Sheet: Output Display

File: Output Display.sch

Sheet: Register XY

File: Register XY.sch

Sheet: Speed Control

File: Speed Control.sch

Sheet: Program Counter

File: Program Counter.sch

Sheet: Clock

File: Clock.sch

Sheet: Instruction Fetch

File: Instruction Fetch.sch

Sheet: Power-on Reset

File: Power-on Reset.sch

Sheet: Data RAM

File: Data RAM.sch

Sheet: Instruction Decode

File: Instruction Decode.sch

Sheet: Register A

File: Register A.sch

Sheet: Serial

File: Serial.sch

Sheet: Execute

File: Execute.sch

Sheet: Register B

File: Register B.sch

Sheet: Register D

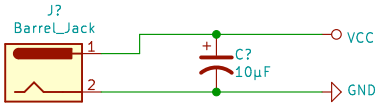
File: Register D.sch

Sheet: Bus Display

File: Bus Display.sch

Sheet: ALU

File: ALU.sch

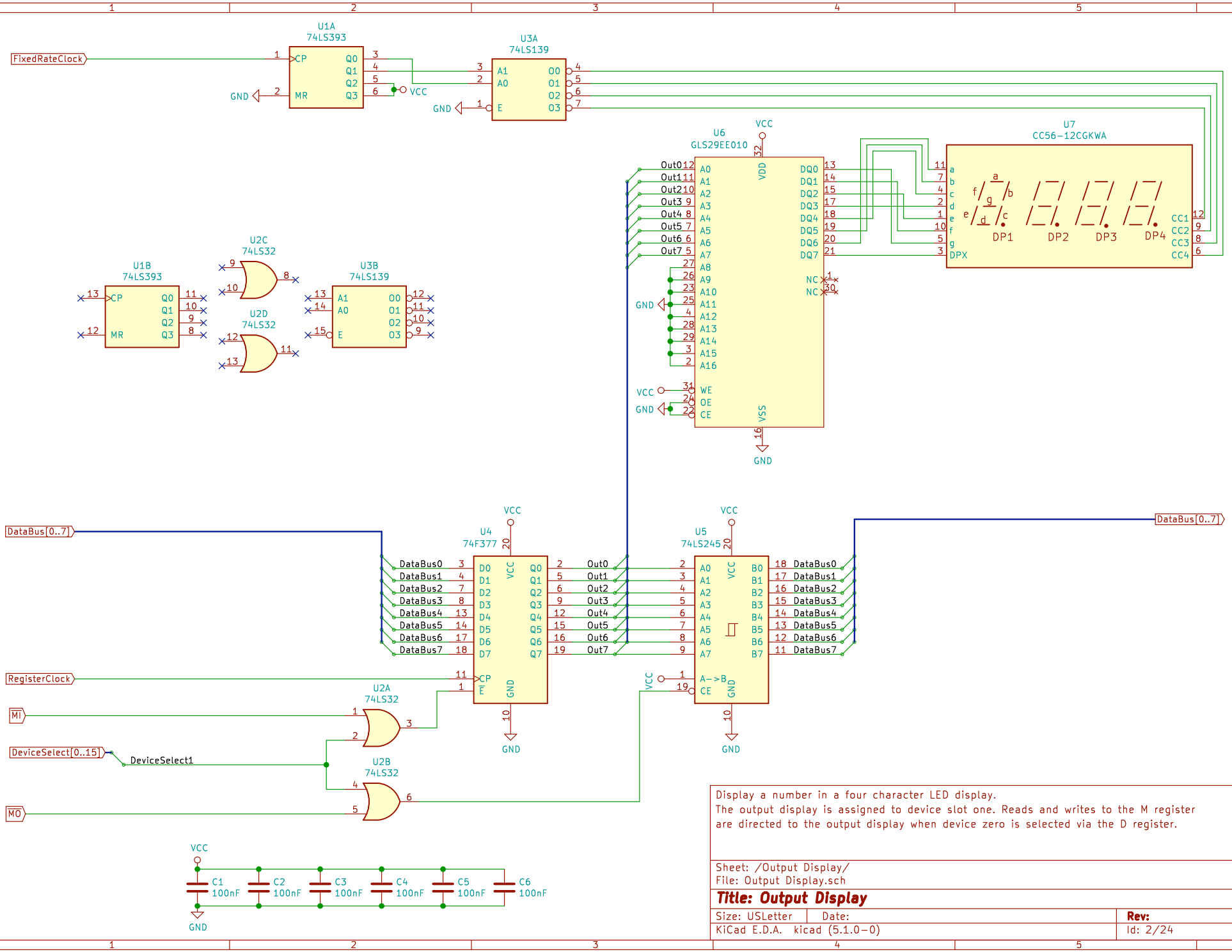


TTL microcomputer built from 74xx series logic chips.

