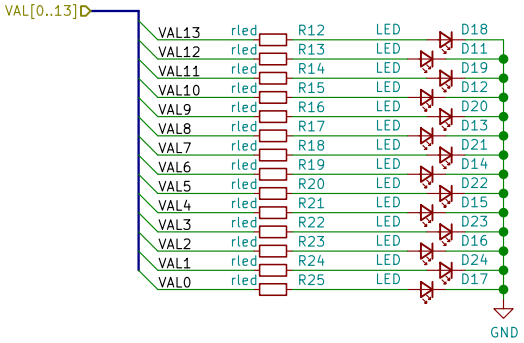
Displays the current value on the ROMA bus if a different module is providing one (indicated by the ROMA_OUT signal)

Philipp Schilk

Sheet: /ROMA Bus Display/
File: ROMA_DISPLAY.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 31/97



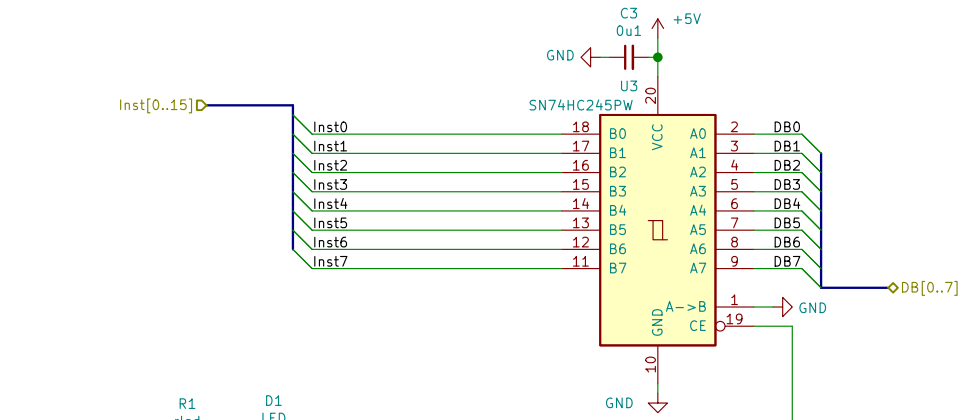
14bit binary LED display.

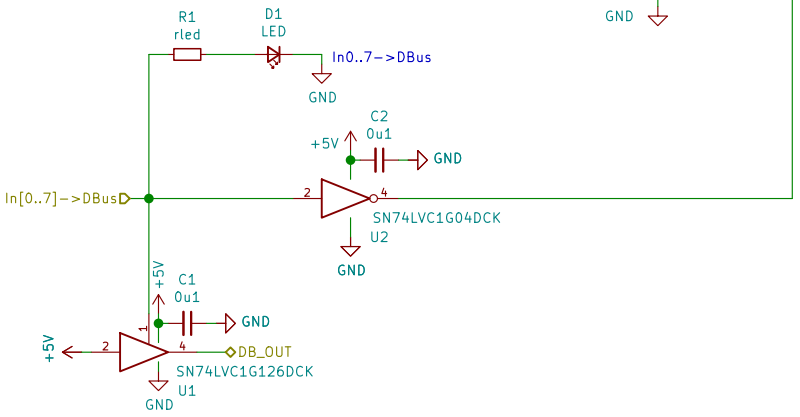
Philipp Schilk

Sheet: /ROMA Bus Display/LEDs: ROMA Bus/
File: 14BitLED.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 32/97





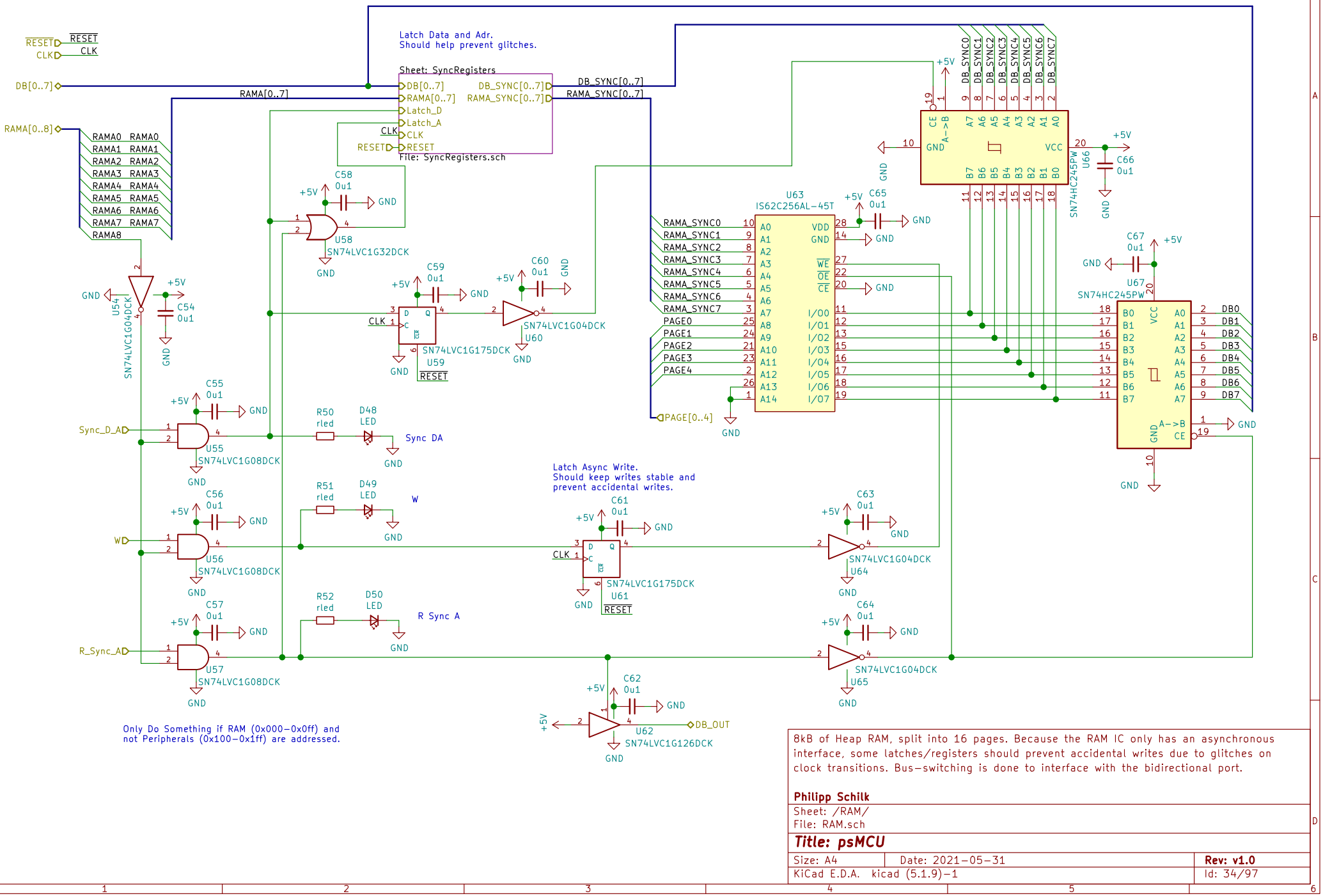
Puts the lowest byte of the current instruction onto the DBus. Used to load literals into registers.

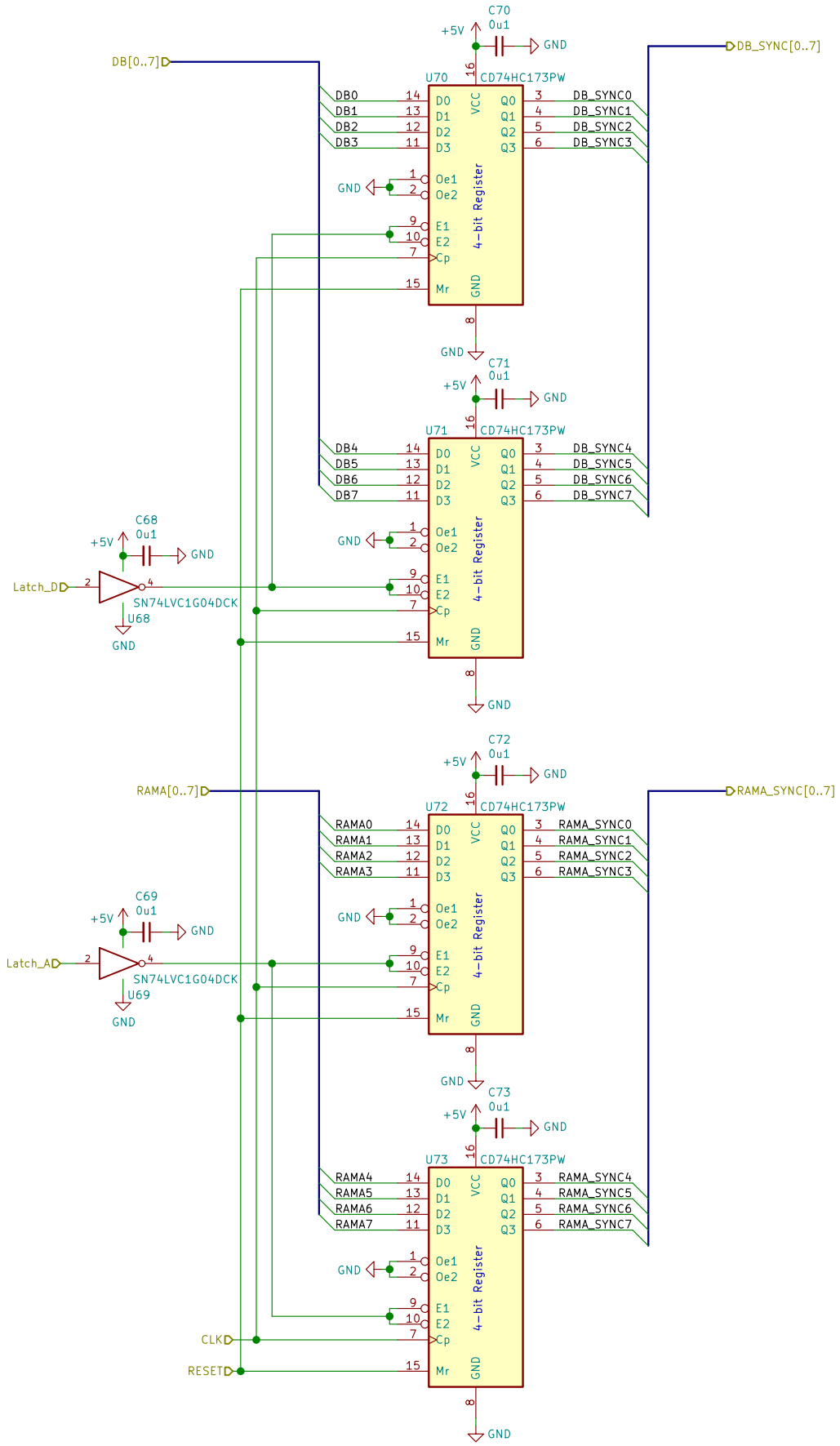
Philipp Schilk

Sheet: /Inst[0..7]->DBus/
File: Inst0..7_to_DBus.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 33/97


Latch Data and Adr.
Should help prevent glitches.
Sheet: SyncRegisters
DB[0..7]
RAMA[0..7]
Latch_D
Latch_A
CLK
RESET
File: SyncRegisters.sch
DB_SYNC[0..7]
RAMA_SYNC[0..7]
RAMA[0..8]
U58
SN74LVC1G32DCK
U54
SN74LVC1G04DCK
U59
SN74LVC1G175DCK
U60
SN74LVC1G04DCK
U63
IS62C256AL-45T
U66
SN74HC245PW
U67
SN74HC245PW
PAGE[0..4]
Sync_D_A
Sync DA
U55
SN74LVC1G08DCK
W
U56
SN74LVC1G08DCK
R_Sync_A
R Sync A
U57
SN74LVC1G08DCK
Latch Async Write.
Should keep writes stable and
prevent accidental writes.
U61
SN74LVC1G175DCK
U64
SN74LVC1G04DCK
U65
SN74LVC1G04DCK
U62
SN74LVC1G126DCK
DB_OUT
Only Do Something if RAM (0x000-0x0ff) and
not Peripherals (0x100-0x1ff) are addressed.
8kB of Heap RAM, split into 16 pages. Because the RAM IC only has an asynchronous interface, some latches/registers should prevent accidental writes due to glitches on clock transitions. Bus-switching is done to interface with the bidirectional port.
Philipp Schilk
Sheet: /RAM/
File: RAM.sch
Title: psMCU
Size: A4
Date: 2021-05-31
Rev: v1.0
KiCad E.D.A. kicad (5.1.9)-1
Id: 34/97



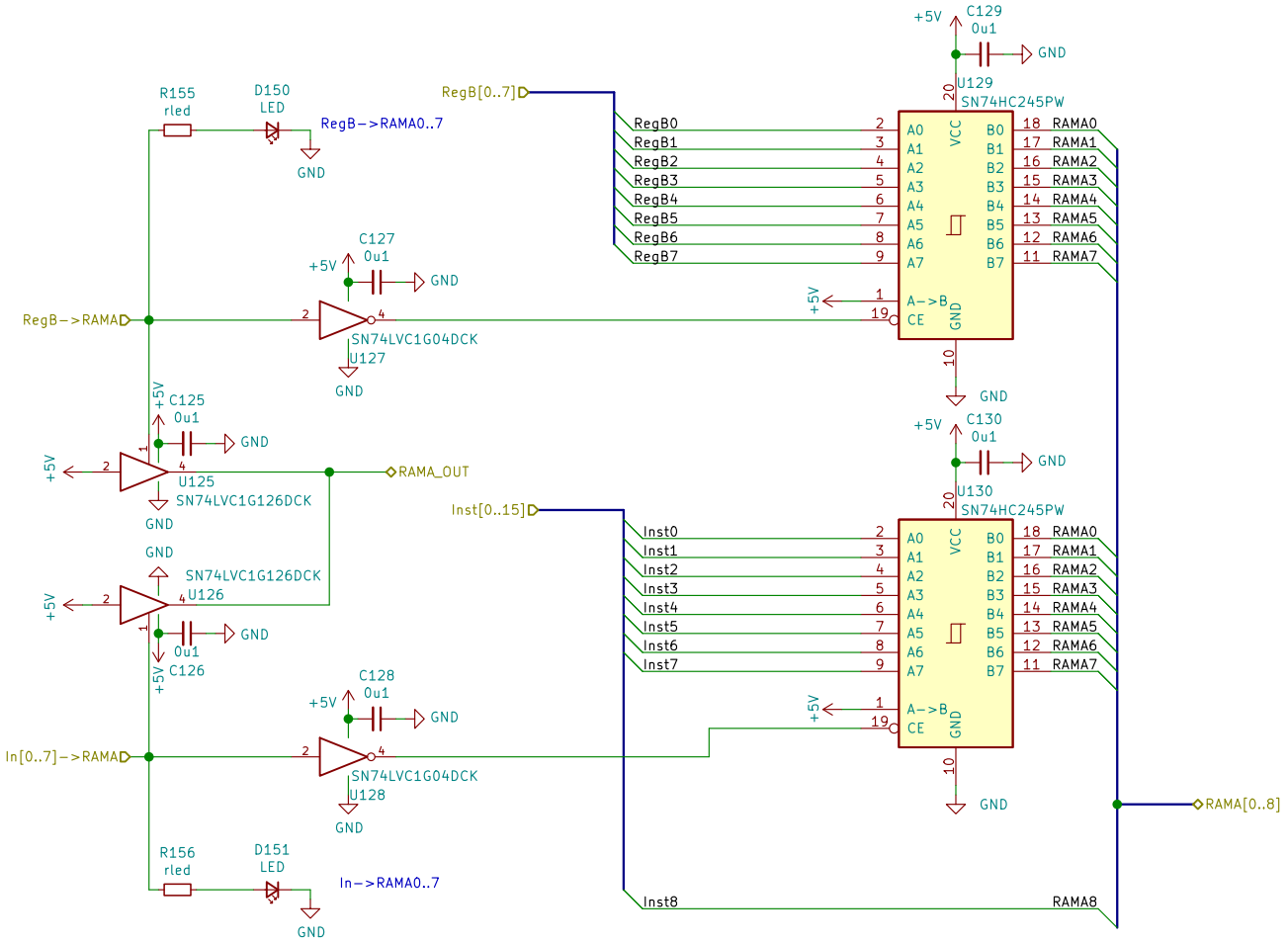
Registers to latch data/adr for RAM access.

Philipp Schilk

Sheet: /RAM/SyncRegisters/
File: SyncRegisters.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 35/97



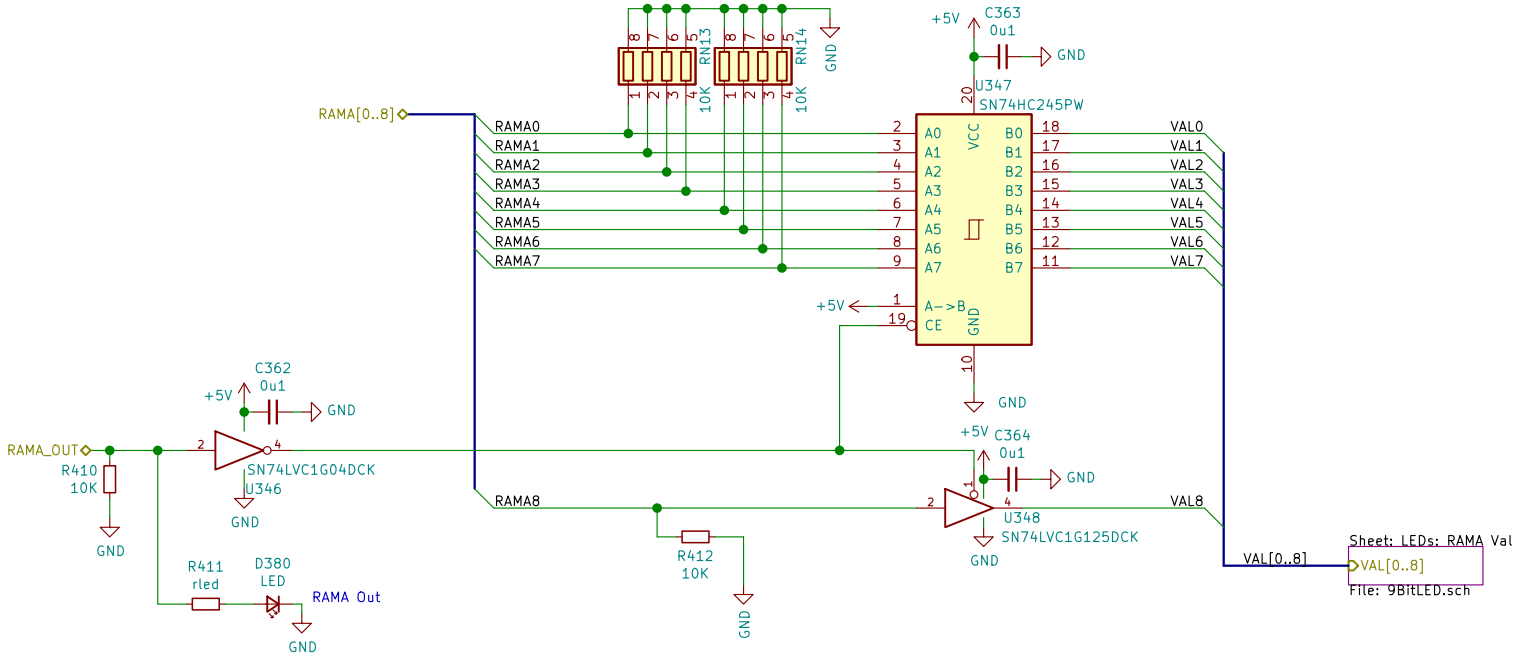
Puts either RegB or the lowest byte of the current instruction on the RAMA bus.
Used to access fixed/dynamic RAM addresses.

Philipp Schilk

Sheet: /In[0..7]/RegB->RAMA[0..7]/
File: In0..7_RegB_to_RAMA.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 36/97



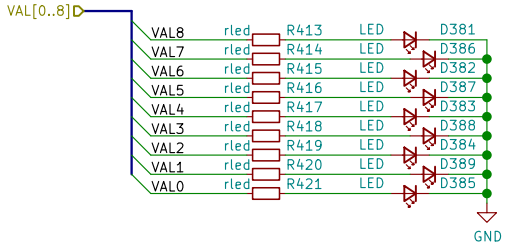
Displays the current value on the RAMA bus if a different module is providing one (indicated by the RAMA_OUT signal)

Philipp Schilk

Sheet: /RAMA Bus Display/
File: RAMA_DISPLAY.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 37/97



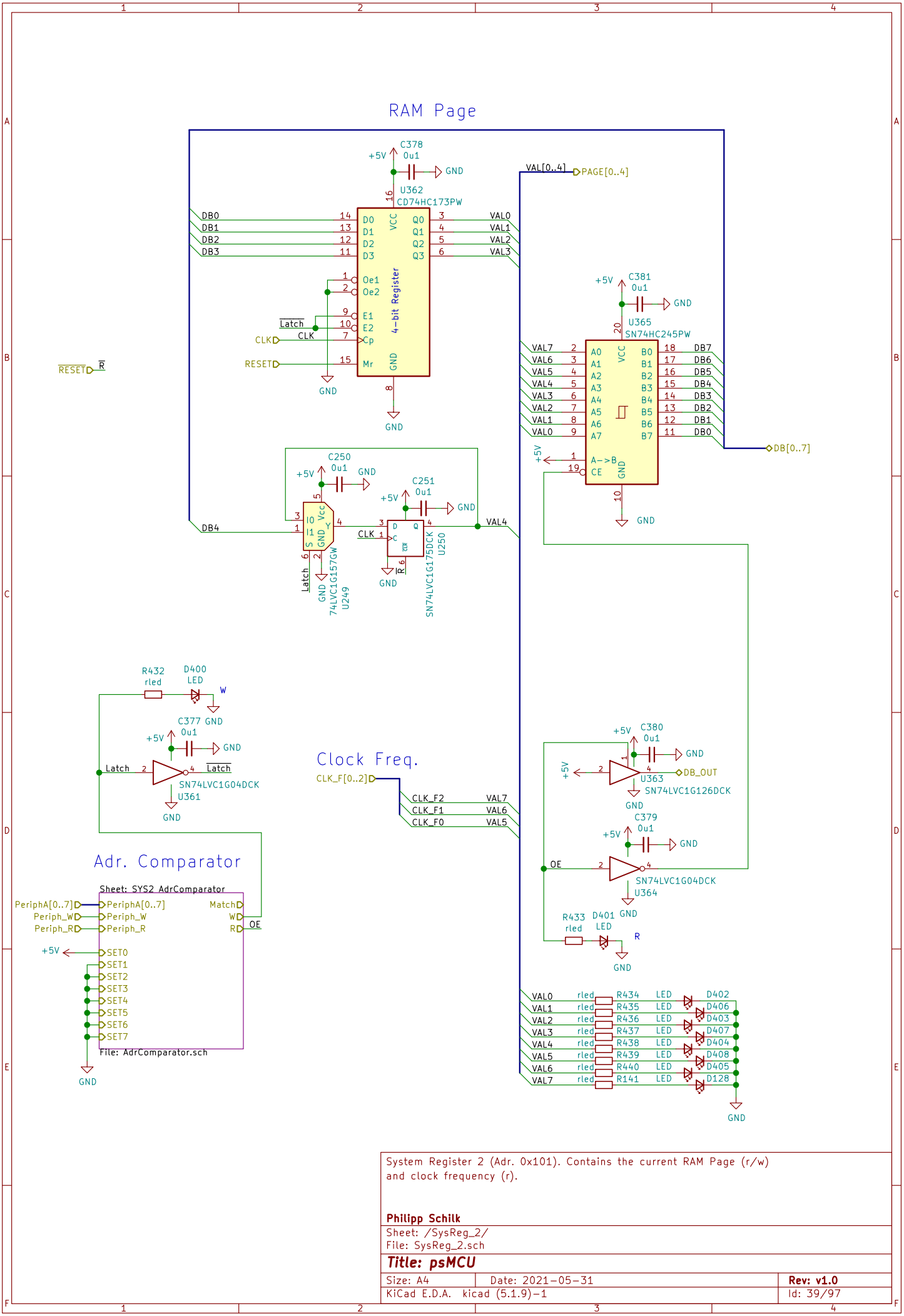
9bit binary LED display.