Sheet: /
File: TurtleTTL.sch

Title: Turtle TTL

Size: A	Date:	**Rev:**
KiCad E.D.A. kicad (5.1.0-0)		Id: 1/24

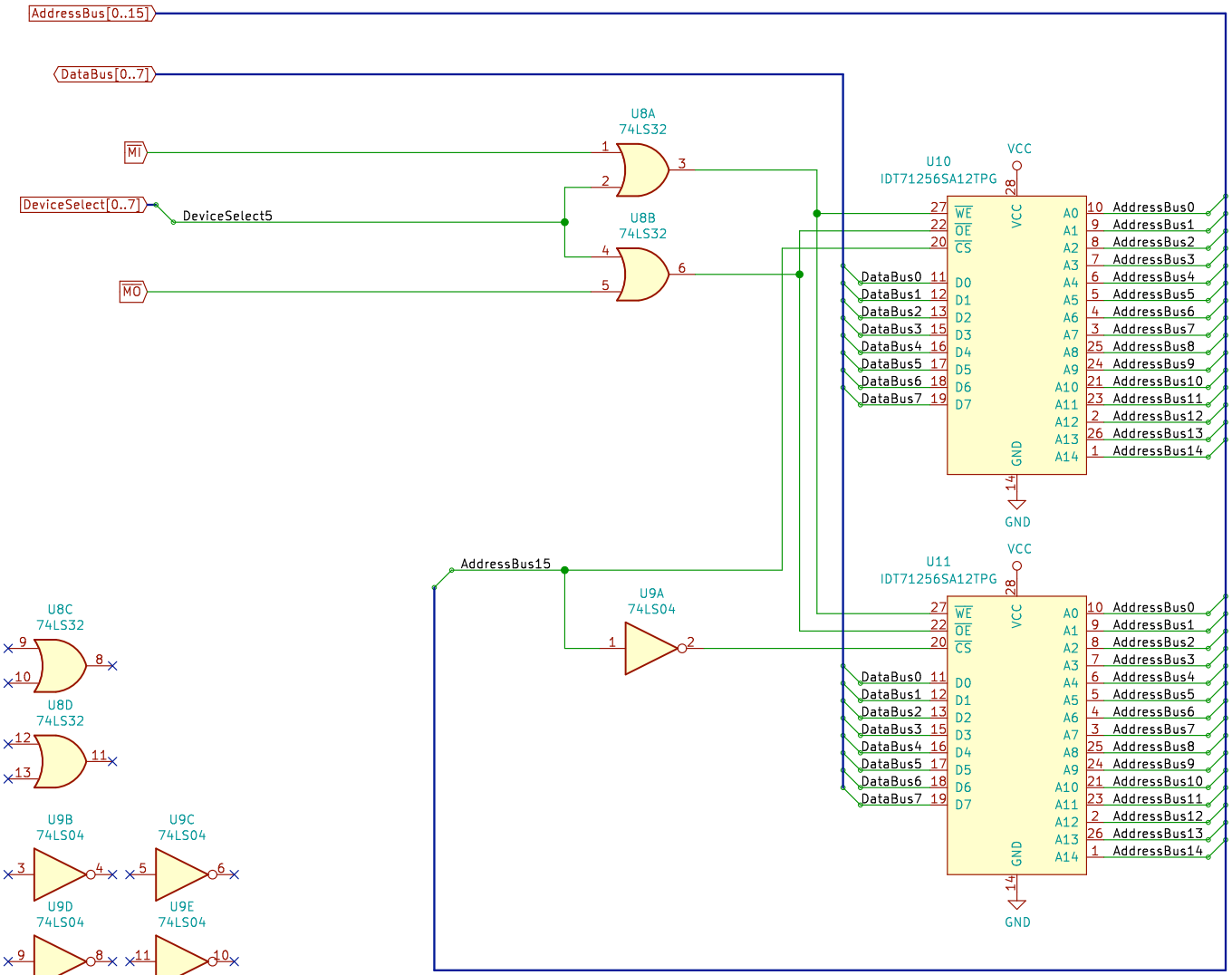


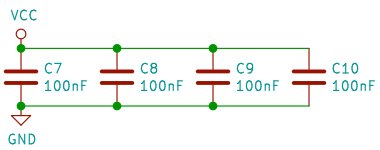
Display a number in a four character LED display.
The output display is assigned to device slot one. Reads and writes to the M register are directed to the output display when device zero is selected via the D register.