Philipp Schilk

Sheet: /RAMA Bus Display/LEDs: RAMA Val/
File: 9BitLED.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 38/97



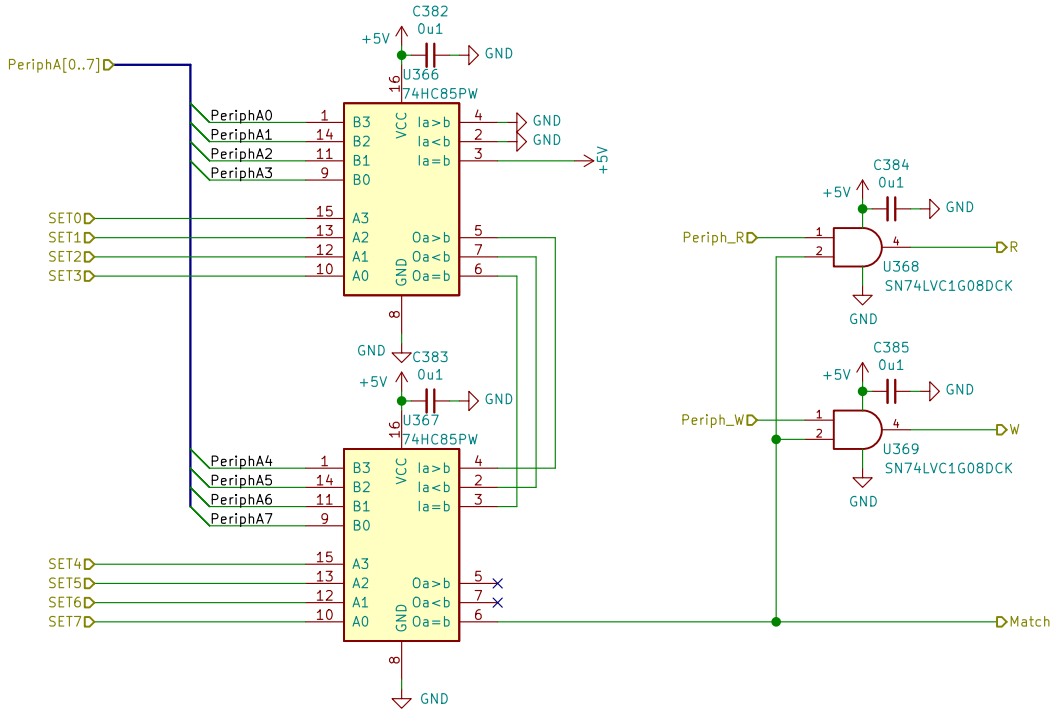
System Register 2 (Adr. 0x101). Contains the current RAM Page (r/w) and clock frequency (r).

Philipp Schilk

Sheet: /SysReg_2/
File: SysReg_2.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 39/97



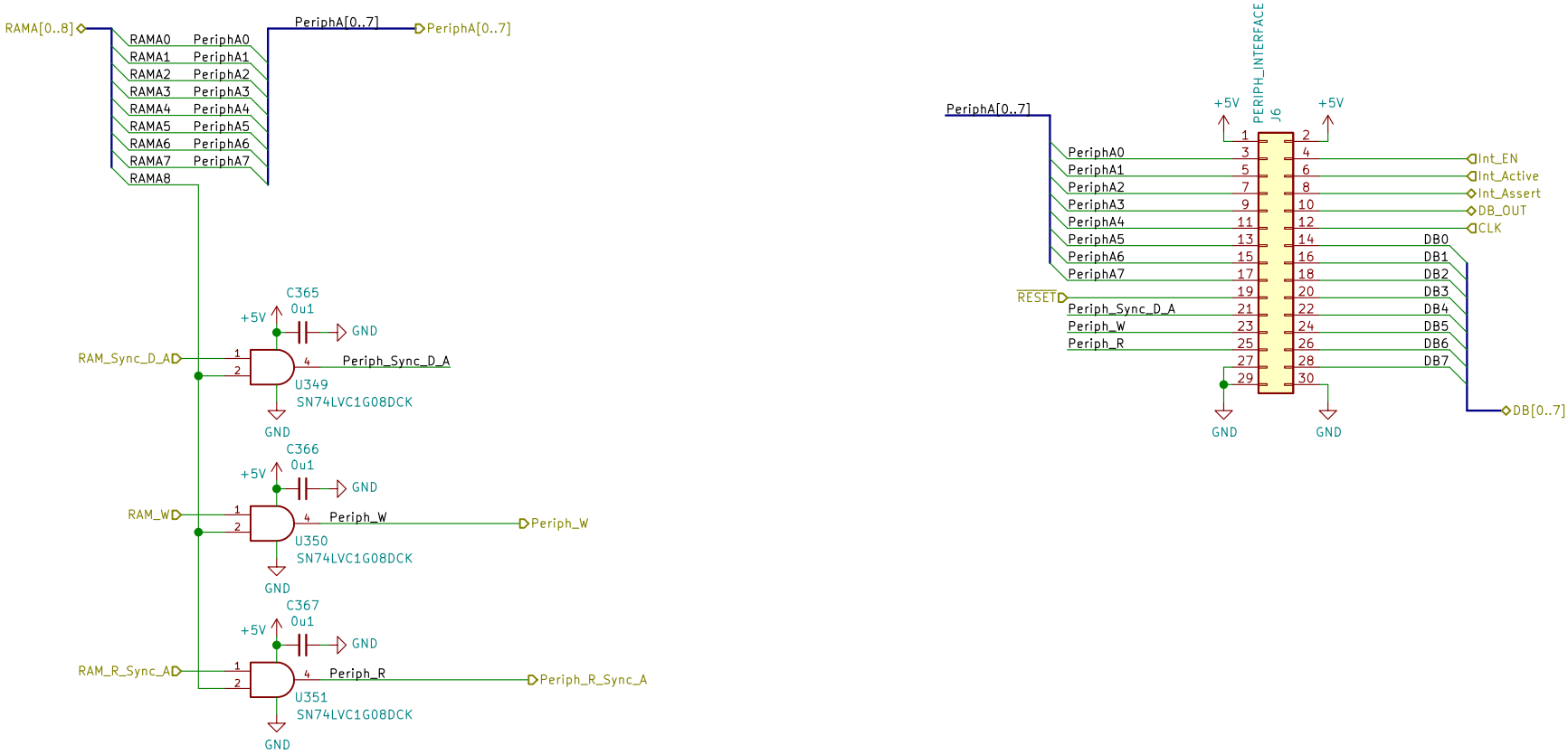
An adr. comparator. Used to check if the address currently on the RAMA bus corresponds to a specific address.

Philipp Schilk

Sheet: /SysReg_2/SYS2 AdrComparator/
File: AdrComparator.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 40/97



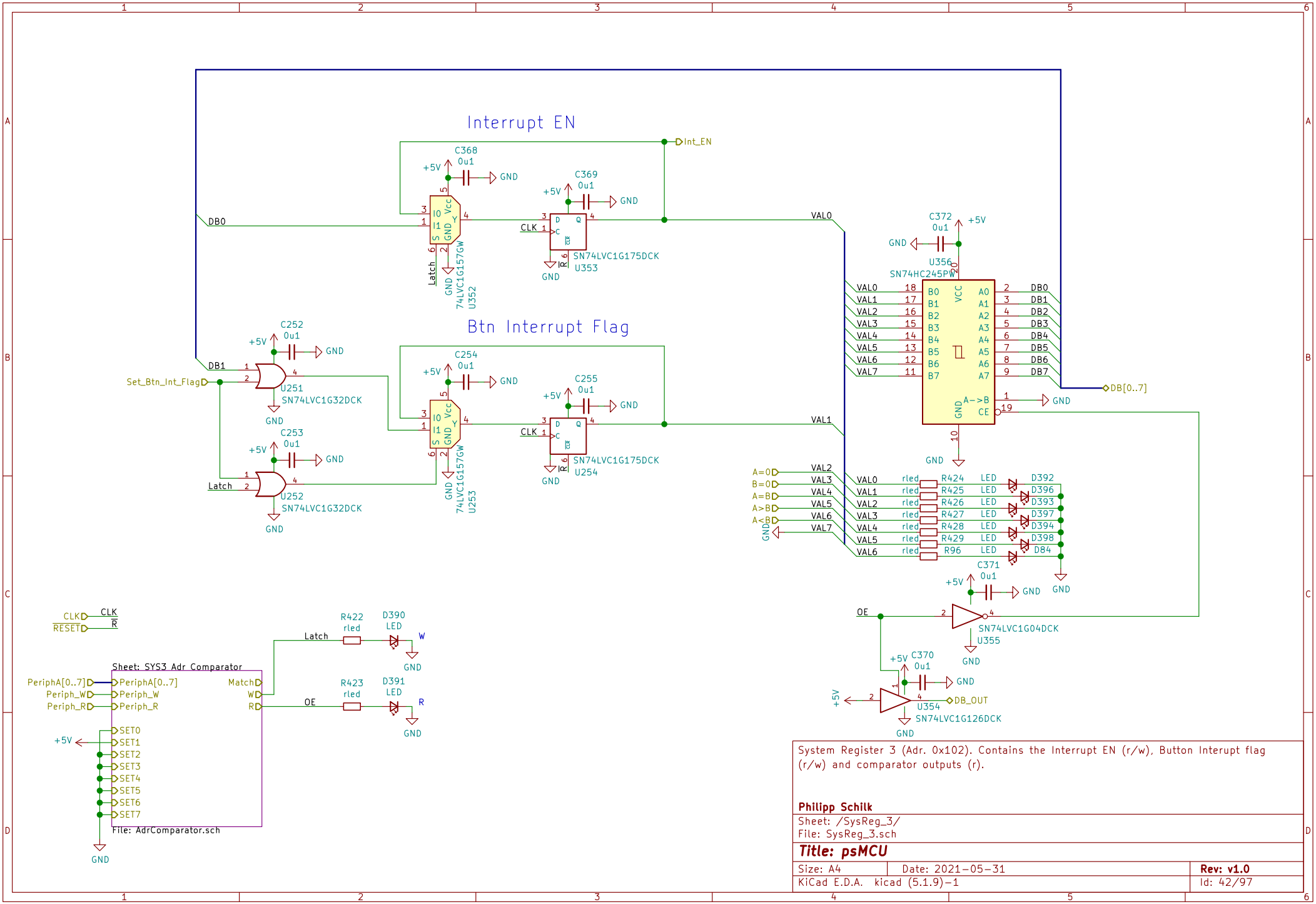
Peripheral Connector. Also pre-filters RAMA addresses for peripherals.

Philipp Schilk

Sheet: /PeriphealInterface/
File: PeripheralInterface.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 41/97



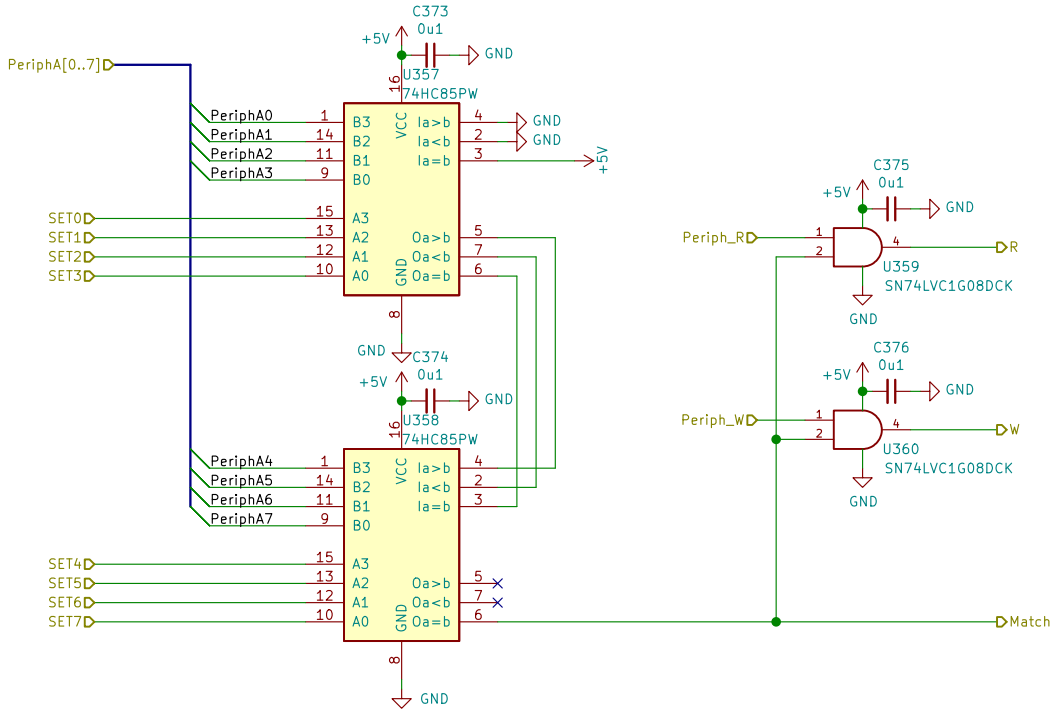
System Register 3 (Adr. 0x102). Contains the Interrupt EN (r/w), Button Interupt flag (r/w) and comparator outputs (r).

Philipp Schilk

Sheet: /SysReg_3/
File: SysReg_3.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 42/97



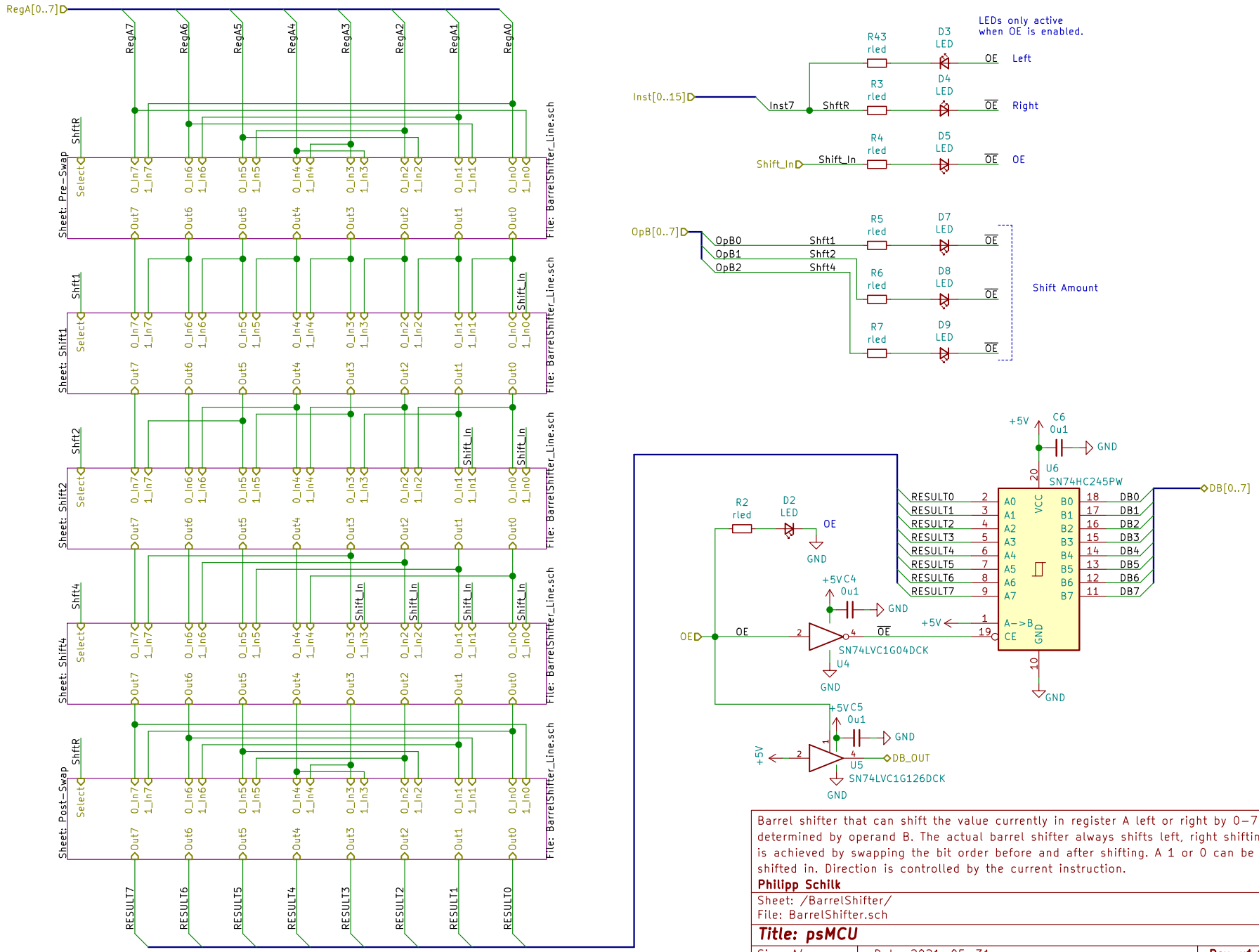
An adr. comparator. Used to check if the address currently on the RAMA bus corresponds to a specific address.

Philipp Schilk

Sheet: /SysReg_3/SYS3 Adr Comparator/
File: AdrComparator.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 43/97



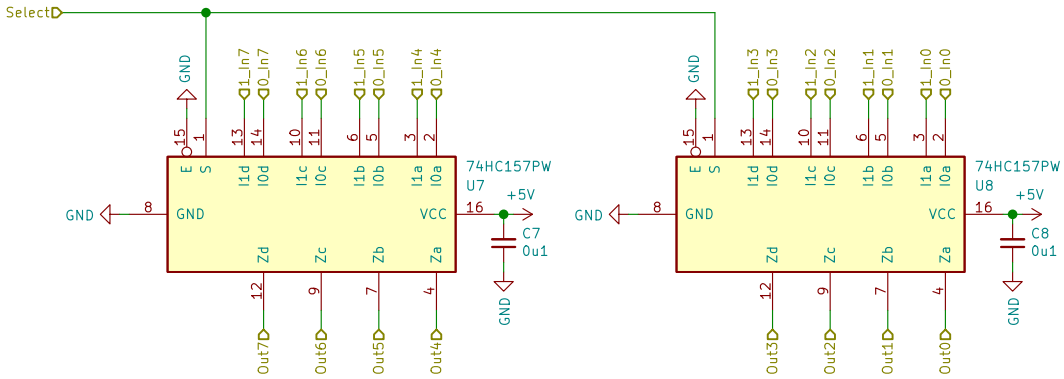
Barrel shifter that can shift the value currently in register A left or right by 0–7, determined by operand B. The actual barrel shifter always shifts left, right shifting is achieved by swapping the bit order before and after shifting. A 1 or 0 can be shifted in. Direction is controlled by the current instruction.

Philipp Schilk

Sheet: /BarrelShifter/
File: BarrelShifter.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 44/97



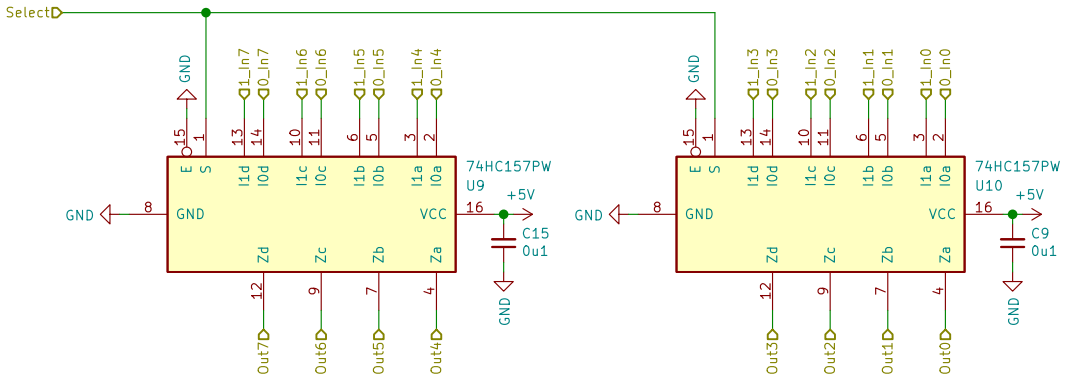
A line of 8 2in-1out multiplexers used multiple times in the barrel shifter.

Philipp Schilk

Sheet: /BarrelShifter/Shift2/
File: BarrelShifter_Line.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 45/97



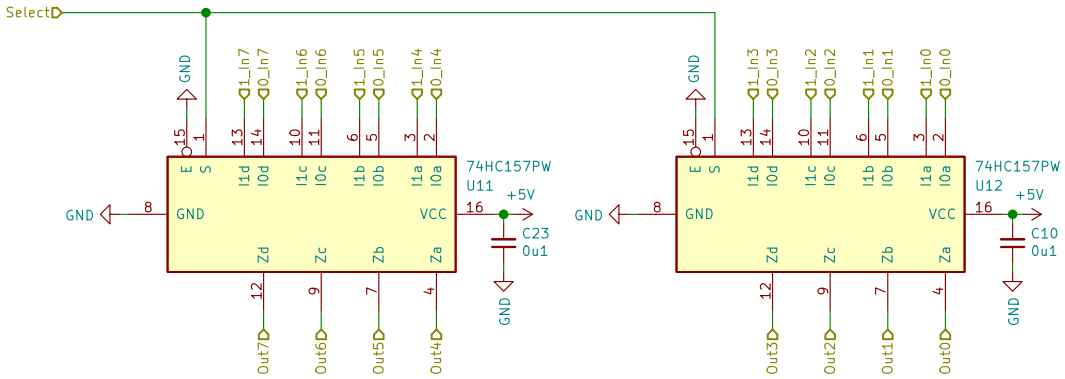
A line of 8 2in-1out multiplexers used multiple times in the barrel shifter.