Sheet: /Output Display/
File: Output Display.sch

Title: Output Display

Size: USLetter	Date:	Rev:
KiCad E.D.A. kicad (5.1.0-0)		Id: 2/24



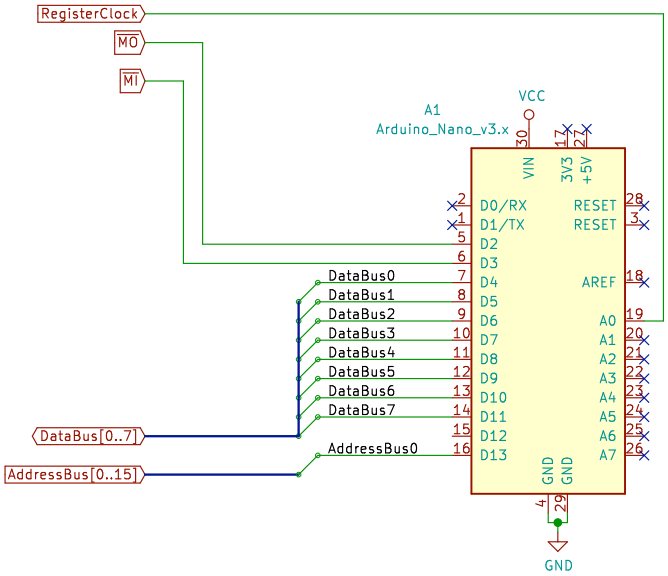


64KB Data RAM is connected to device slot five.
Reads and writes to the M register are directed to Data RAM when device 5 is selected via the D register.
The MSB of the address selects between two 32KB SRAM ICs.

Sheet: /Data RAM/
File: Data RAM.sch

Title: Data RAM

Size: USLetter	Date:	Rev:
KiCad E.D.A. kicad (5.1.0-0)		Id: 3/24

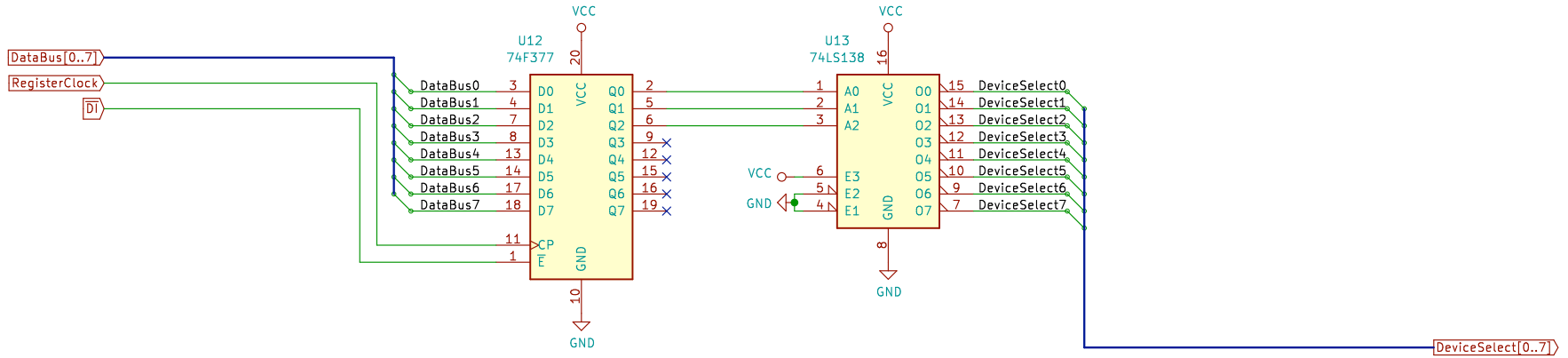


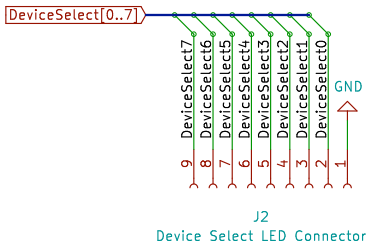
An Arduino Nano serves as a serial interface module.