Philipp Schilk

Sheet: /BarrelShifter/Shift4/
File: BarrelShifter_Line.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 46/97



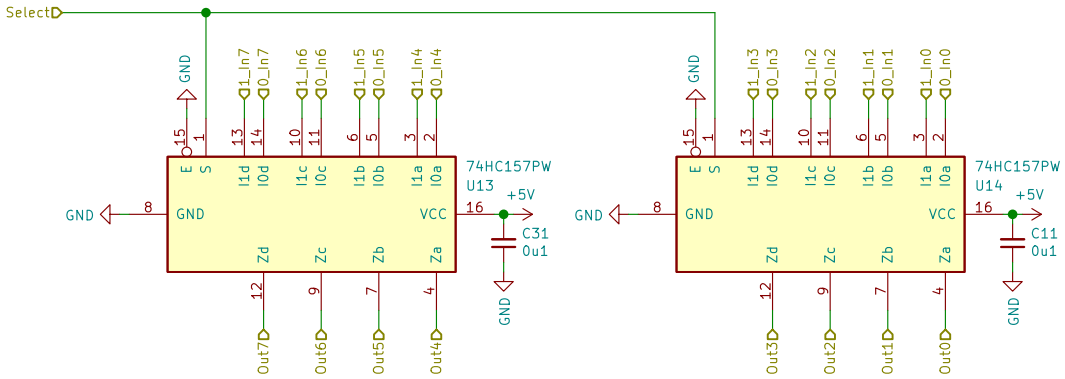
A line of 8 2in-1out multiplexers used multiple times in the barrel shifter.

Philipp Schilk

Sheet: /BarrelShifter/Post-Swap/
File: BarrelShifter_Line.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 47/97



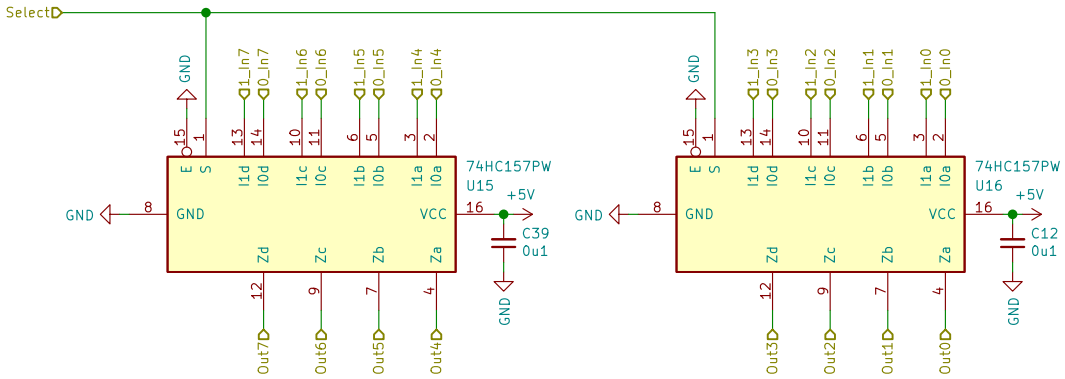
A line of 8 2in-1out multiplexers used multiple times in the barrel shifter.

Philipp Schilk

Sheet: /BarrelShifter/Pre-Swap/
File: BarrelShifter_Line.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 48/97



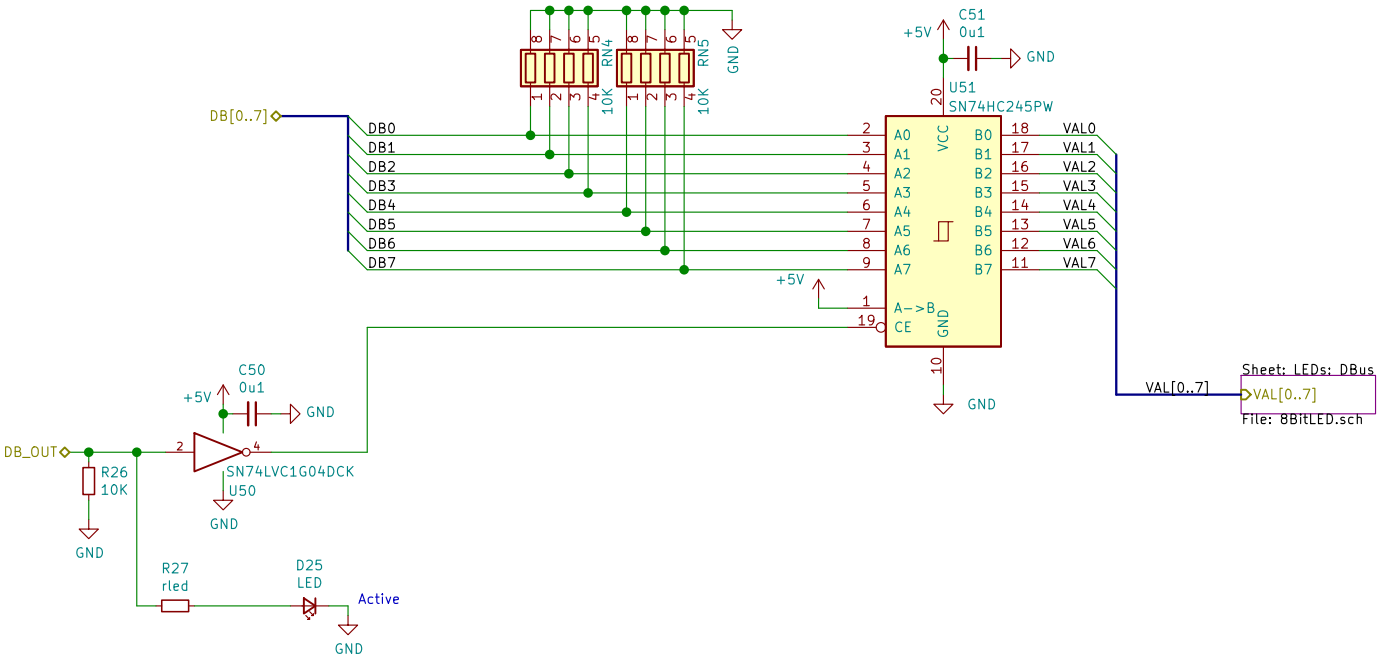
A line of 8 2in-1out multiplexers used multiple times in the barrel shifter.

Philipp Schilk

Sheet: /BarrelShifter/Shift1/
File: BarrelShifter_Line.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 49/97



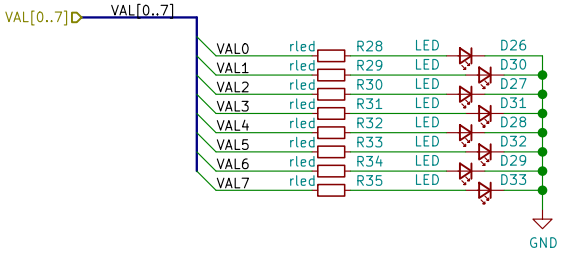
Displays the current value on the DBus if a different module is providing one (indicated by the DBUS_OUT signal).

Philipp Schilk

Sheet: /Data Bus Display/
File: DBUS_DISPLAY.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 50/97



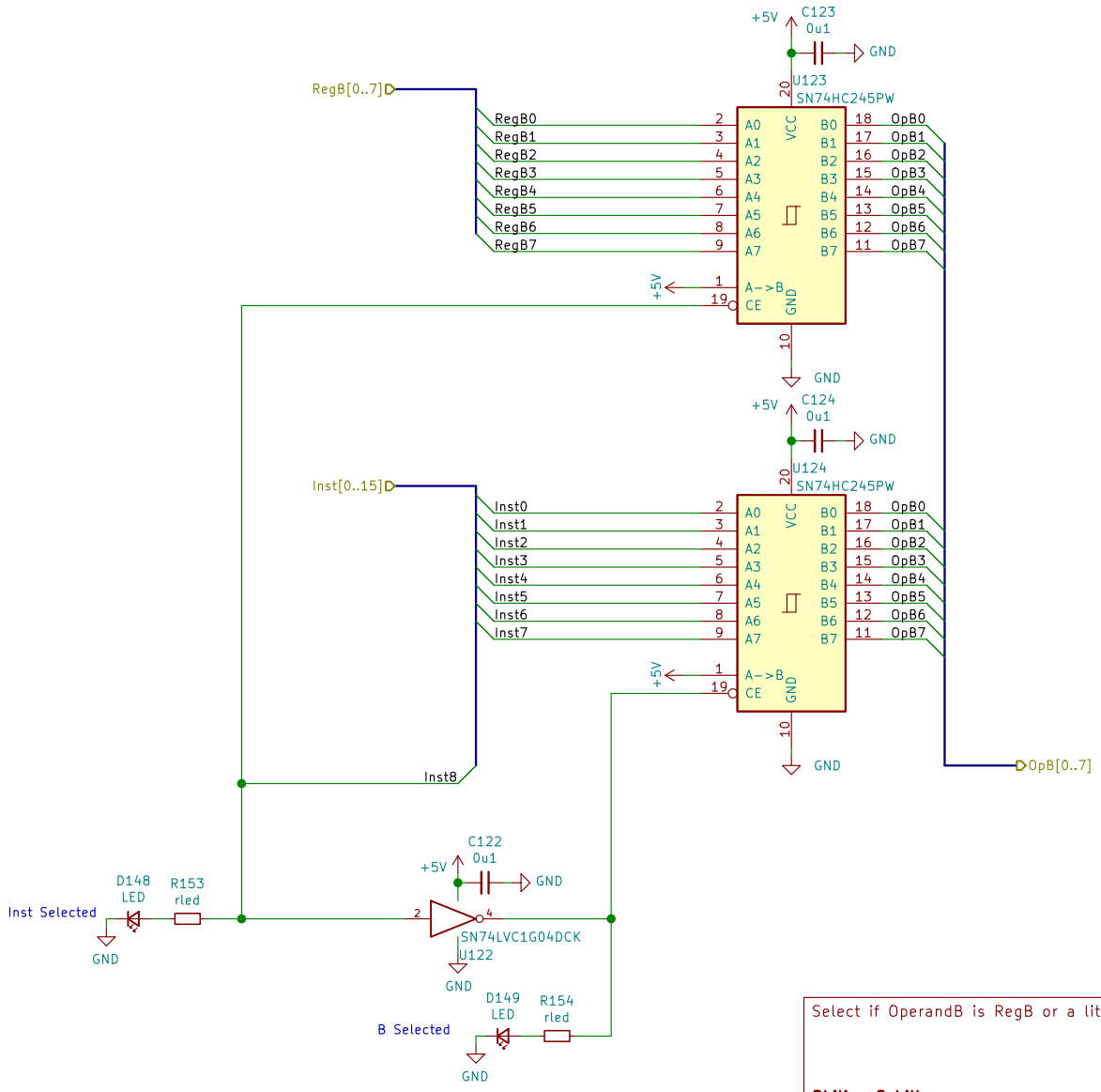
8bit binary LED display.

Philipp Schilk

Sheet: /Data Bus Display/LEDs: DBus /
File: 8BitLED.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 51/97



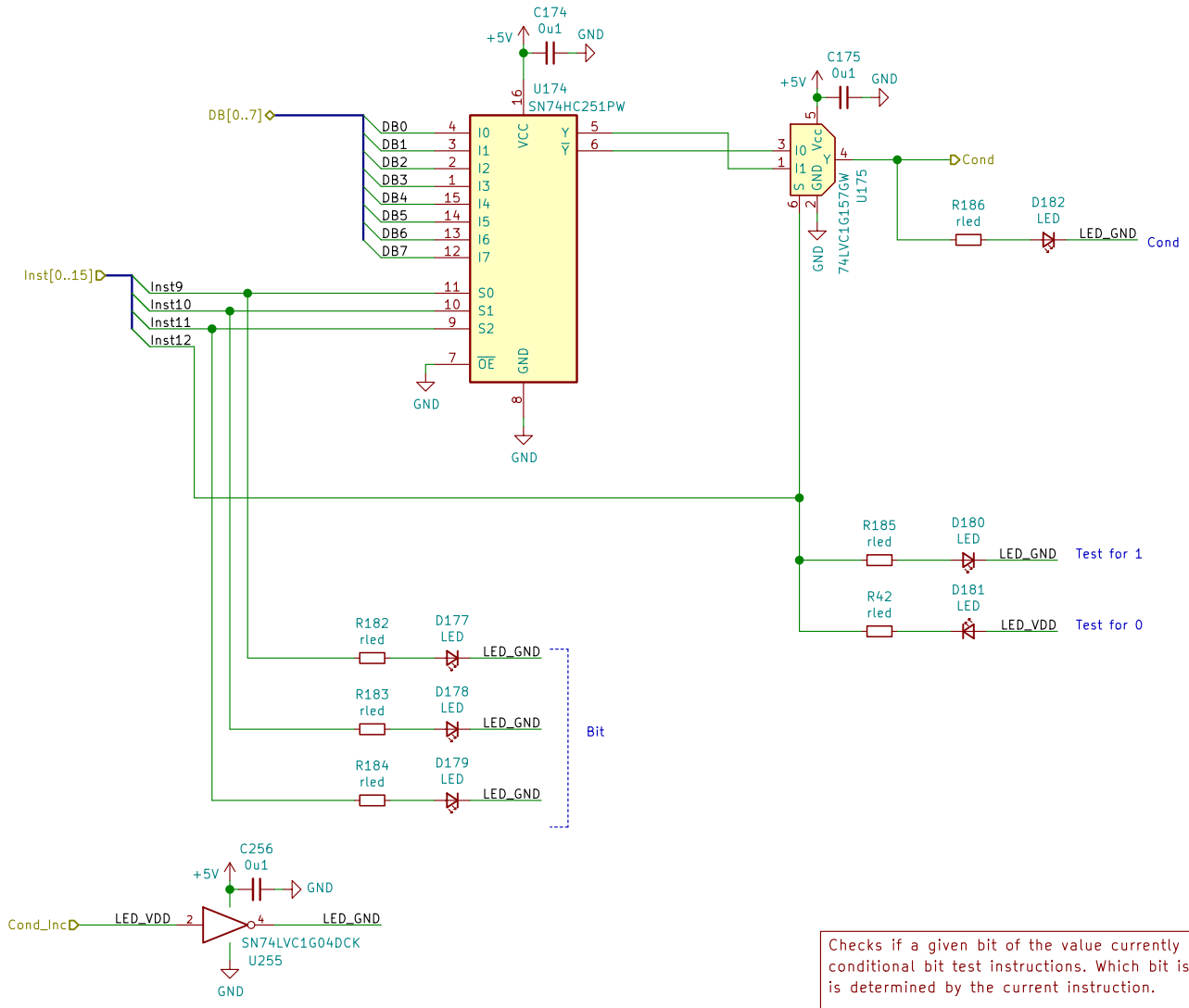
Select if OperandB is RegB or a literal from the current instruction.

Philipp Schilk

Sheet: /Operand B Select/
File: OperandB_select.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 52/97



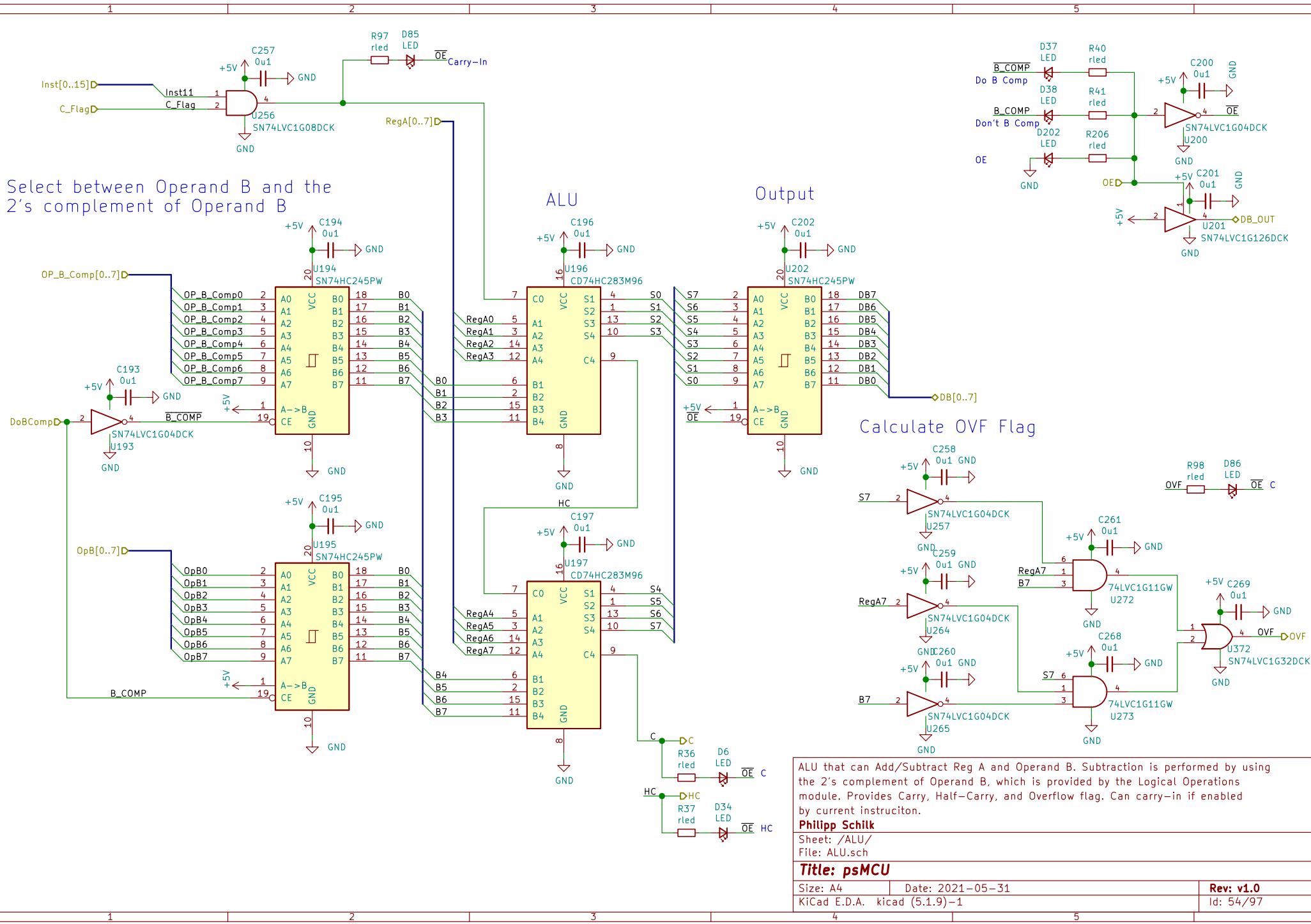
Checks if a given bit of the value currently on the DBus is set/reset. Used for the conditional bit test instructions. Which bit is tested, and if it is being tested for 1/0 is determined by the current instruction.

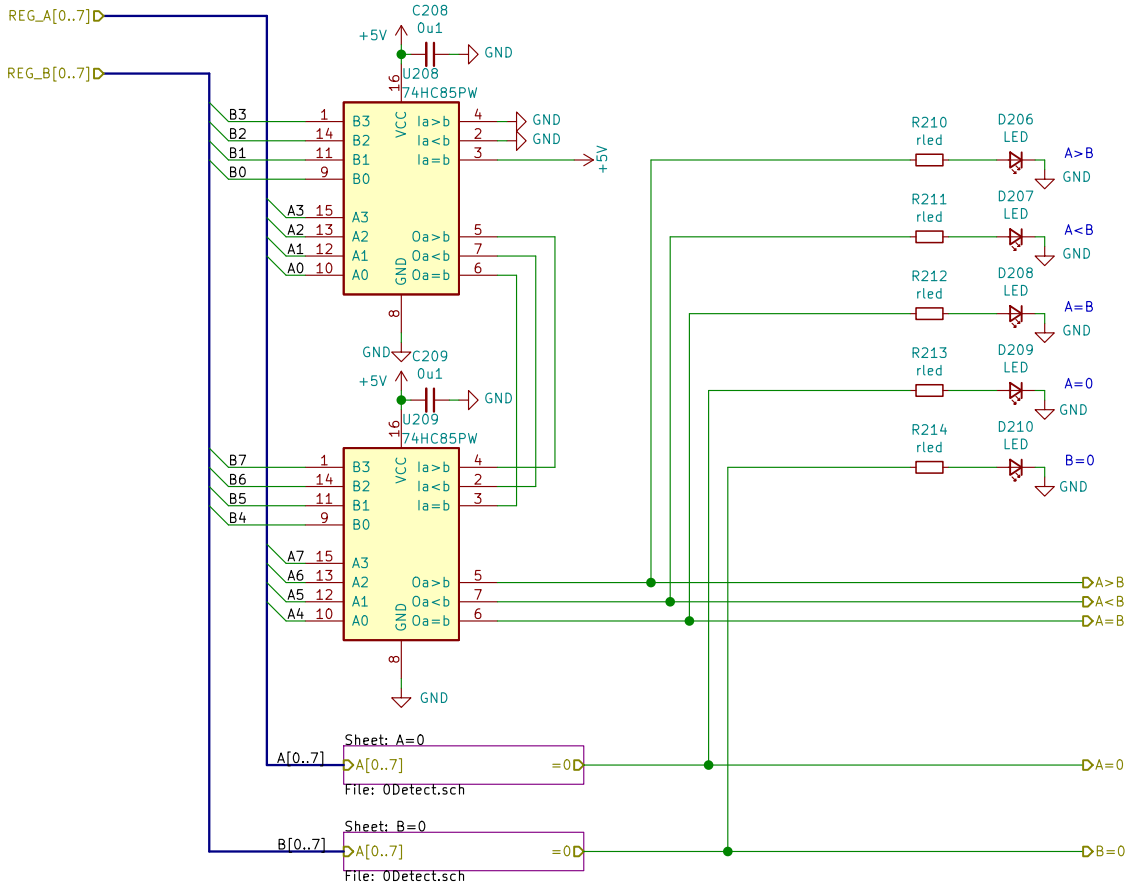
Philipp Schilk

Sheet: /BitTest/
File: BitTest.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 53/97


Select between Operand B and the
2's complement of Operand B
ALU
Output
Calculate OVF Flag
Inst[0..15]
C_Flag
Inst11
C257
0u1
+5V
GND
U256
SN74LVC1G08DCK
R97
rled
D85
LED
OE
Carry-In
RegA[0..7]
OP_B_Comp[0..7]
OP_B_Comp0
OP_B_Comp1
OP_B_Comp2
OP_B_Comp3
OP_B_Comp4
OP_B_Comp5
OP_B_Comp6
OP_B_Comp7
C194
U194
SN74HC245PW
C193
U193
SN74LVC1G04DCK
DoBComp
B_COMP
OpB[0..7]
OpB0
OpB1
OpB2
OpB3
OpB4
OpB5
OpB6
OpB7
C195
U195
C196
U196
CD74HC283M96
C197
U197
RegA0
RegA1
RegA2
RegA3
RegA4
RegA5
RegA6
RegA7
HC
C
R36
D6
R37
D34
C202
U202
DB[0..7]
D37
R40
D38
R41
D202
R206
B_COMP
Do B Comp
Don't B Comp
OE
C200
U200
C201
U201
DB_OUT
SN74LVC1G126DCK
C258
U257
C259
U264
C260
U265
C261
U272
74LVC1G11GW
C268
U273
C269
U372
SN74LVC1G32DCK
OVF
R98
D86
ALU that can Add/Subtract Reg A and Operand B. Subtraction is performed by using the 2's complement of Operand B, which is provided by the Logical Operations module. Provides Carry, Half-Carry, and Overflow flag. Can carry-in if enabled by current instruciton.
Philipp Schilk
Sheet: /ALU/
File: ALU.sch
Title: psMCU
Size: A4
Date: 2021-05-31
Rev: v1.0
KiCad E.D.A. kicad (5.1.9)-1
Id: 54/97



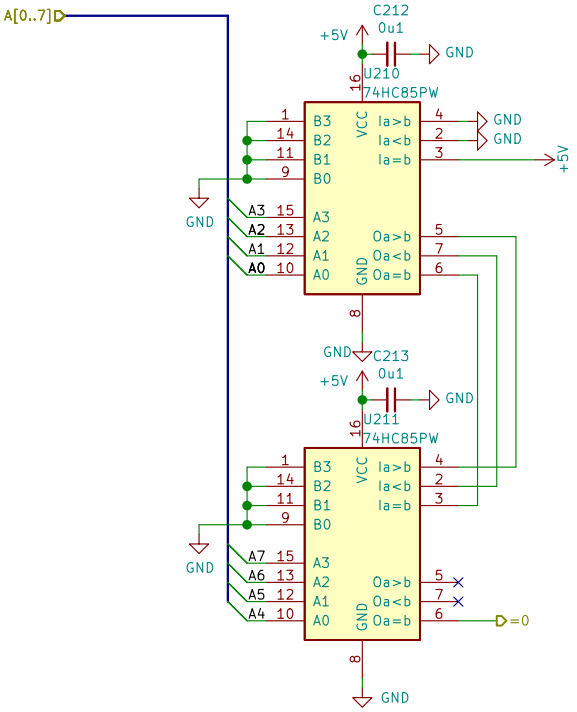
Performs unsigned magnitude comparison of RegA and RegB, also tests for A=0 and B=0.