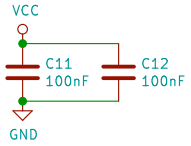
Sheet: /Serial/
File: Serial.sch

Title: Serial I/O

Size: USLetter | Date: | **Rev:**
KiCad E.D.A. kicad (5.1.0-0) | Id: 4/24







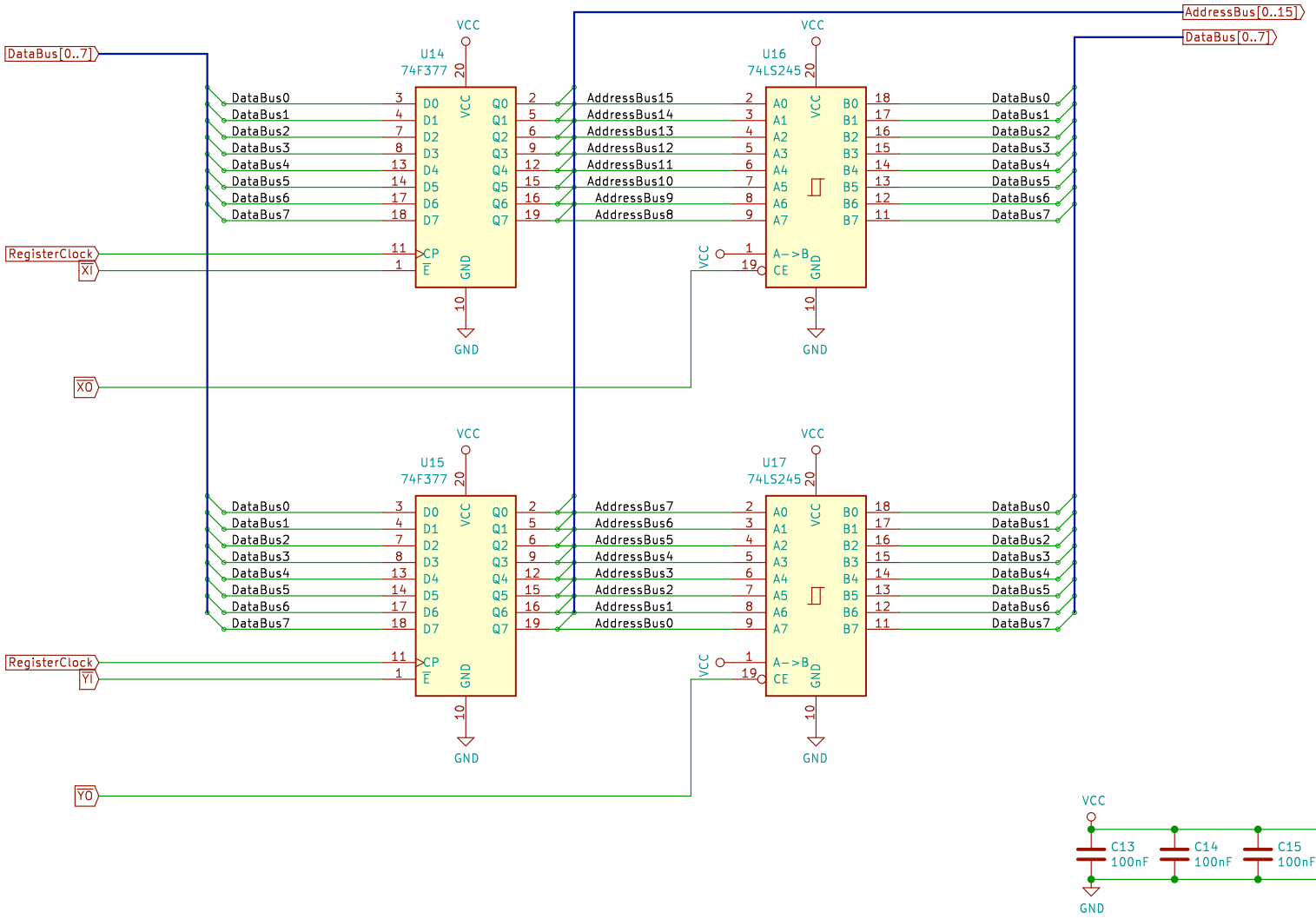
Register D controls the device select lines for peripherals and memory.