Philipp Schilk

Sheet: /Comparator.sch/
File: Comparator.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 55/97



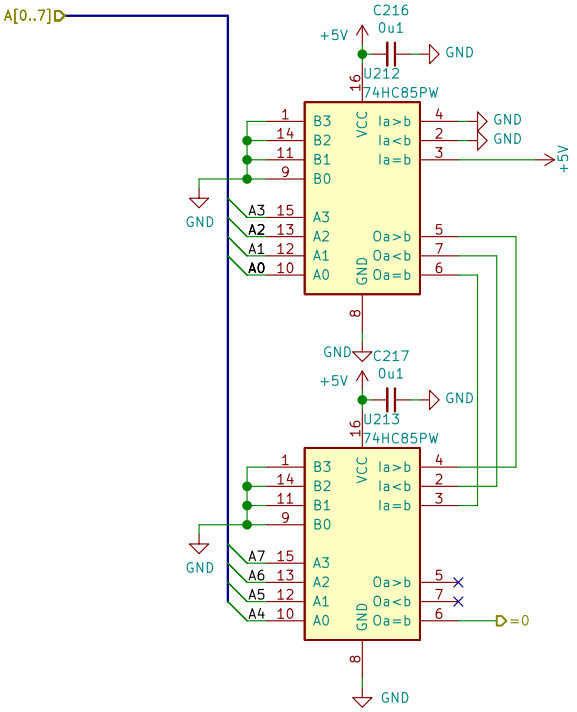
Test if the input value is equal to 0.

Philipp Schilk

Sheet: /Comparator.sch/A=0/
File: 0Detect.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 56/97



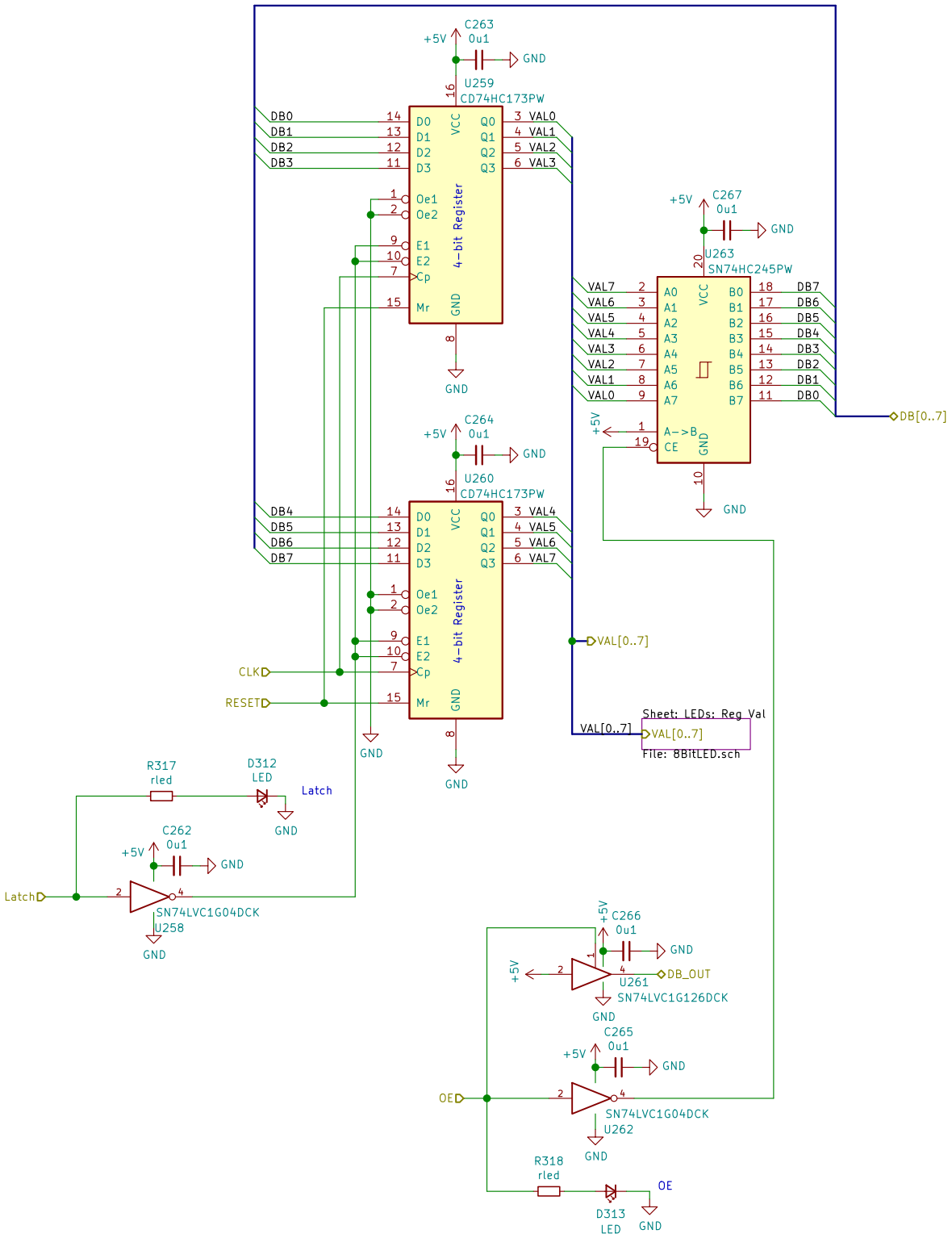
Test if the input value is equal to 0.

Philipp Schilk

Sheet: /Comparator.sch/B=0/
File: 0Detect.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 57/97



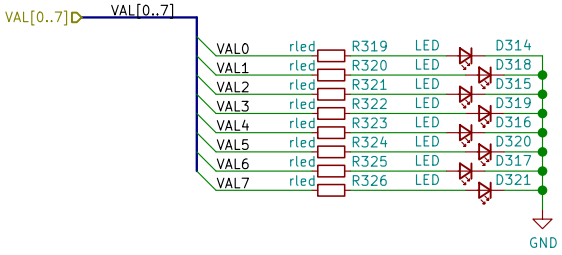
A basic 8-bit register. Interfaces with the DBus.

Philipp Schilk

Sheet: /RegA/
File: Reg.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 58/97



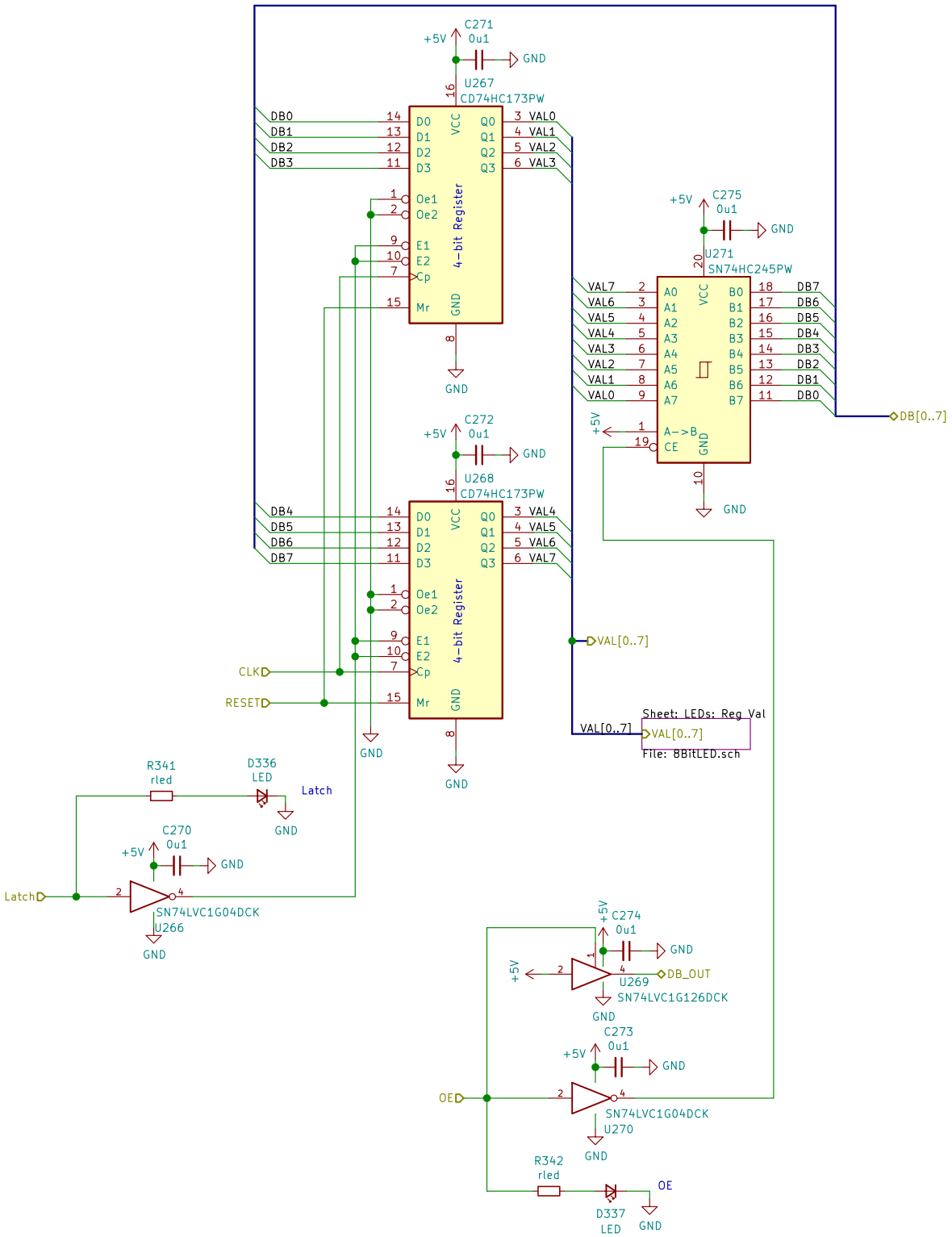
8bit binary LED display.

Philipp Schilk

Sheet: /RegA/LEDs: Reg Val/
File: 8BitLED.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 59/97



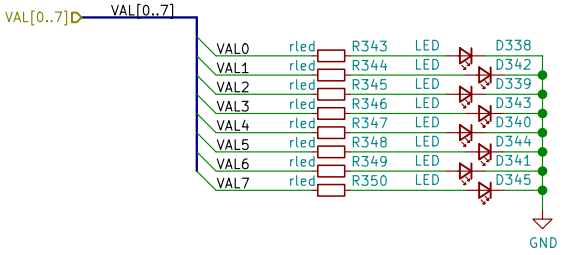
A basic 8-bit register. Interfaces with the DBus.

Philipp Schilk

Sheet: /RegB/
File: Reg.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 60/97



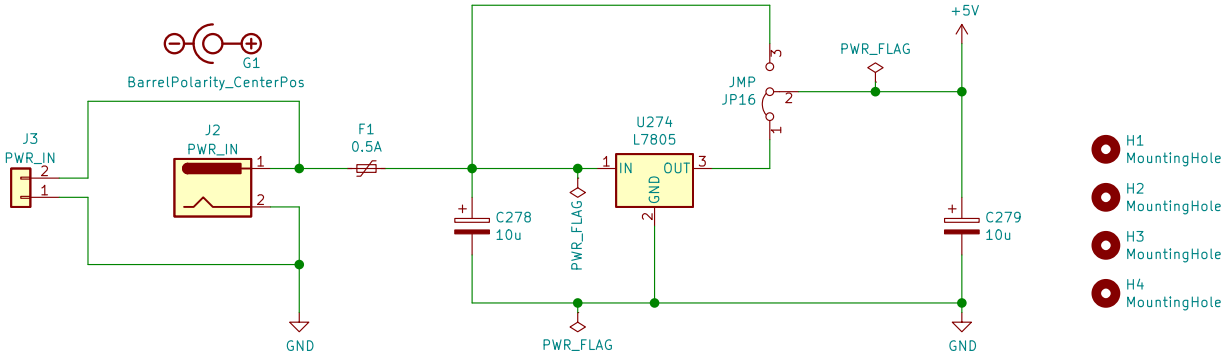
8bit binary LED display.

Philipp Schilk

Sheet: /RegB/LEDs: Reg Val/
File: 8BitLED.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 61/97



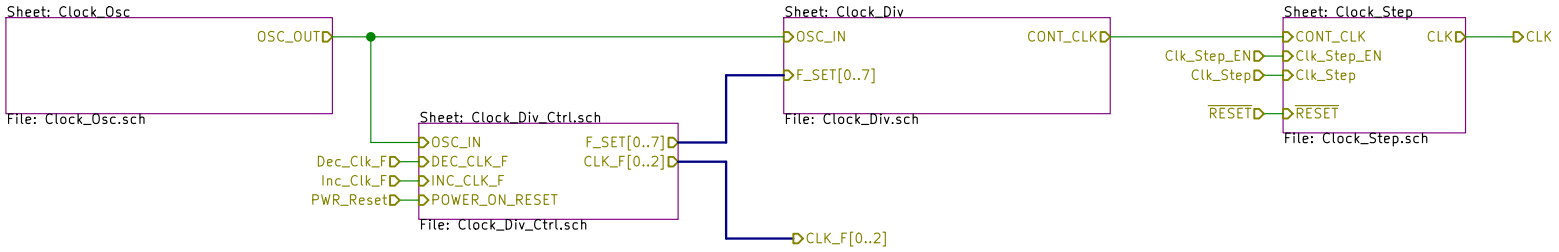
Power input connectors and voltage regulation. Also includes the
4 M4 mounting holes.

Philipp Schilk

Sheet: /PowerInput/
File: PowerInput.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 62/97



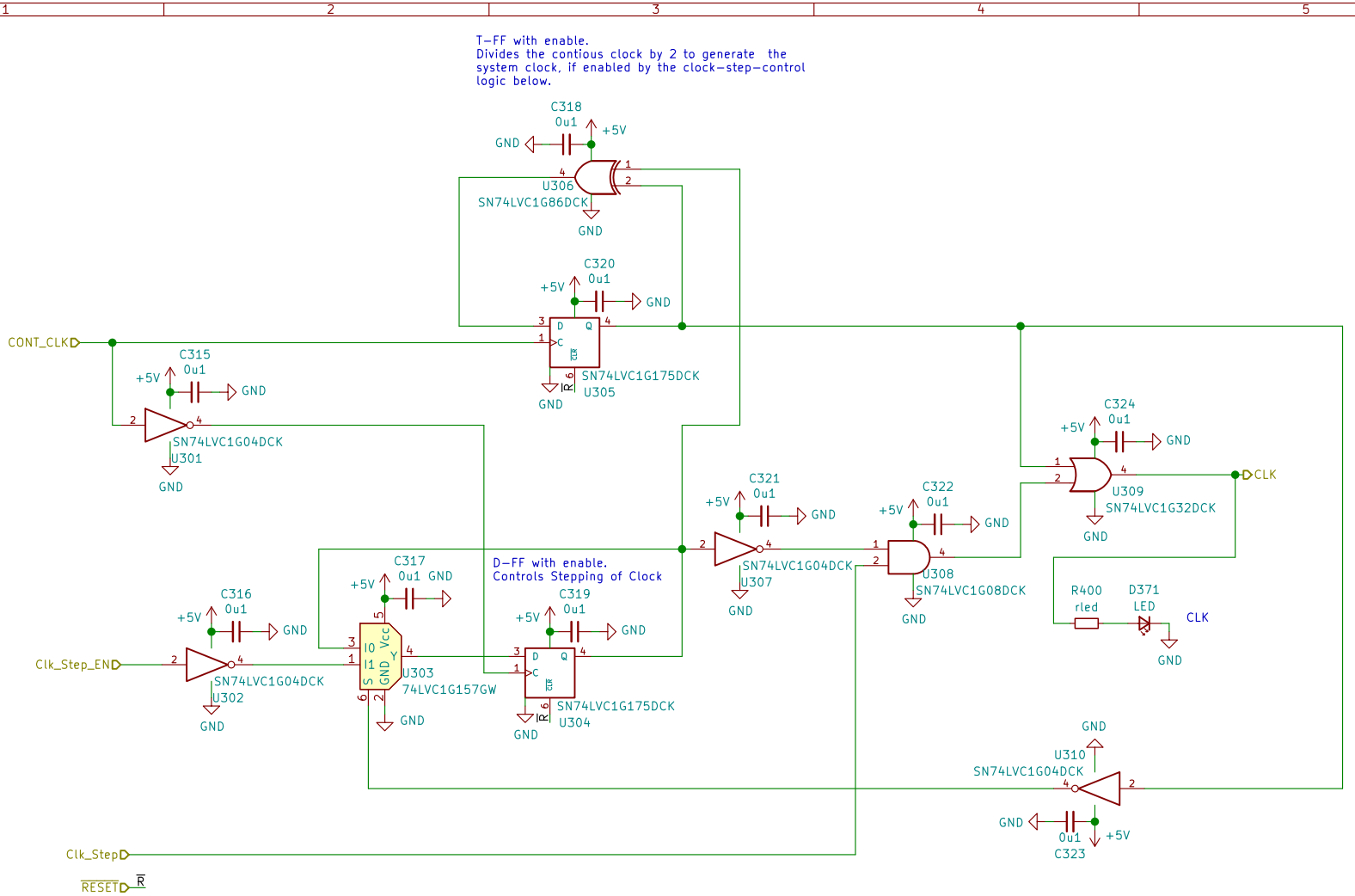
Variable frequency clock generation.

Philipp Schilk

Sheet: /Clock/
File: Clock.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 63/97



Generates the actual system clock. Can pause the clock and allow manual 'clock stepping'. Avoids clock-glitches when changing modes.

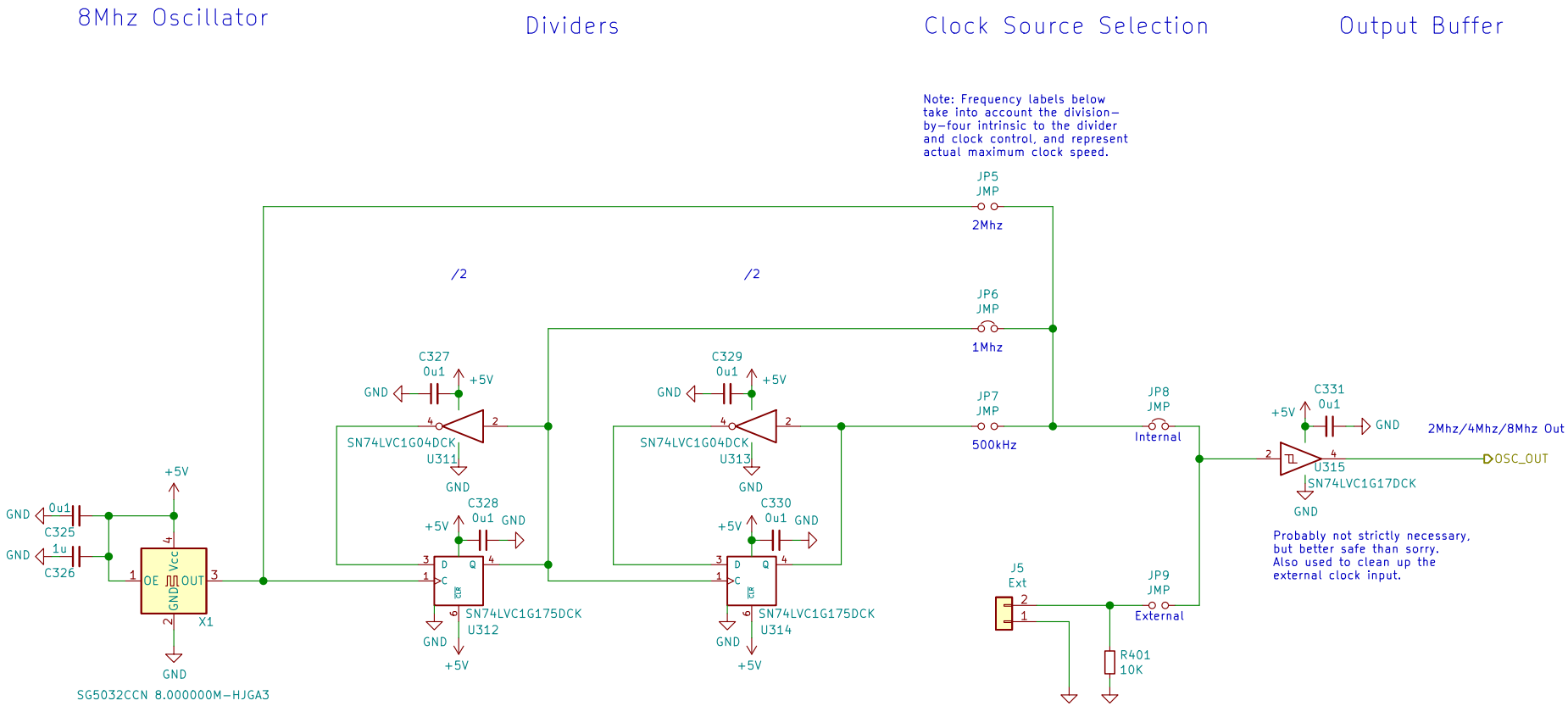
(Black Magic. I don't quite remember how this works!)

Philipp Schilk

Sheet: /Clock/Clock_Step/
File: Clock_Step.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 64/97



The central oscillator. Allows for 2 optional dividers or an external clock source.
Using the internal crystal, this module can generate 2MHz, 4Mhz, or 8MHz

Philipp Schilk

Sheet: /Clock/Clock_Osc/
File: Clock_Osc.sch

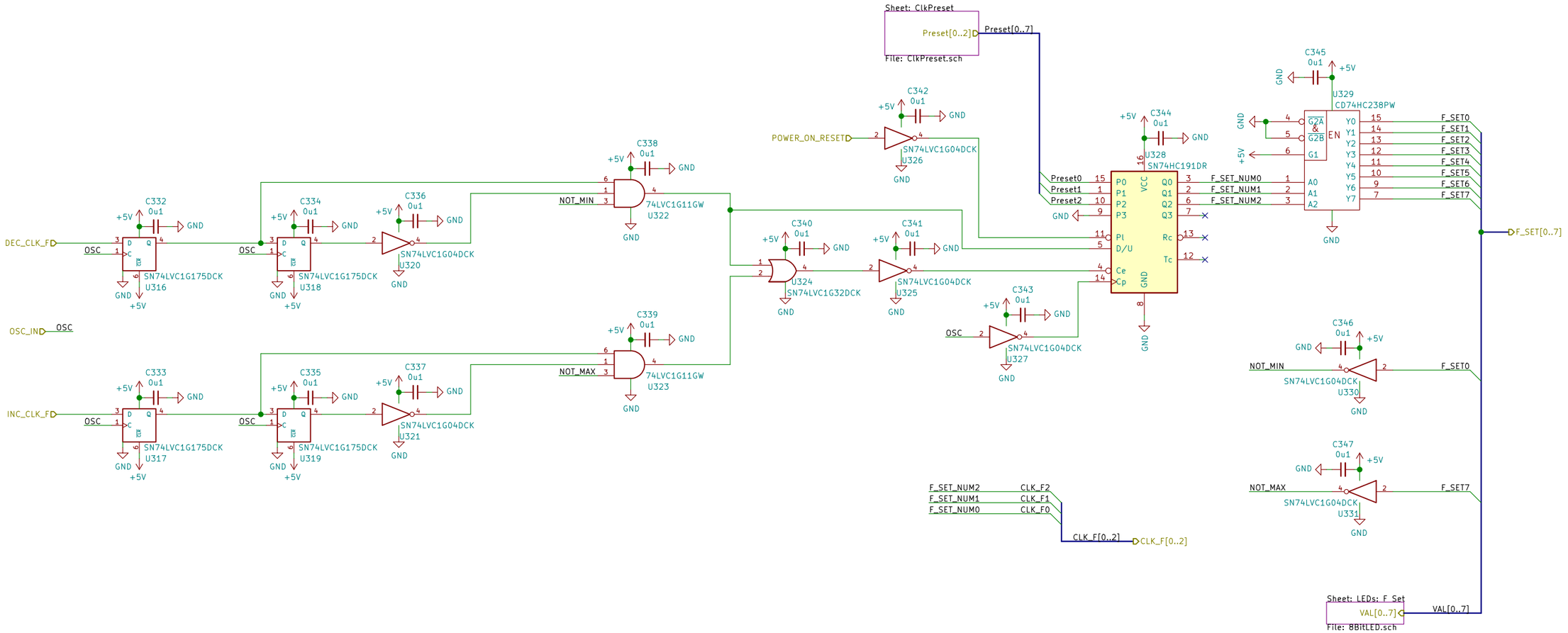
Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 65/97

Input Rising-Edge Detectors

Up/Down Counter

Binary to one-hot converter



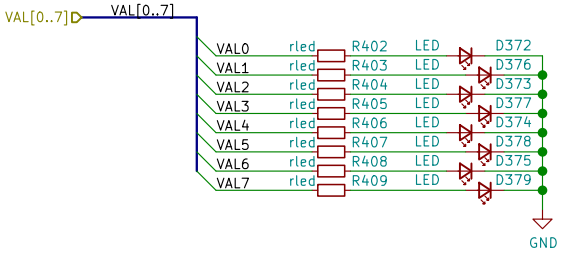
Frequency selection logic/state machine. Allows selection between 8 frequency set-points. Rising-Edge detectors ensure each button press is only counted once. The default clock setting during power-on is configurable with jumpers. Output encoded as 1-of-8/one-hot signal.

Philipp Schilk

Sheet: /Clock/Clock_Div_Ctrl.sch/
File: Clock_Div_Ctrl.sch

Title: psMCU

Size: A3	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 66/97



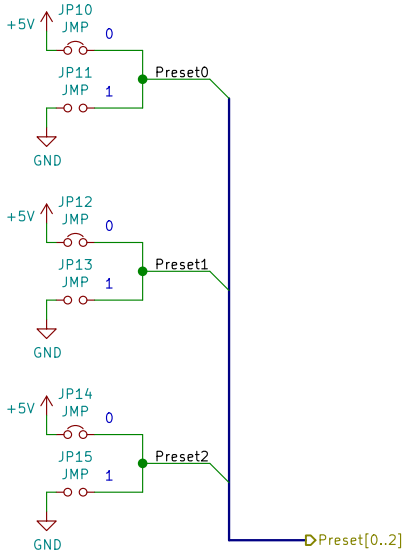
8bit binary LED display.

Philipp Schilk

Sheet: /Clock/Clock_Div_Ctrl.sch/LEDs: F Set/
File: 8BitLED.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 67/97



Jumpers to configure default clock frequency after power-on.

Philipp Schilk

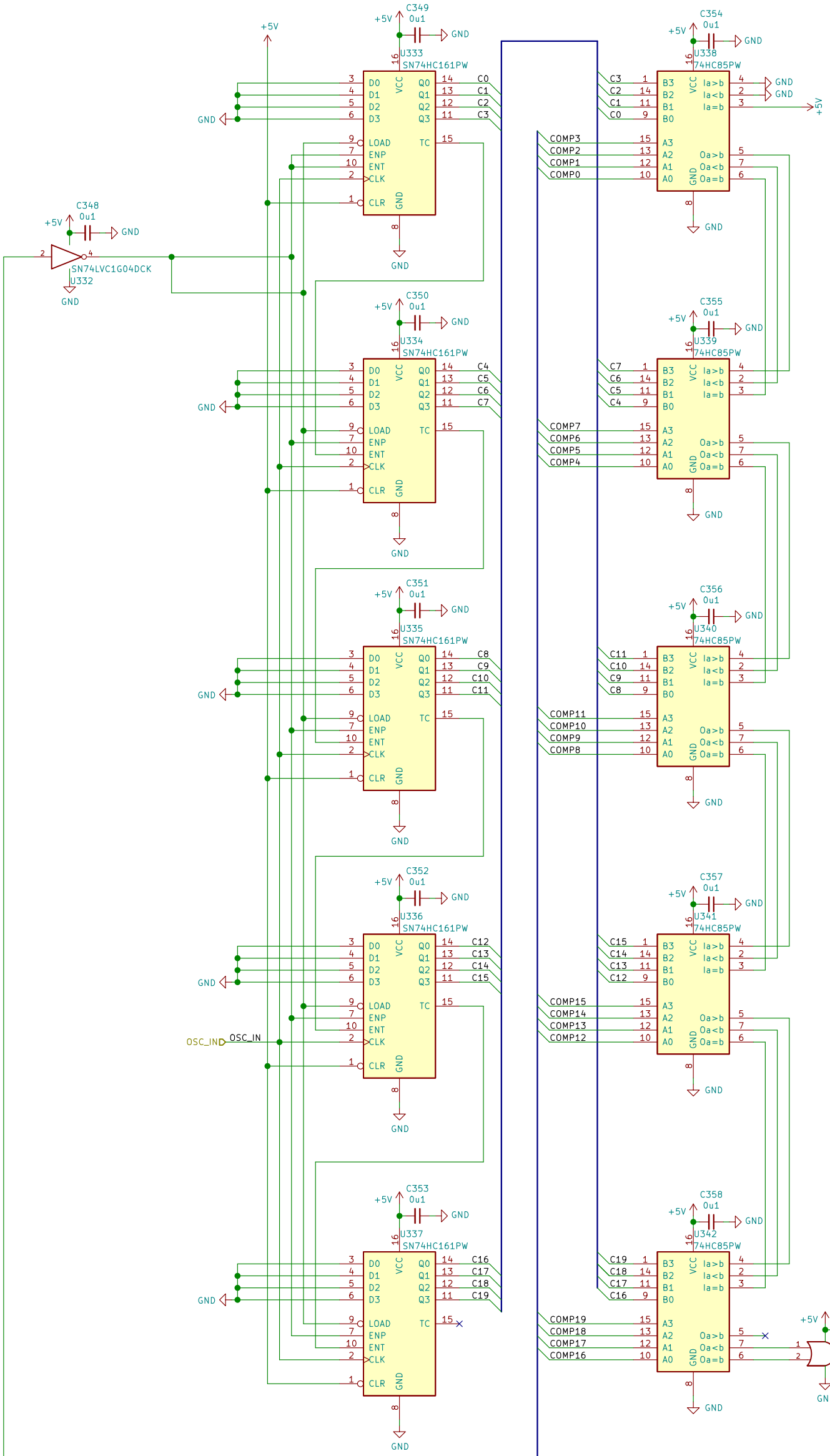
Sheet: /Clock/Clock_Div_Ctrl.sch/ClkPreset/
File: ClkPreset.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 68/97

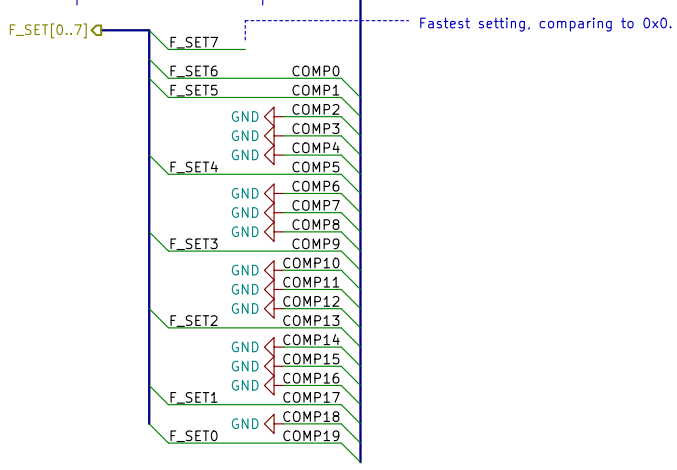
Counter

Comparator



Output T-FF

Convert Frequency Setting to Comparator set-point



Variable clock divider based on 20-bit binary counter and comparator.
Should switch between frequencies without any clock-glitches.
Minimum division is /2.

Philipp Schilk

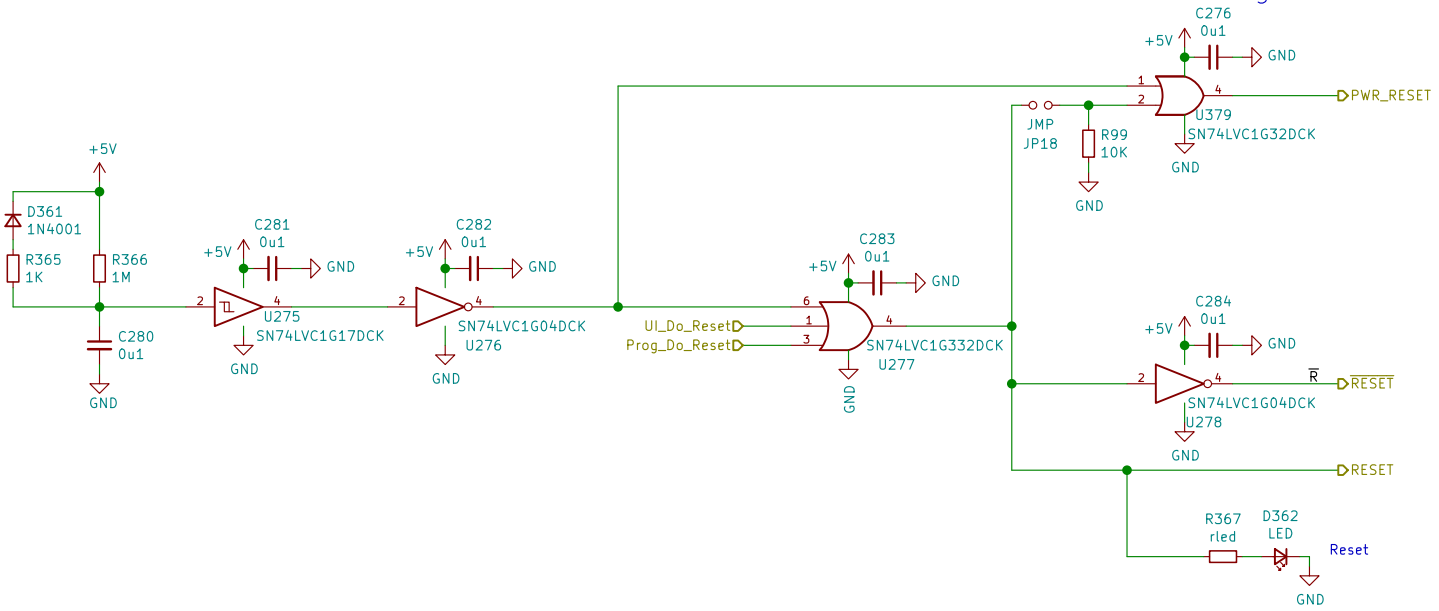
Sheet: /Clock/Clock_Div/
File: Clock_Div.sch

Title: psMCU

Size: A3	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 69/97

Automatic Reset on Power-on

Generate different Reset signals



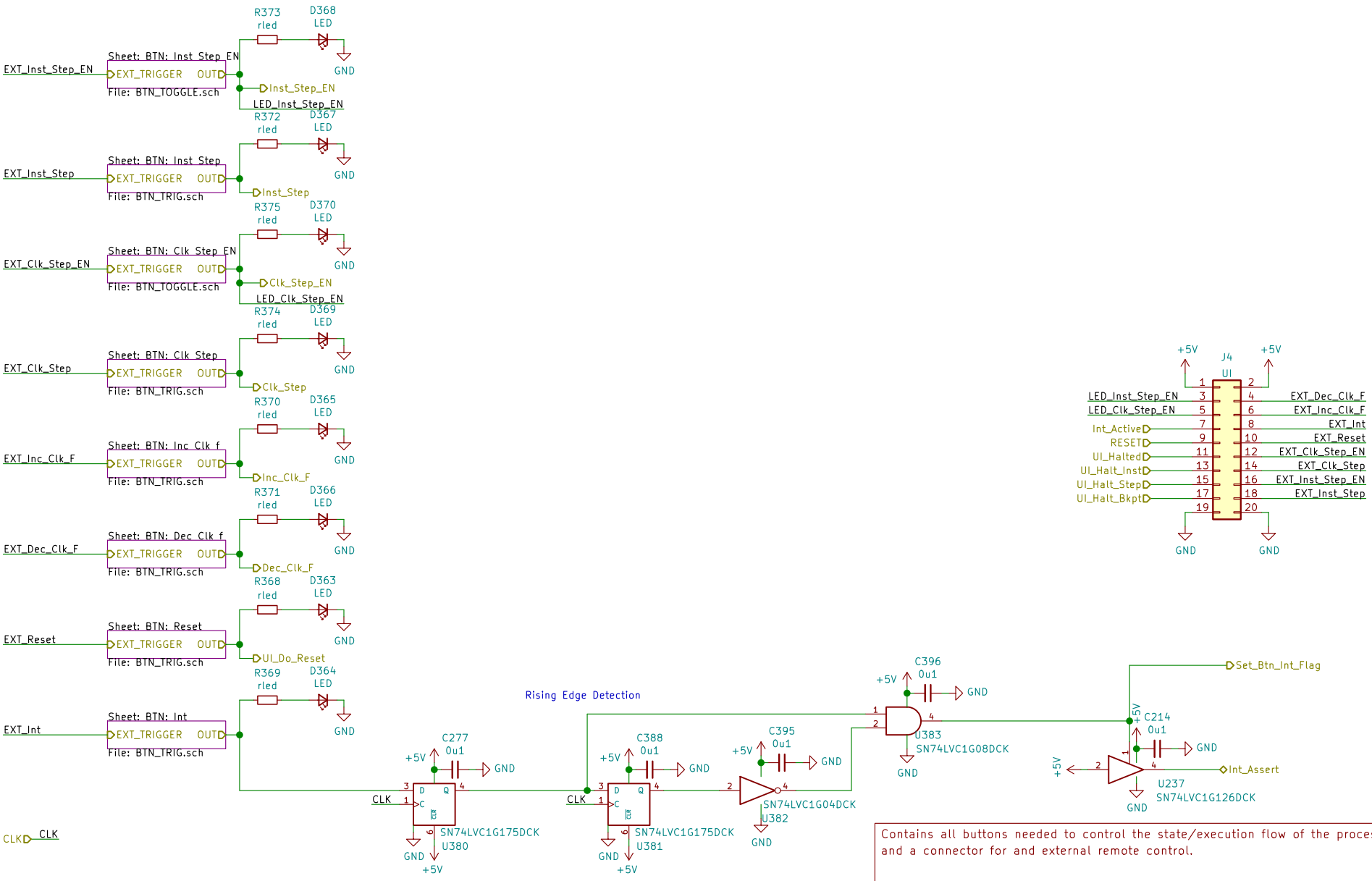
Generates reset during power-on and combines the different reset sources to generate the RESET and $\overline{\text{RESET}}$ signals used globally.

Philipp Schilk

Sheet: /ResetCtrl/
File: ResetCtrl.sch

Title: psMCU

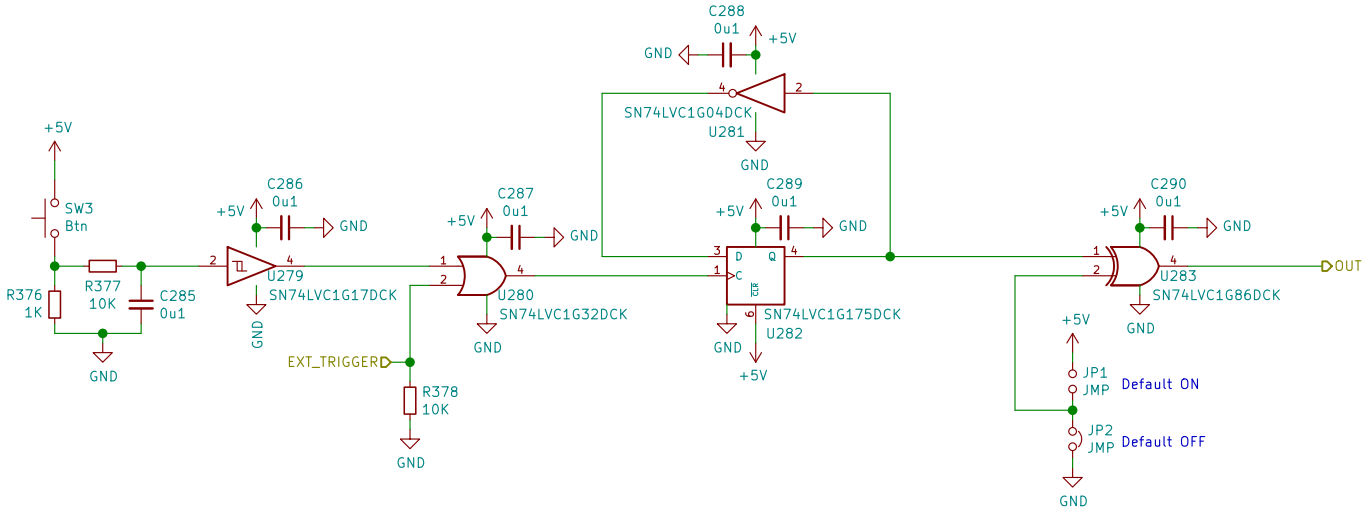
Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 70/97


R373
rled
D368
LED
GND
EXT_Inst_Step_EN
Sheet: BTN: Inst Step EN
EXT_TRIGGER OUT
File: BTN_TOGGLE.sch
Inst_Step_EN
LED_Inst_Step_EN
R372
rled
D367
LED
GND
EXT_Inst_Step
Sheet: BTN: Inst Step
EXT_TRIGGER OUT
File: BTN_TRIG.sch
Inst_Step
R375
rled
D370
LED
GND
EXT_Clk_Step_EN
Sheet: BTN: Clk Step EN
EXT_TRIGGER OUT
File: BTN_TOGGLE.sch
Clk_Step_EN
LED_Clk_Step_EN
R374
rled
D369
LED
GND
EXT_Clk_Step
Sheet: BTN: Clk Step
EXT_TRIGGER OUT
File: BTN_TRIG.sch
Clk_Step
R370
rled
D365
LED
GND
EXT_Inc_Clk_F
Sheet: BTN: Inc Clk f
EXT_TRIGGER OUT
File: BTN_TRIG.sch
Inc_Clk_F
R371
rled
D366
LED
GND
EXT_Dec_Clk_F
Sheet: BTN: Dec Clk f
EXT_TRIGGER OUT
File: BTN_TRIG.sch
Dec_Clk_F
R368
rled
D363
LED
GND
EXT_Reset
Sheet: BTN: Reset
EXT_TRIGGER OUT
File: BTN_TRIG.sch
UI_Do_Reset
R369
rled
D364
LED
GND
EXT_Int
Sheet: BTN: Int
EXT_TRIGGER OUT
File: BTN_TRIG.sch
CLK
CLK
Rising Edge Detection
C277
0u1
+5V
GND
CLK
D Q
C
SN74LVC1G175DCK
U380
GND
+5V
C388
0u1
+5V
GND
CLK
D Q
C
SN74LVC1G175DCK
U381
GND
+5V
C395
0u1
+5V
GND
SN74LVC1G04DCK
U382
GND
C396
0u1
+5V
GND
U383
SN74LVC1G08DCK
GND
Set_Btn_Int_Flag
C214
0u1
+5V
GND
Int_Assert
+5V
U237
SN74LVC1G126DCK
GND
J4
UI
+5V
+5V
1
2
LED_Inst_Step_EN 3
4 EXT_Dec_Clk_F
LED_Clk_Step_EN 5
6 EXT_Inc_Clk_F
7
8 EXT_Int
Int_Active 9
10 EXT_Reset
RESET 11
12 EXT_Clk_Step_EN
UI_Halted 13
14 EXT_Clk_Step
UI_Halt_Inst 15
16 EXT_Inst_Step_EN
UI_Halt_Step 17
18 EXT_Inst_Step
UI_Halt_Bkpt 19
20
GND
GND
Contains all buttons needed to control the state/execution flow of the processor and a connector for and external remote control.
Philipp Schilk
Sheet: /UI/
File: UI.sch
Title: psMCU
Size: A4
Date: 2021-05-31
Rev: v1.0
KiCad E.D.A. kicad (5.1.9)-1
Id: 71/97

BTN + Debounce

T-FF

Set default Position



A button that toggles a state on/off. Handles de-bounce and combines the signal from an external remote control. Allows for the default state during power-on to be set by jumpers

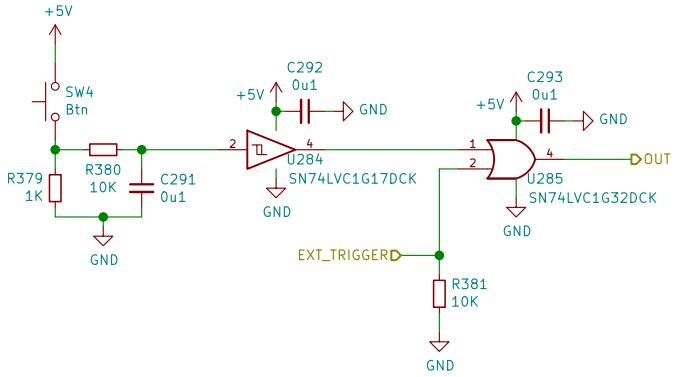
Philipp Schilk

Sheet: /UI/BTN: Inst Step EN/
File: BTN_TOGGLE.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 72/97

BTN + Debounce



A simple single-trigger button. Handles de-bouncing and also combines the signal from an external remote.

Philipp Schilk

Sheet: /UI/BTN: Inst Step/
File: BTN_TRIG.sch

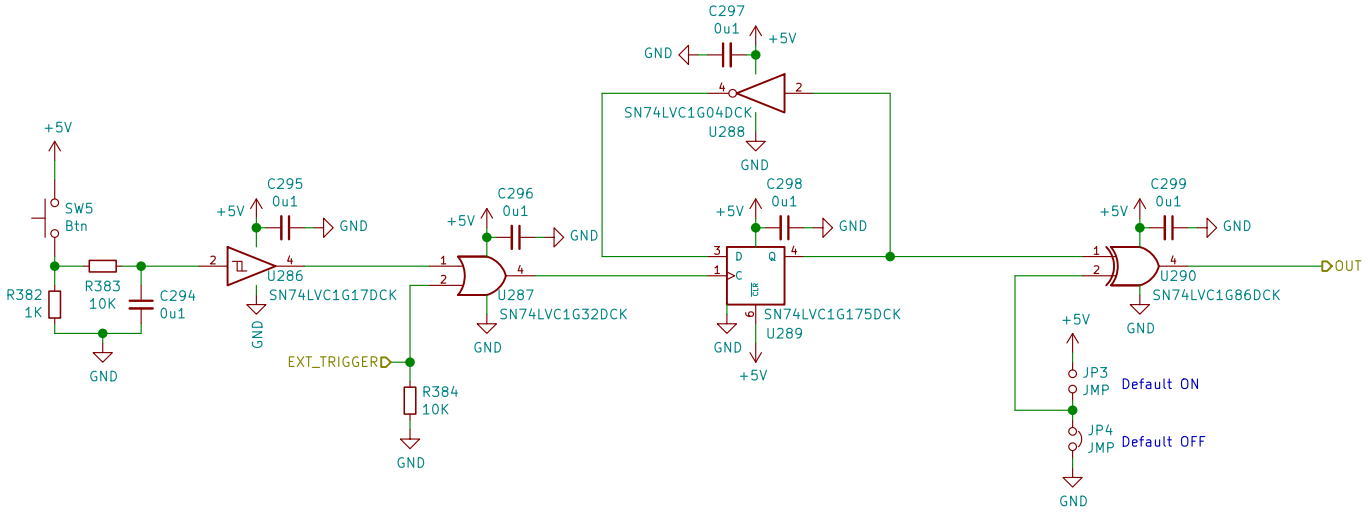
Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 73/97

BTN + Debounce

T-FF

Set default Position



A button that toggles a state on/off. Handles de-bounce and combines the signal from an external remote control. Allows for the default state during power-on to be set by jumpers

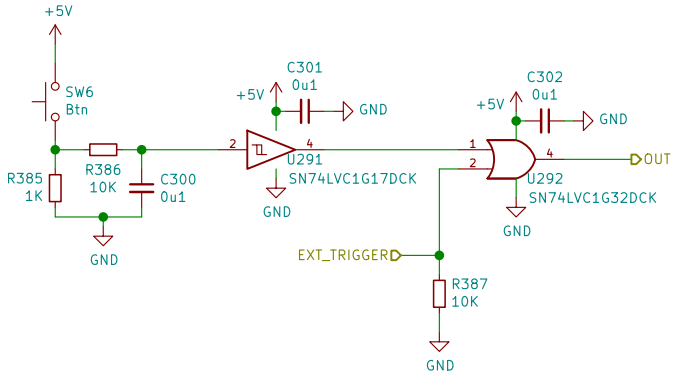
Philipp Schilk

Sheet: /UI/BTN: Clk Step EN/
File: BTN_TOGGLE.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 74/97

BTN + Debounce



A simple single-trigger button. Handles de-bouncing and also combines the signal from an external remote.

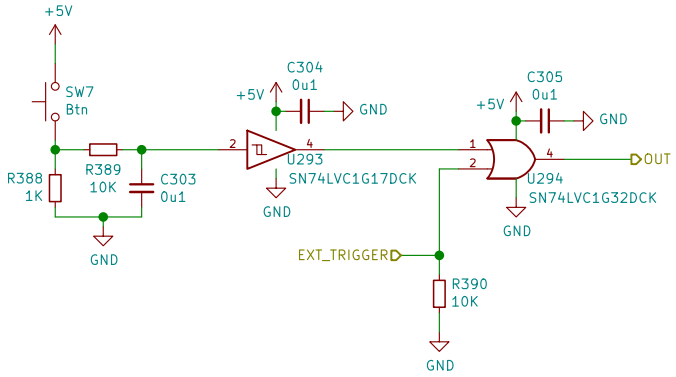
Philipp Schilk

Sheet: /UI/BTN: Clk Step/
File: BTN_TRIG.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 75/97

BTN + Debounce



A simple single-trigger button. Handles de-bouncing and also combines the signal from an external remote.

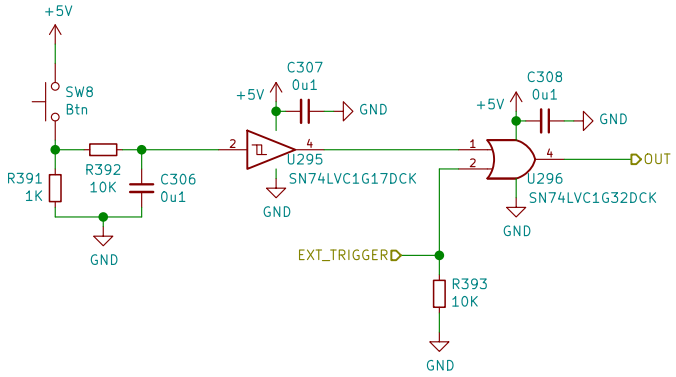
Philipp Schilk

Sheet: /UI/BTN: Reset/
File: BTN_TRIG.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 76/97

BTN + Debounce



A simple single-trigger button. Handles de-bouncing and also combines the signal from an external remote.

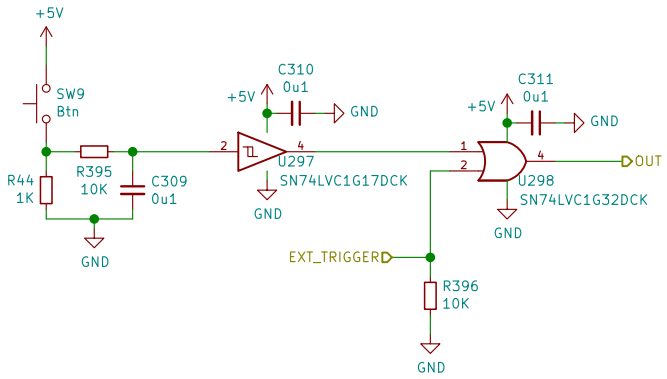
Philipp Schilk

Sheet: /UI/BTN: Int/
File: BTN_TRIG.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 77/97

BTN + Debounce



A simple single-trigger button. Handles de-bouncing and also combines the signal from an external remote.

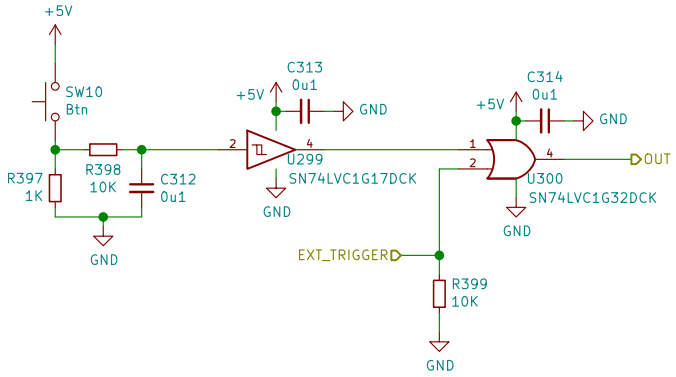
Philipp Schilk

Sheet: /UI/BTN: Inc Clk f/
File: BTN_TRIG.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 78/97

BTN + Debounce



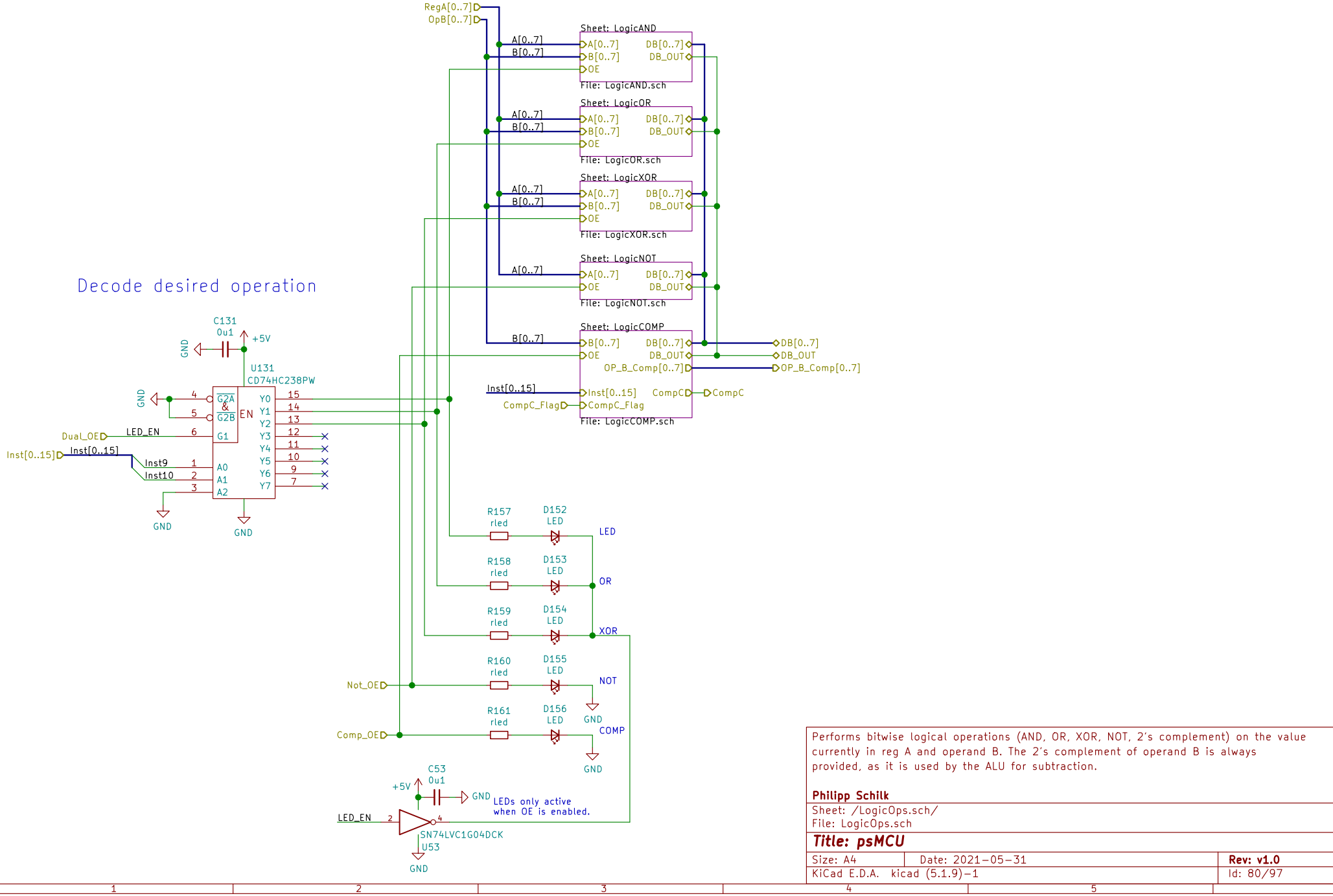
A simple single-trigger button. Handles de-bouncing and also combines the signal from an external remote.

Philipp Schilk

Sheet: /UI/BTN: Dec Clk f/
File: BTN_TRIG.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 79/97



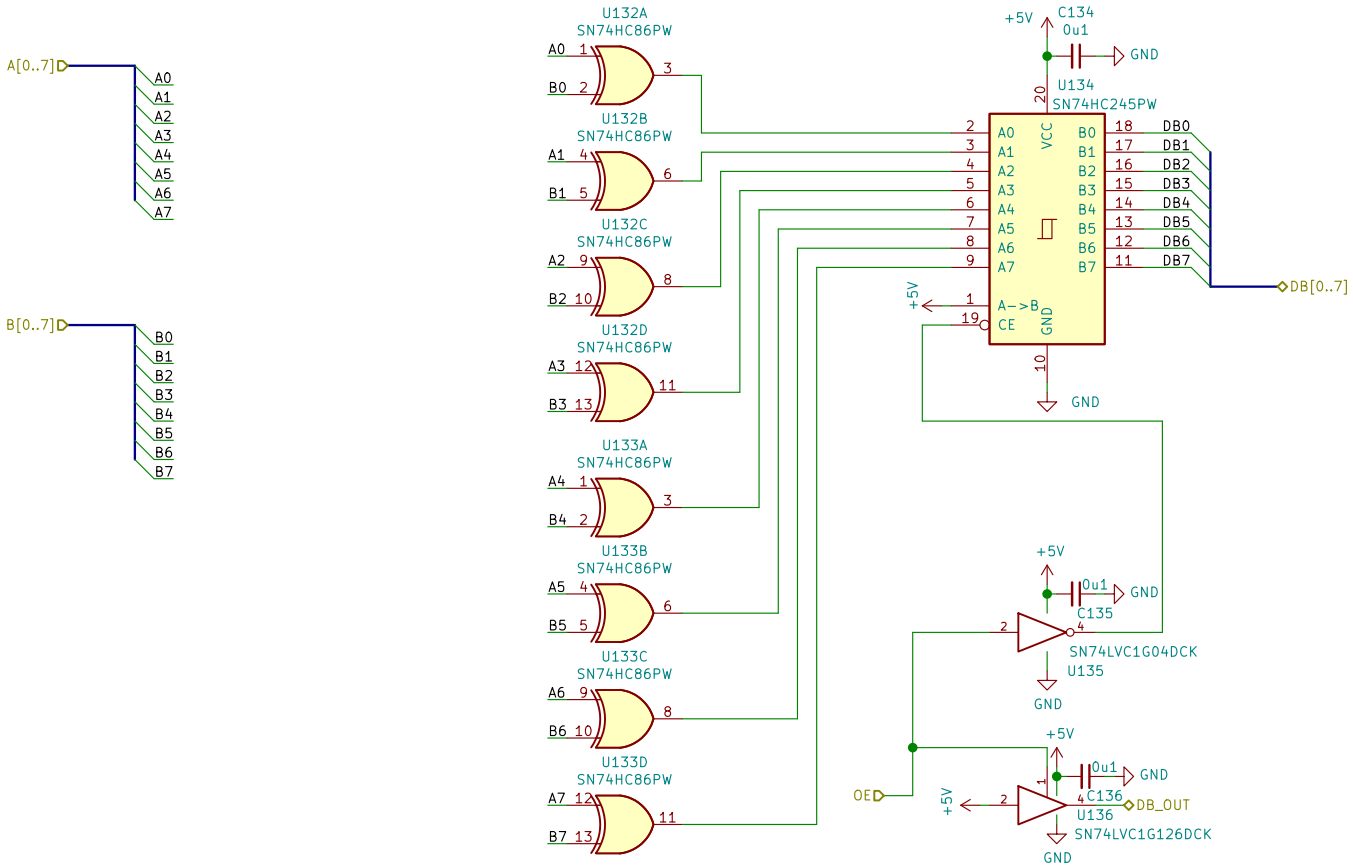
Performs bitwise logical operations (AND, OR, XOR, NOT, 2's complement) on the value currently in reg A and operand B. The 2's complement of operand B is always provided, as it is used by the ALU for subtraction.

Philipp Schilk

Sheet: /LogicOps.sch/
File: LogicOps.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 80/97



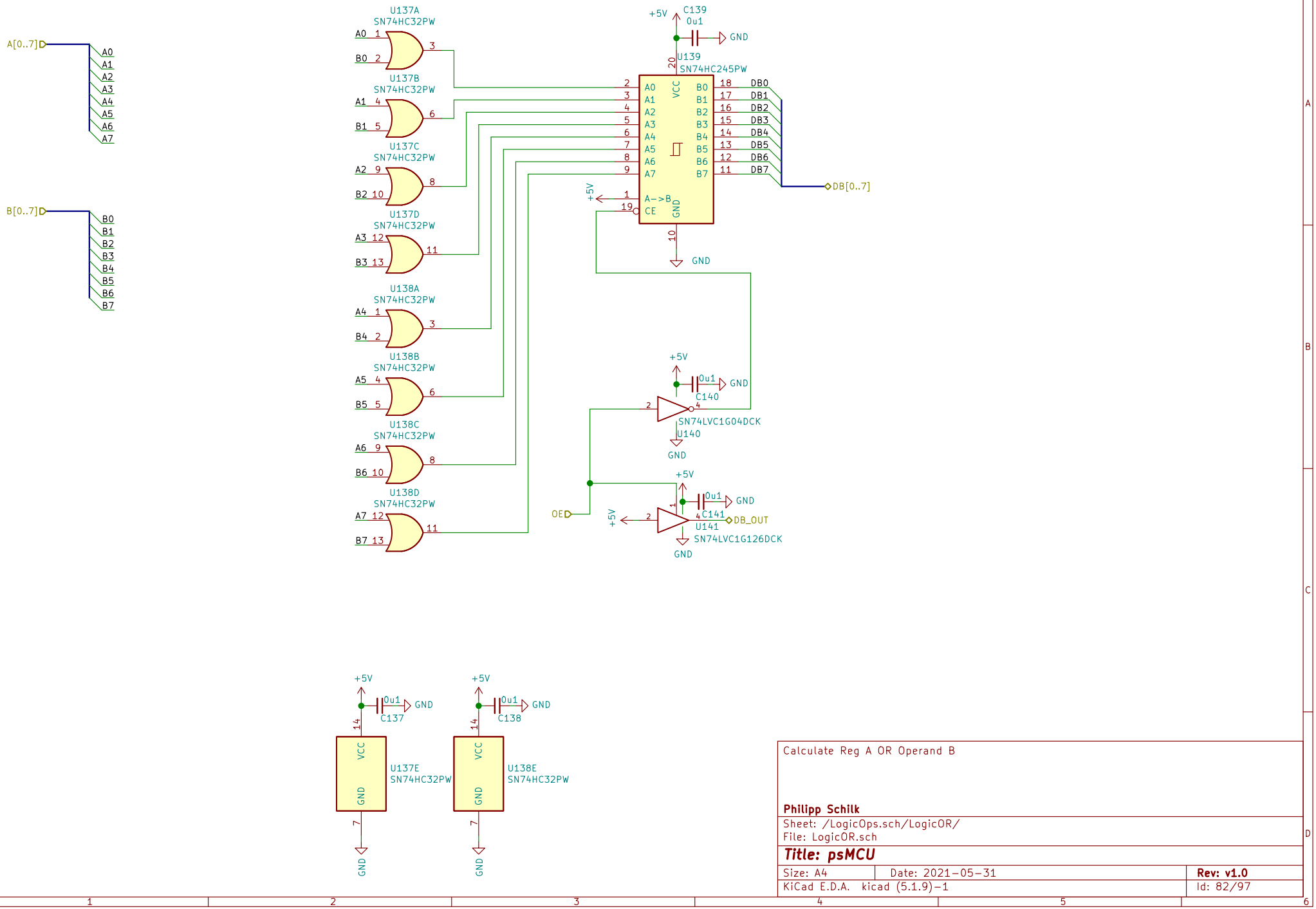
Calculate Reg A XOR Operand B

Philipp Schilk

Sheet: /LogicOps.sch/LogicXOR/
File: LogicXOR.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 81/97



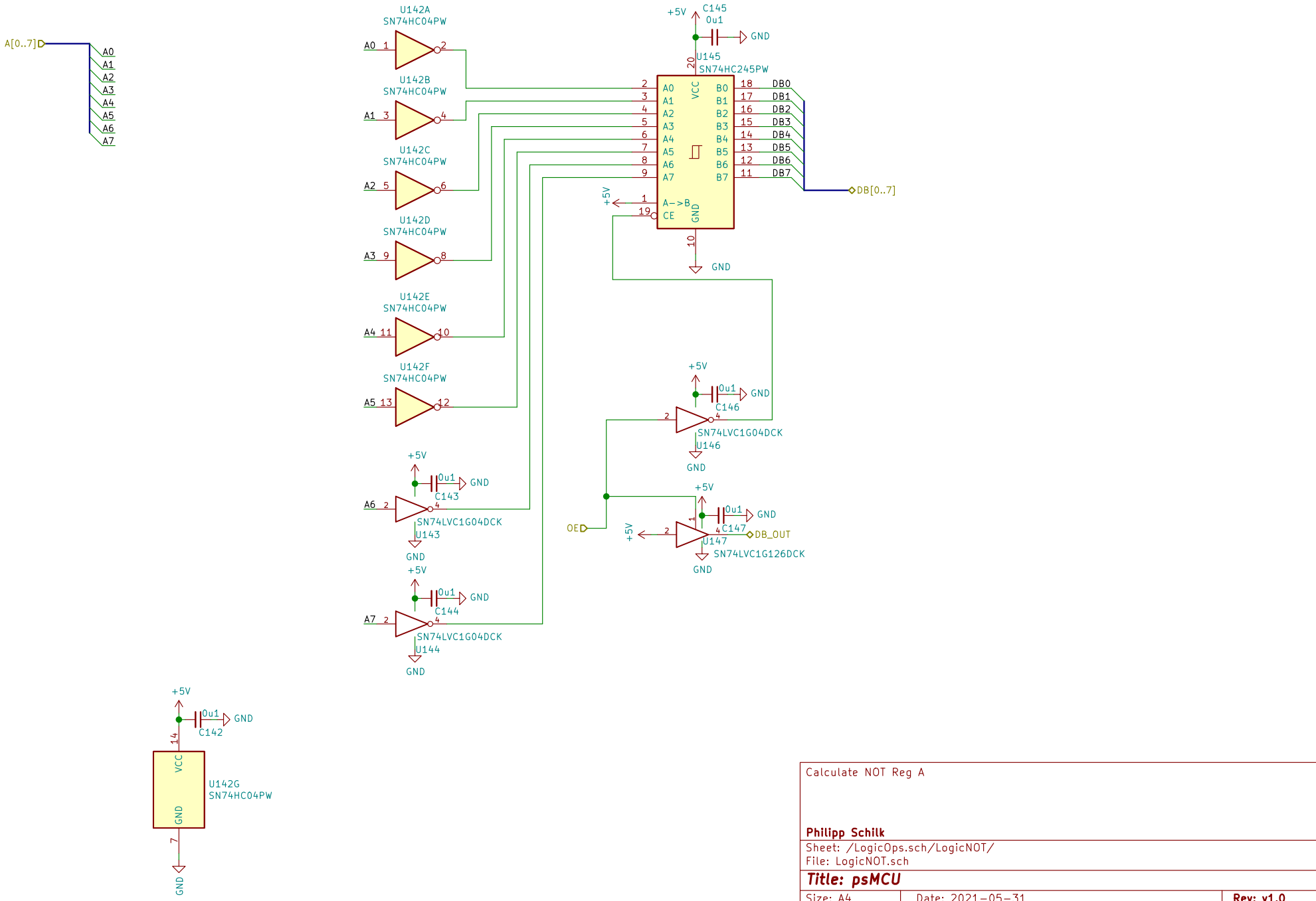
Calculate Reg A OR Operand B

Philipp Schilk

Sheet: /LogicOps.sch/LogicOR/
File: LogicOR.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 82/97



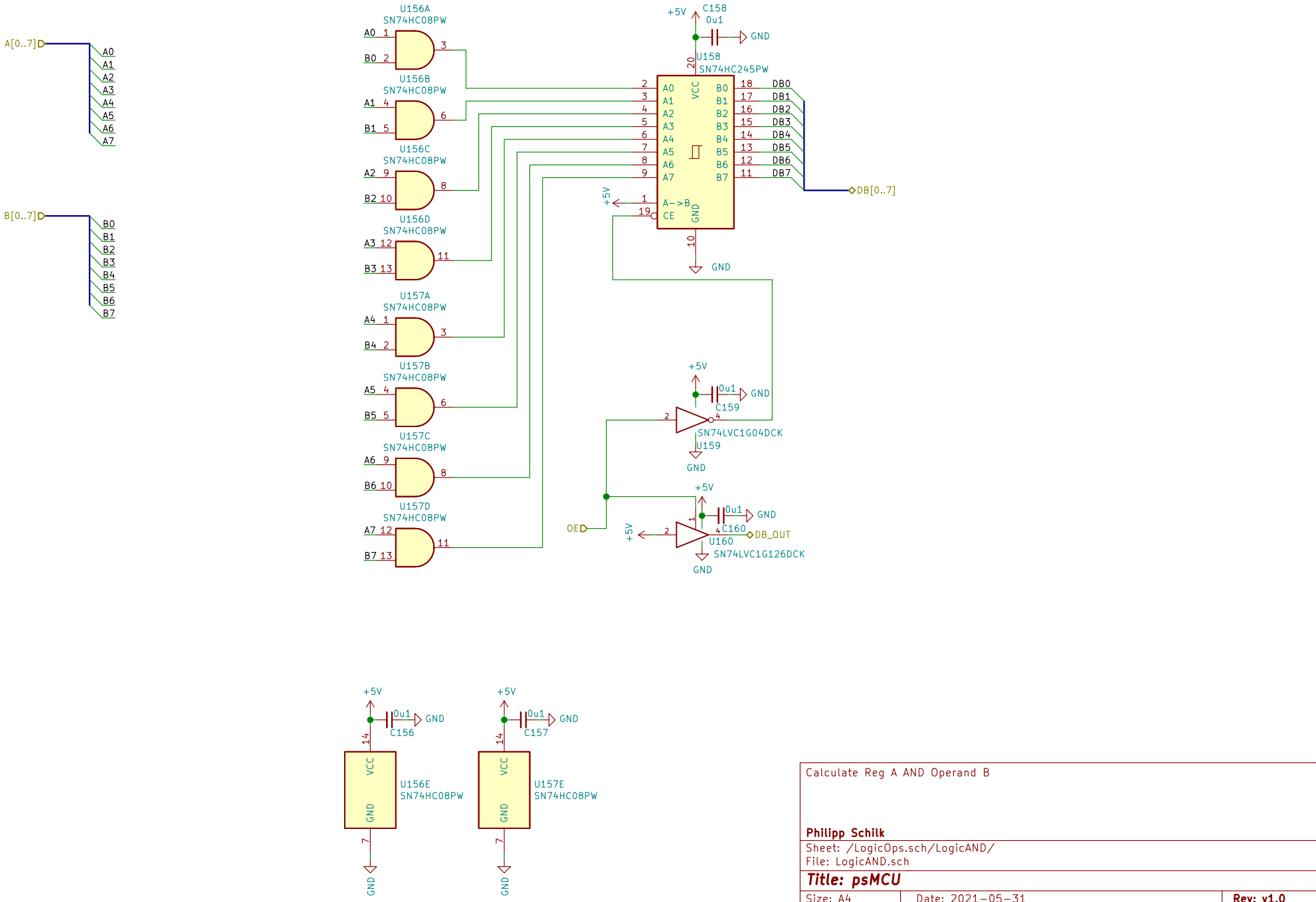
Calculate NOT Reg A

Philipp Schilk

Sheet: /LogicOps.sch/LogicNOT/
File: LogicNOT.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 83/97



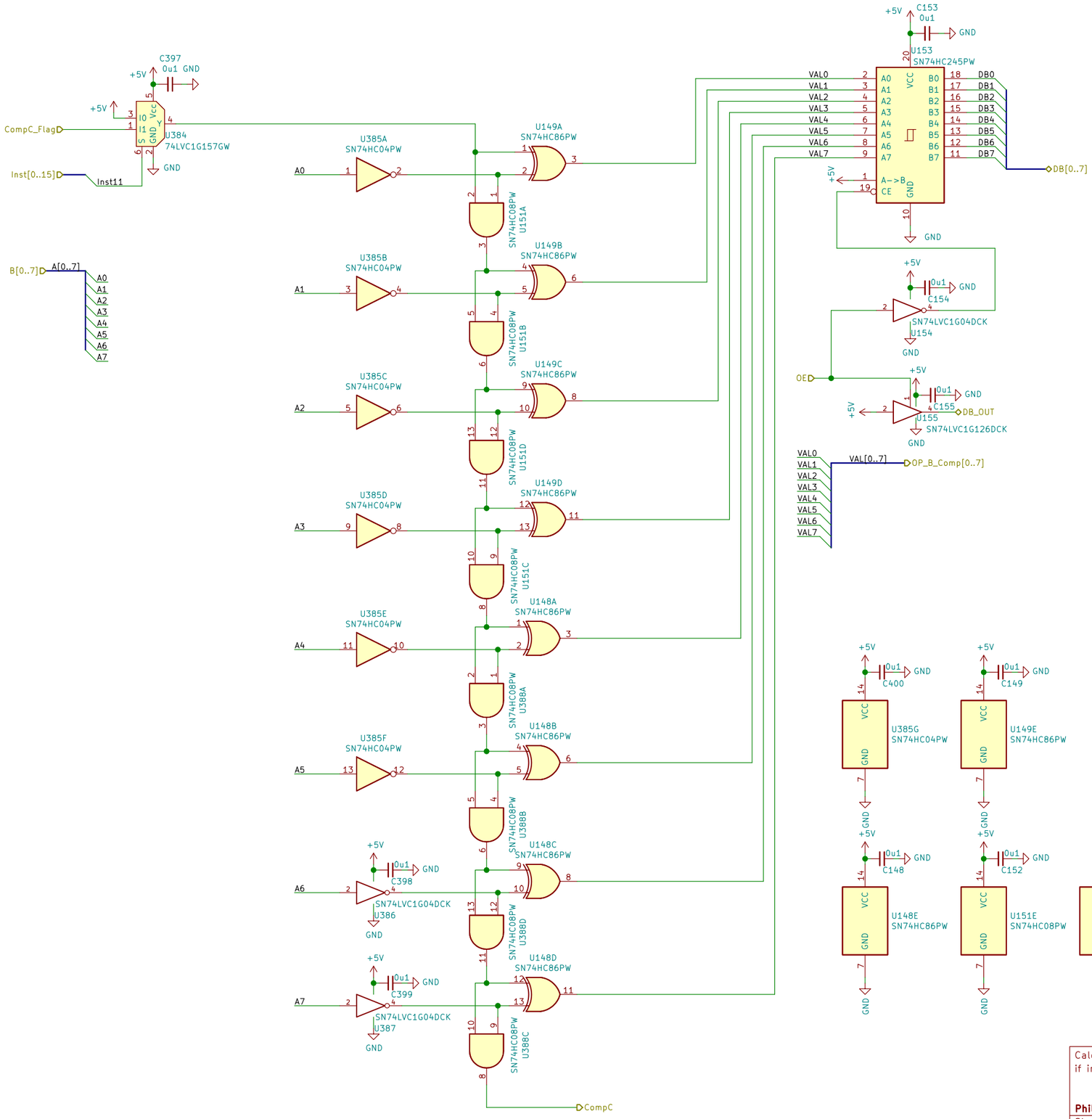
Calculate Reg A AND Operand B

Philipp Schilk

Sheet: /LogicOps.sch/LogicAND/
File: LogicAND.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 84/97



Calculate the 2's complement (*-1) of Operand B. Can carry-into the addition if instruction requires.

Philipp Schilk

Sheet: /LogicOps.sch/LogicCOMP/
File: LogicCOMP.sch

Title: psMCU

Size: A3	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 85/97

Latch correct flags during certain instructions

ALU_OE
ALU_DoBComp
Logic_Comp_OE
Select_Flag_Input
Select_CompC_Input
Latch_Shift-in
Latch_Alu_Flags
Latch_CompC

C402 0u1 — U389 SN74LVC1G08DCK
C403 0u1 — U390 SN74LVC1G32DCK
C404 0u1 — U391 SN74LVC1G32DCK
C405 0u1 — U392 SN74LVC1G32DCK
+5V, GND

Adr. Comparator

Sheet: SYS3 AdrComparator
File: AdrComparator.sch

PeriphA[0..7]
Periph_W
Periph_R
SET0
SET1
SET2
SET3
SET4
SET5
SET6
SET7
Match
W
R

R442 rled — D410 LED — W
R443 rled — D411 LED — R

CLK
RESET
R
R

C386 0u1 — U370 SN74LVC1G126DCK — DB_OUT
C406 0u1 — U393 SN74LVC1G04DCK — OE

Shift-In flag

DB[0..7]
DB0
CLK
Latch_Shift-in
Shift-In
ShiftIn

C387 0u1 — U371 74LVC1G157GW
C389 0u1 — U373 SN74LVC1G175DCK
R446 rled — D413 LED

H/HC/OVF flag

C407 0u1 — U394 74LVC1G157GW
C408 0u1 — U395 74LVC1G157GW
C409 0u1 — U396 74LVC1G157GW
C412 0u1 — U399 CD74HC173PW (4-bit Register)
C415 0u1 — U402 SN74HC245PW

C
HC
OVF
DB1
DB2
Latch_Alu_Flags

R101 rled — D88 LED — C_Out
R102 rled — D89 LED — HC
R104 rled — D90 LED — OVF

CompC flag

C410 0u1 — U397 74LVC1G157GW
C411 0u1 — U398 74LVC1G157GW
C413 0u1 — U400 SN74LVC1G175DCK

CompC
DB4
Select_CompC_Input
Latch_CompC

R100 rled — D87 LED — CompC
CompC_Out

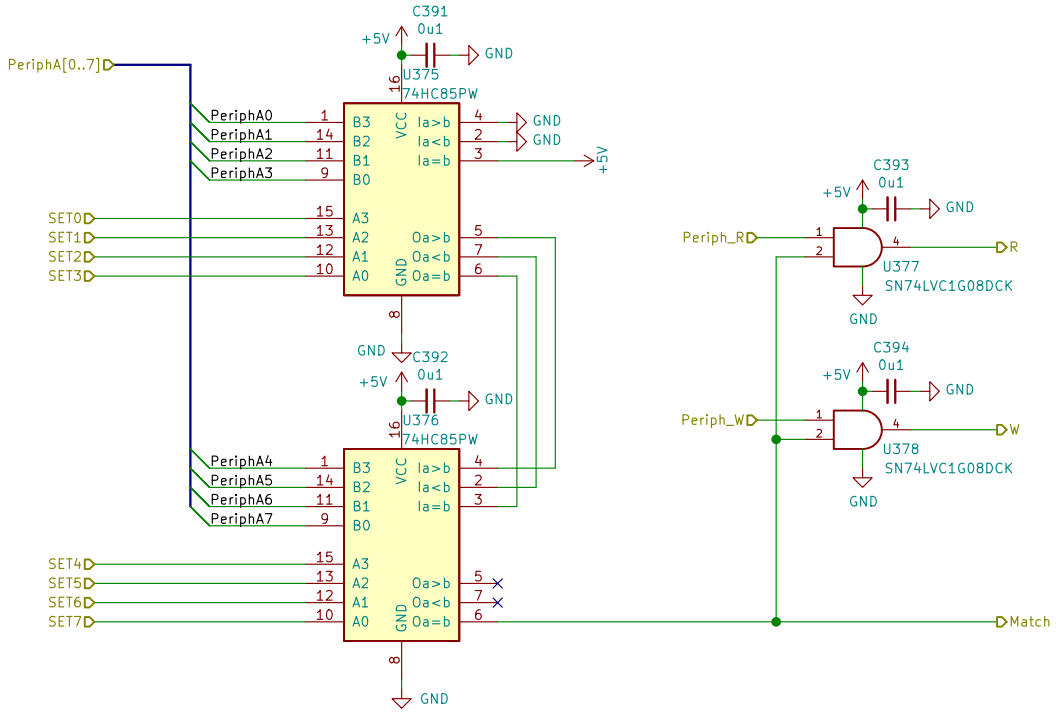
System Register 1 (Adr. 0x100). Contains the 'ShiftIn' bit (r/w), ALU flags (r/w), and complement carry flag (r/w).

Philipp Schilk

Sheet: /SysReg_1/
File: SysReg_1.sch

Title: psMCU

Size: A3	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 86/97



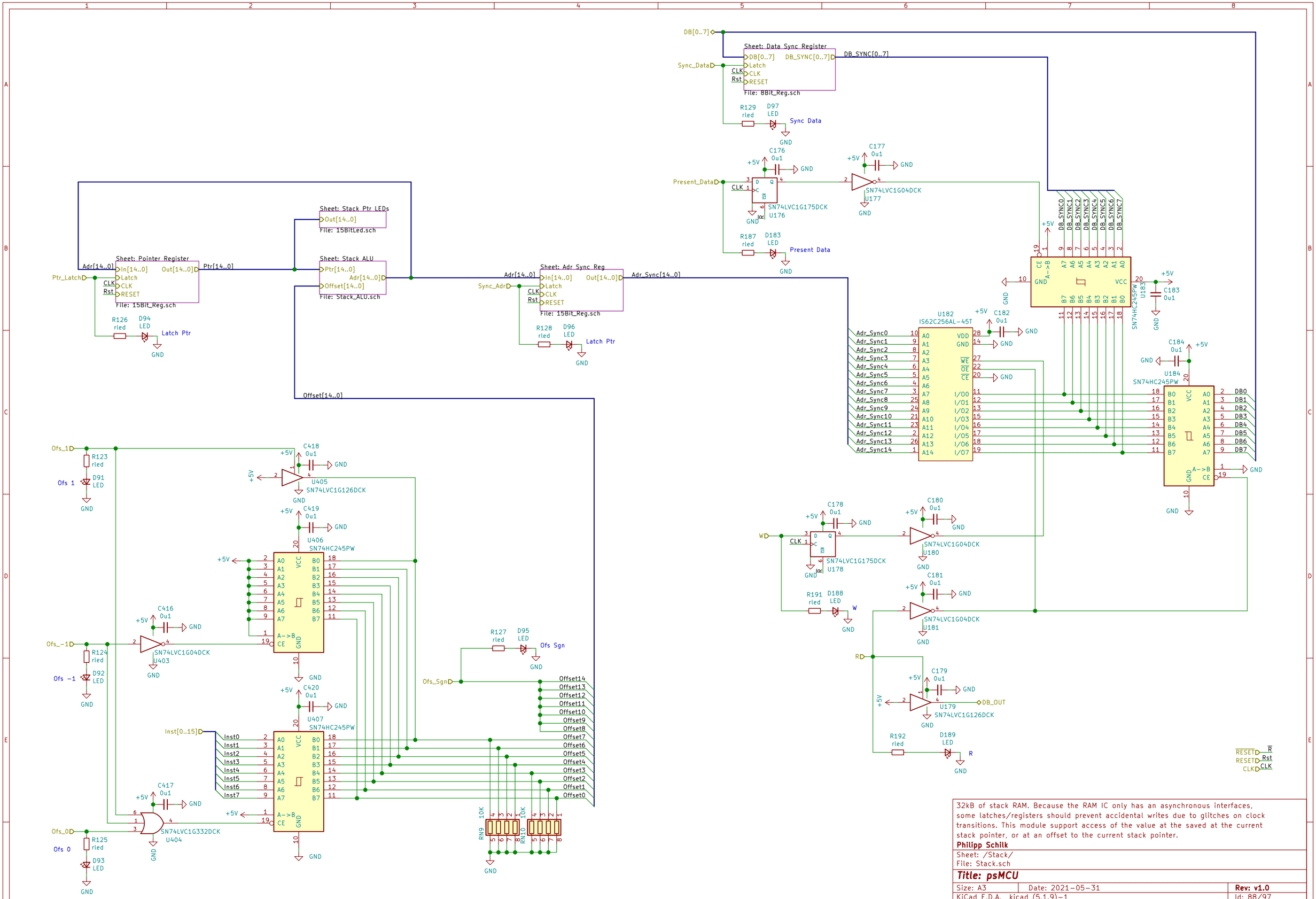
An adr. comparator. Used to check if the address currently on the RAMA bus corresponds to a specific address.

Philipp Schilk

Sheet: /SysReg_1/SYS3 AdrComparator/
File: AdrComparator.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 87/97



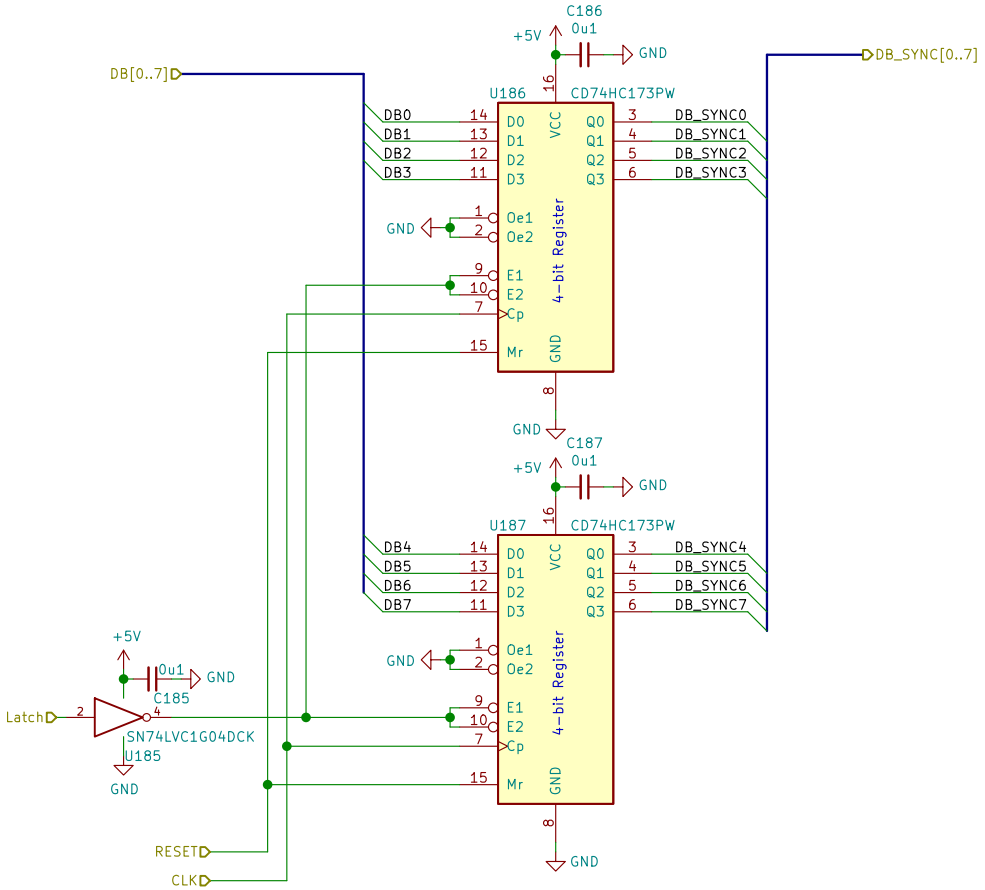
32kB of stack RAM. Because the RAM IC only has an asynchronous interfaces, some latches/registers should prevent accidental writes due to glitches on clock transitions. This module support access of the value at the saved at the current stack pointer, or at an offset to the current stack pointer.

Philipp Schilk

Sheet: /Stack/
File: Stack.sch

Title: psMCU

Size: A3	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 88/97



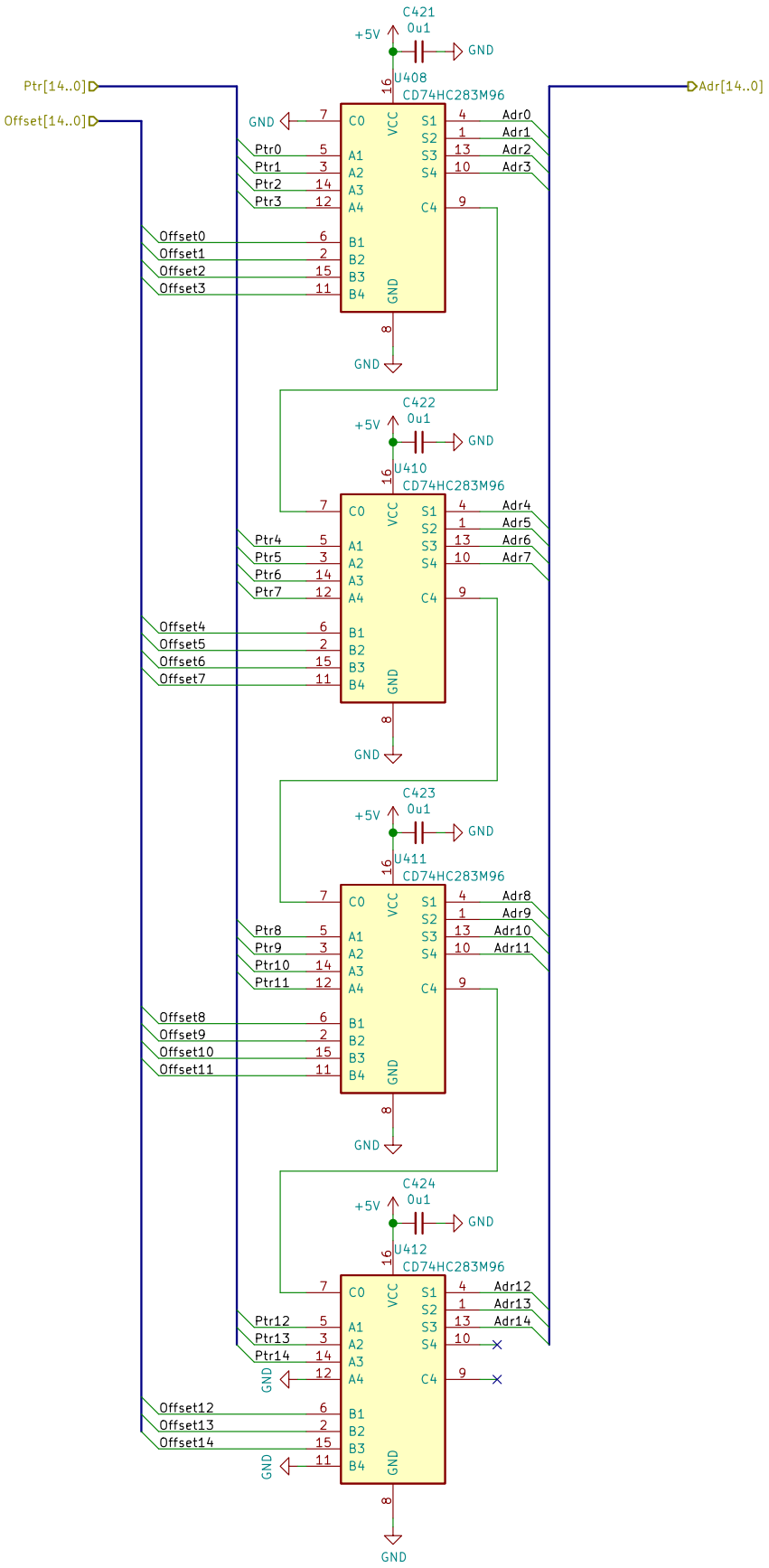
Registers to latch data into for Stack access.

Philipp Schilk

Sheet: /Stack/Data Sync Register/
File: 8Bit_Reg.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 89/97



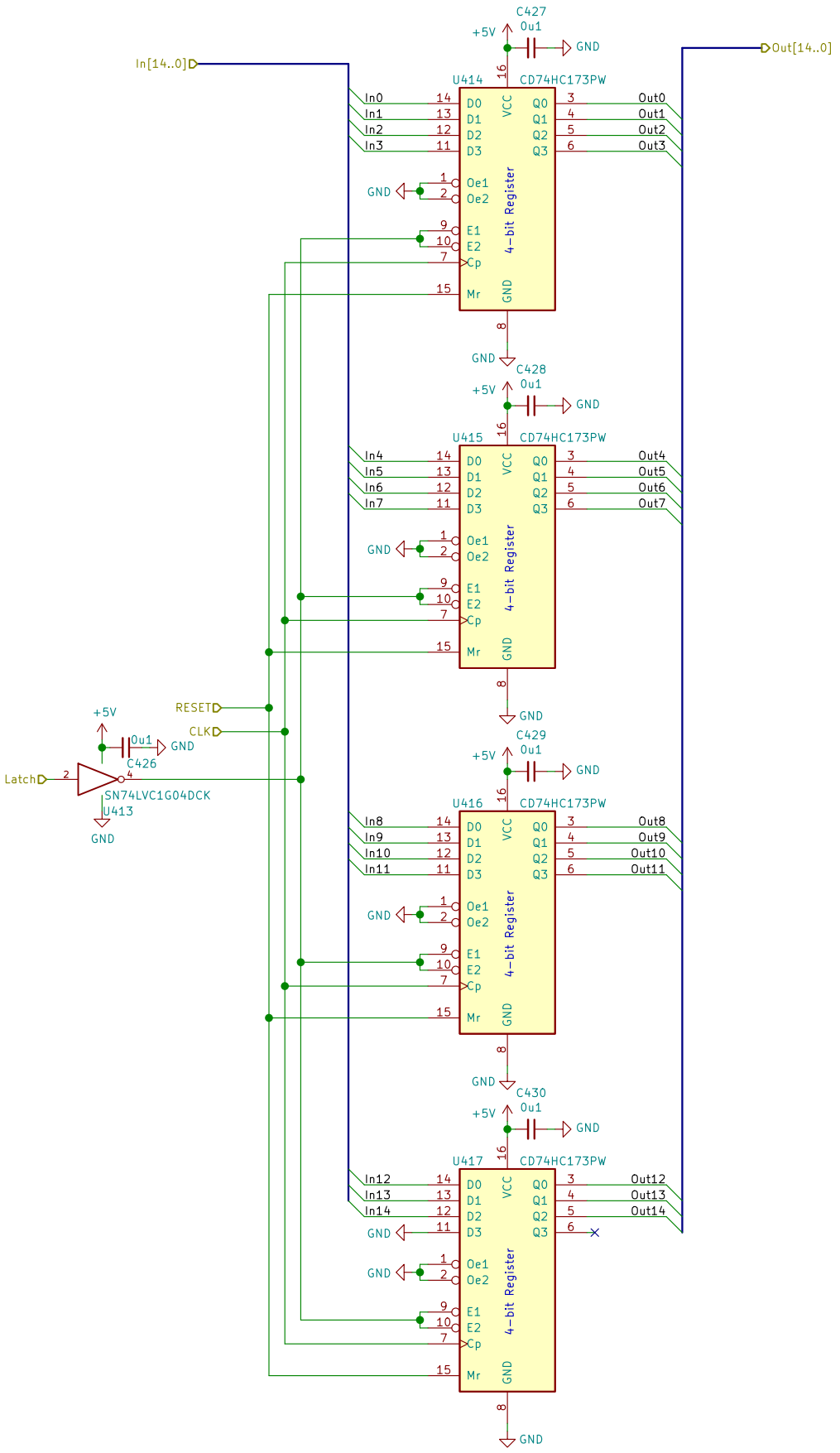
15 bit ALU to add offsets to the current stack pointer.

Philipp Schilk

Sheet: /Stack/Stack ALU/
File: Stack_ALU.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 90/97



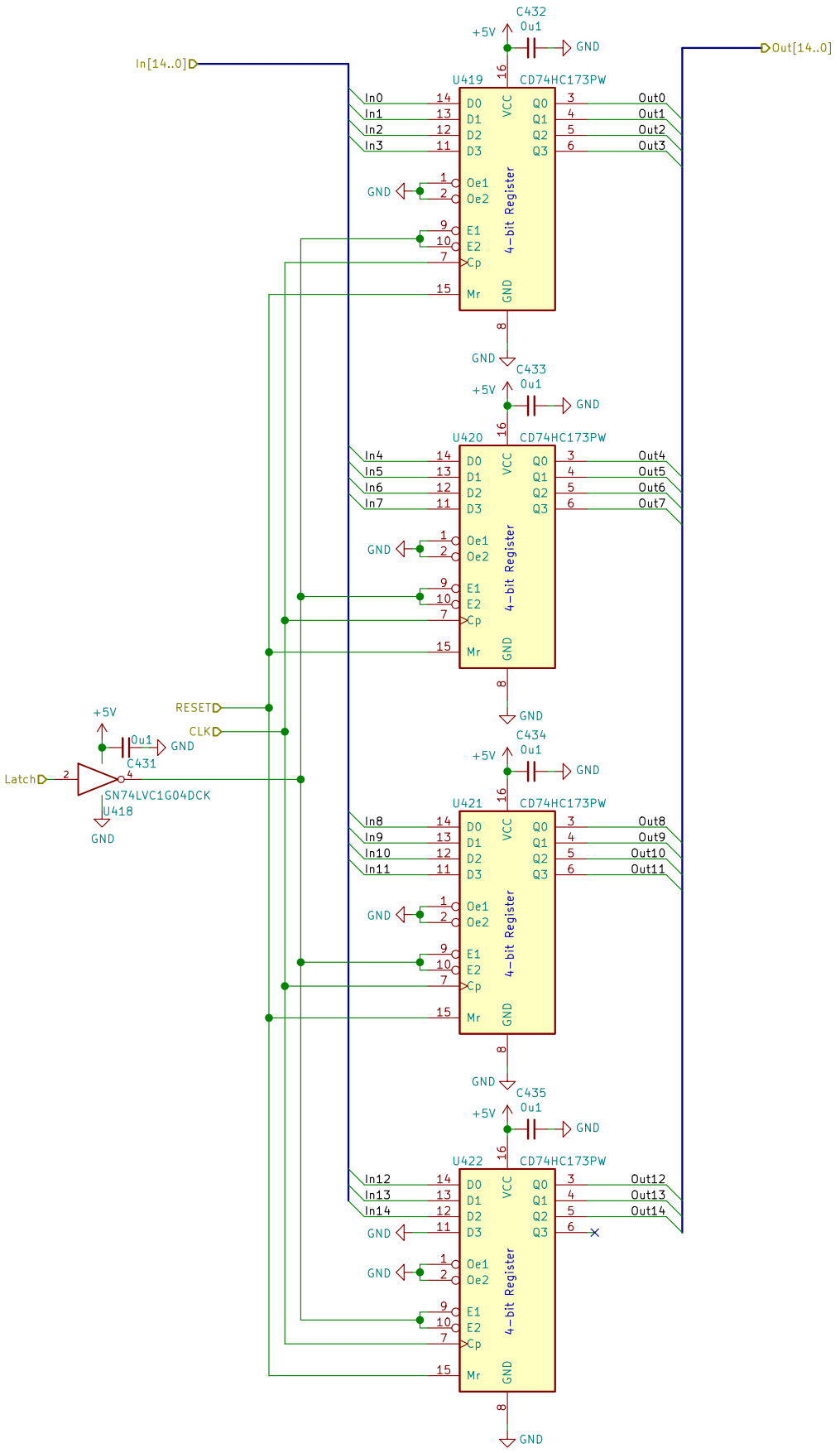
15 bit register.

Philipp Schilk

Sheet: /Stack/Adr Sync Reg/
File: 15Bit_Reg.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 91/97



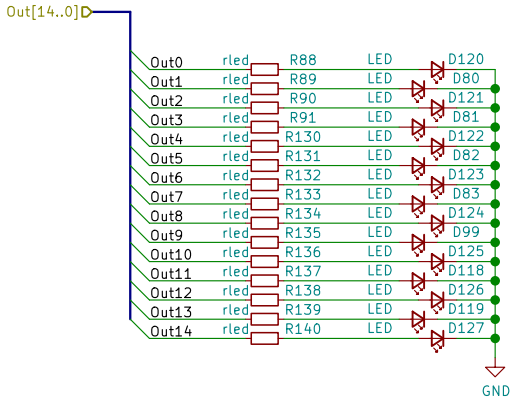
15 bit register.

Philipp Schilk

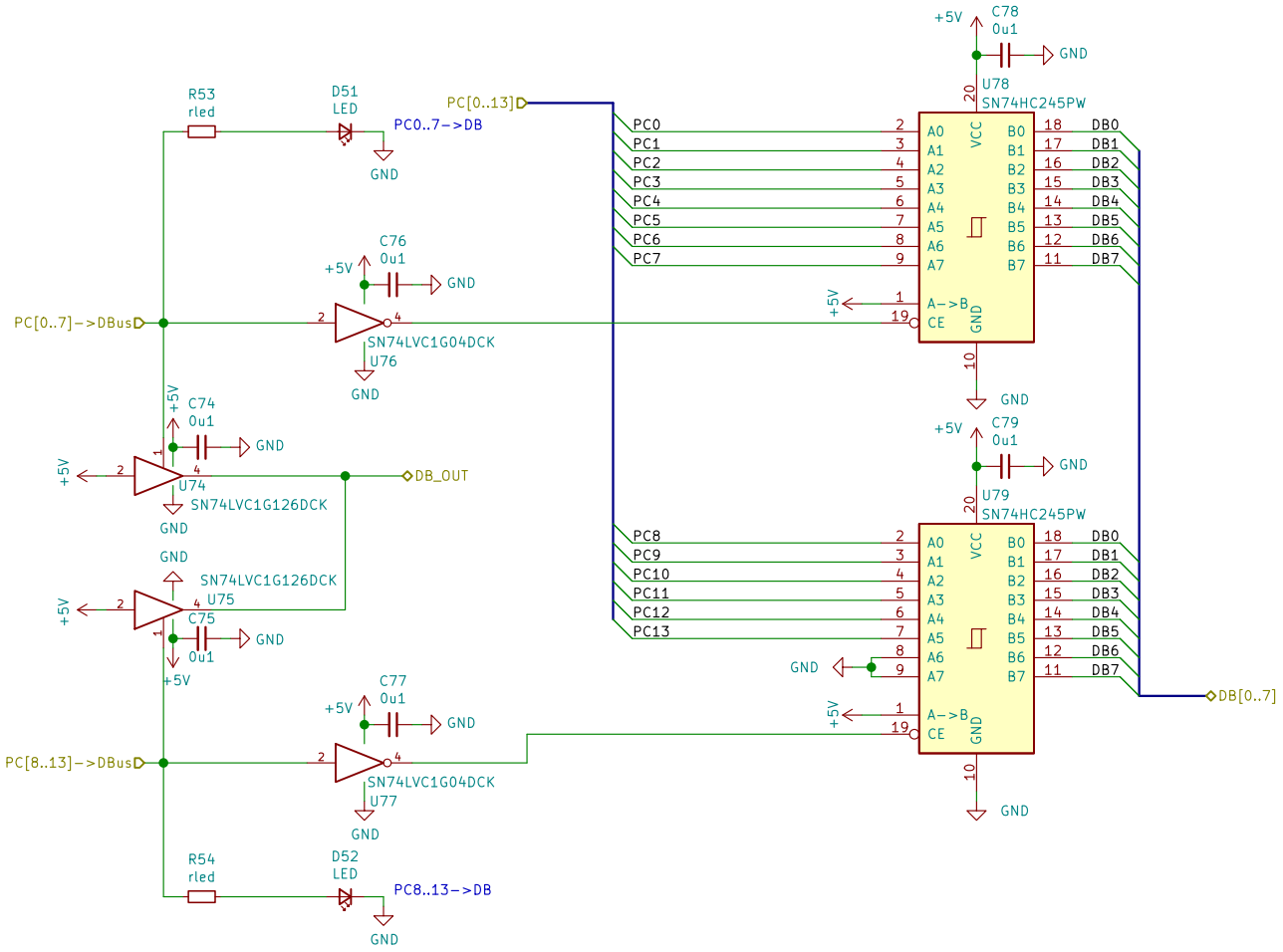
Sheet: /Stack/Pointer Register/
File: 15Bit_Reg.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 92/97



Philipp Schilk		
Sheet: /Stack/Stack Ptr LEDs/		
File: 15BitLed.sch		
Title: psMCU		
Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 93/97



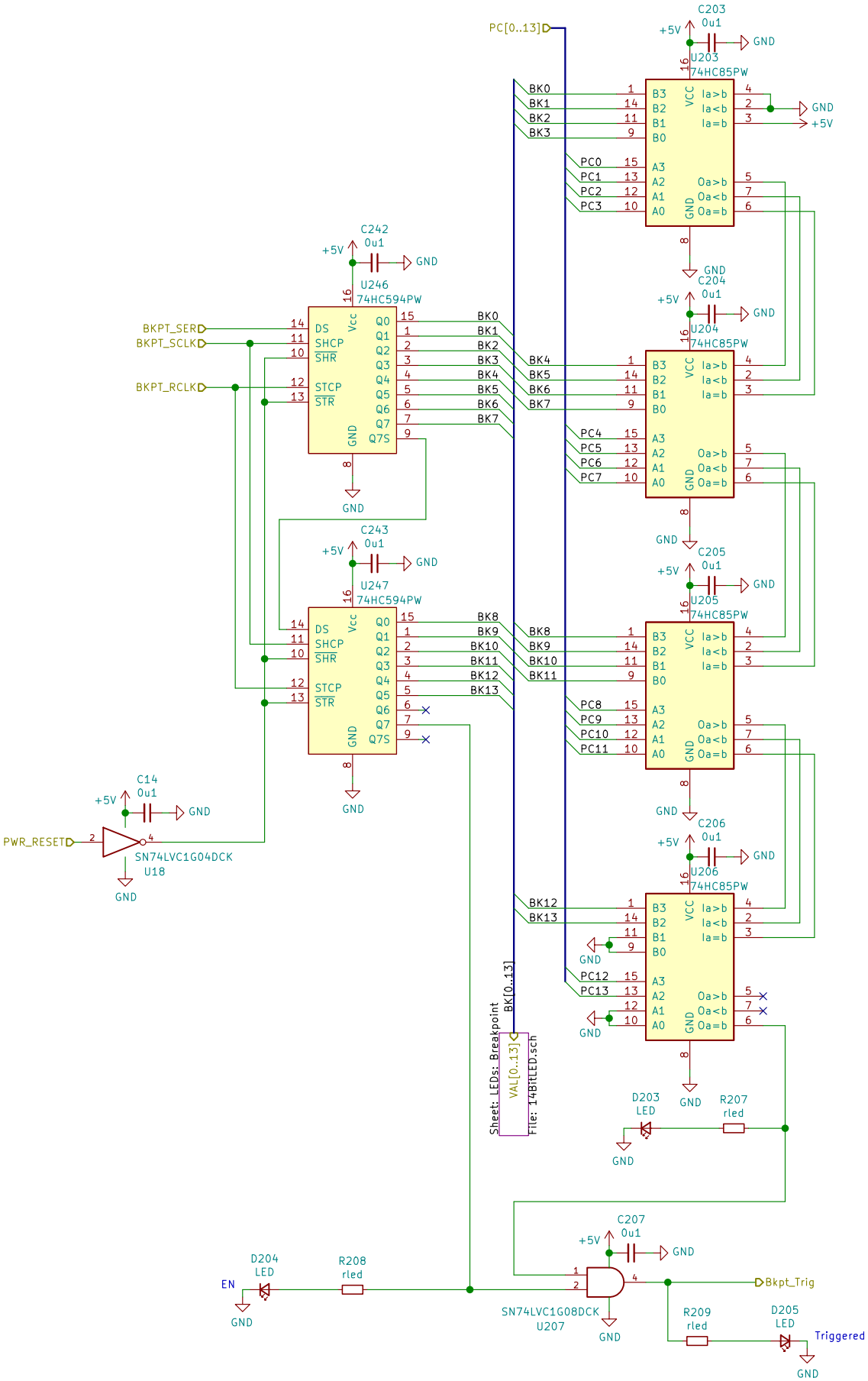
Puts the higher or lower byte of the PC counter onto the DBus. Used to push a return address onto the stack.

Philipp Schilk

Sheet: /PC[0..7]/[8..13] -> DBus/
File: PC_to_DBus.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 94/97



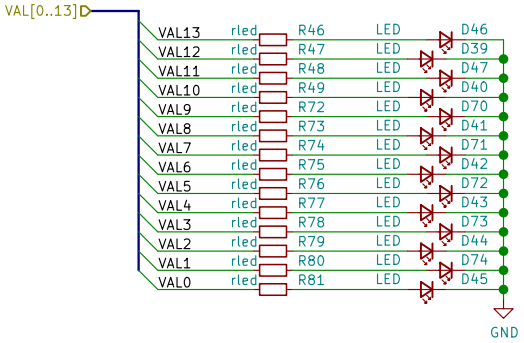
Compares current program counter value against a breakpoint-address settable using a serial interface from the programmer. Can be enabled/disabled.

Philipp Schilk

Sheet: /Breakpoint/
File: Breakpoint.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 95/97



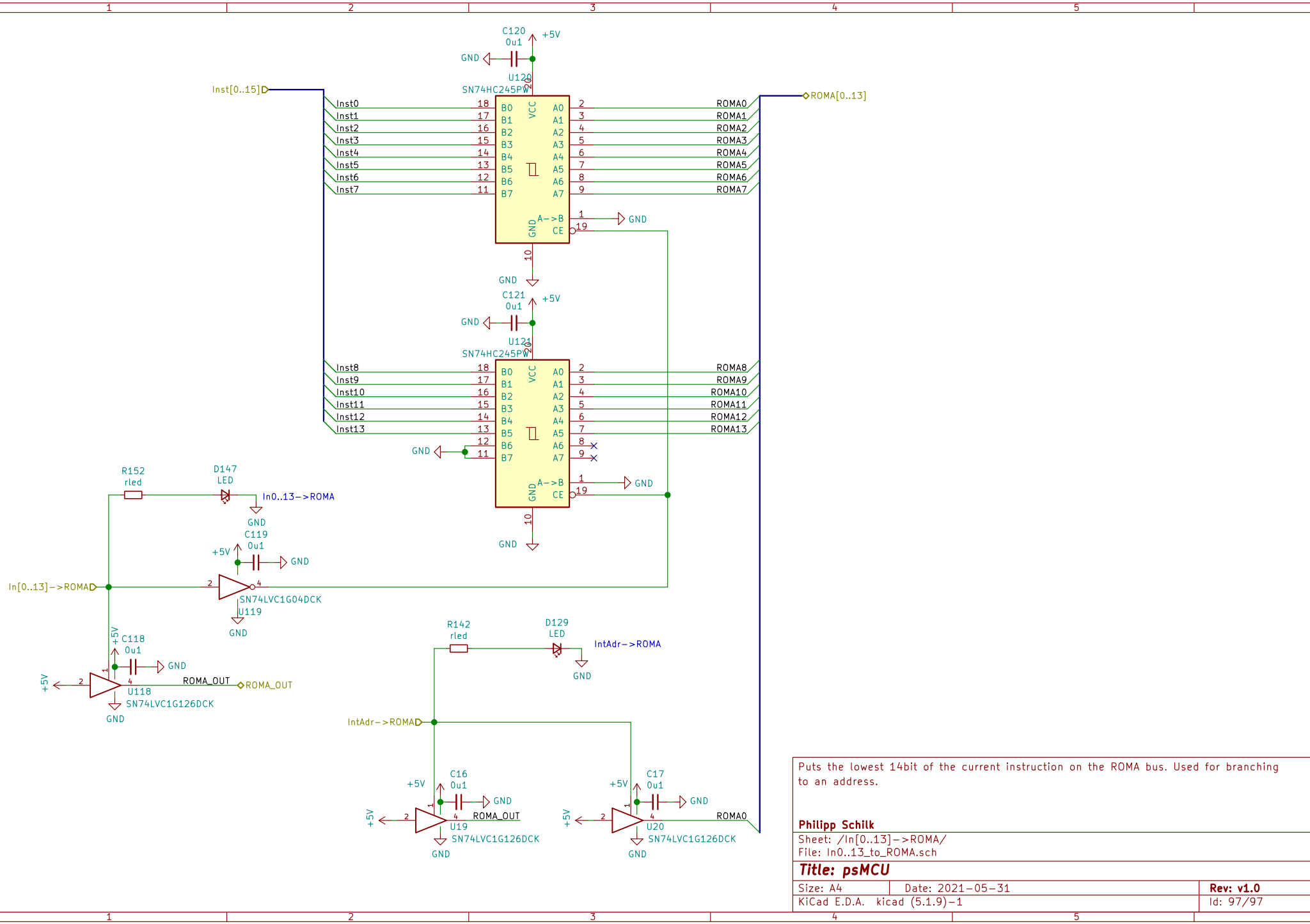
14bit binary LED display.

Philipp Schilk

Sheet: /Breakpoint/LEDs: Breakpoint/
File: 14BitLED.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 96/97



Puts the lowest 14bit of the current instruction on the ROMA bus. Used for branching to an address.

Philipp Schilk

Sheet: /In[0..13]->ROMA/
File: In0..13_to_ROMA.sch

Title: psMCU

Size: A4	Date: 2021-05-31	**Rev: v1.0**
KiCad E.D.A. kicad (5.1.9)-1		Id: 97/97