Sheet: /Register D/
File: Register D.sch

Title: Register D

Size: A | Date: | **Rev:**

KiCad E.D.A. kicad (5.1.0-0) | Id: 5/24

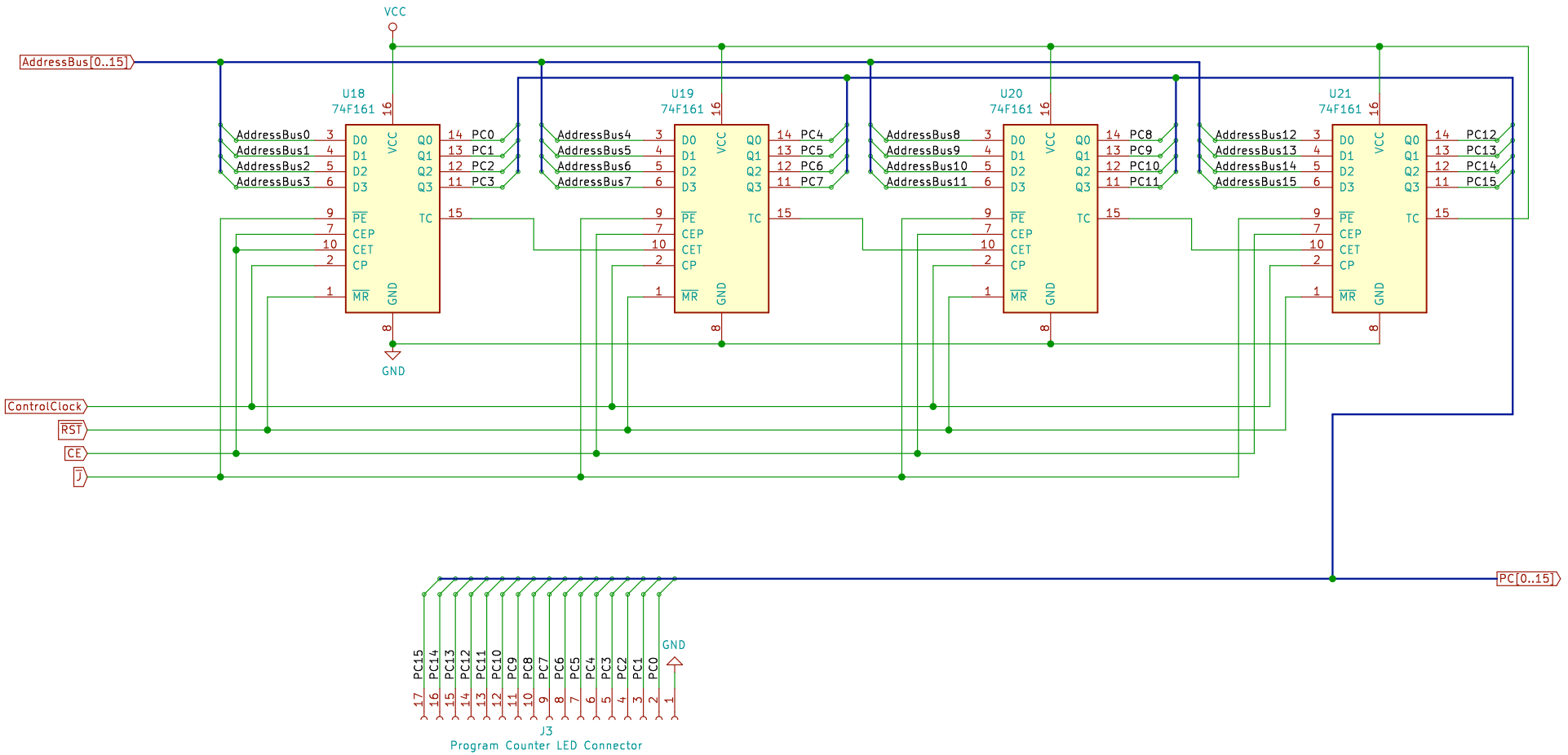


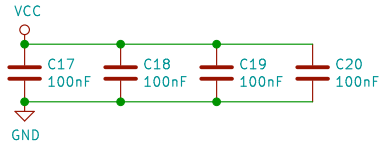
The XY register pair sets the value on the sixteen-bit Address Bus.

Sheet: /Register XY/
File: Register XY.sch

Title: Registers X and Y

Size: USLetter	Date:	Rev:
KiCad E.D.A. kicad (5.1.0-0)		Id: 6/24





Sheet: /Program Counter/	
File: Program Counter.sch	
Title: Program Counter	
Size: USLetter | Date:	**Rev:**
KiCad E.D.A. kicad (5.1.0-0)	Id: 7/24

Sheet: PC/IF

File: PC_IF.sch

Sheet: Instruction RAM Address

File: Instruction RAM Address.sch

Sheet: Instruction ROM

File: Instruction ROM.sch

Sheet: Instruction RAM

File: Instruction RAM.sch

Sheet: Instruction Register

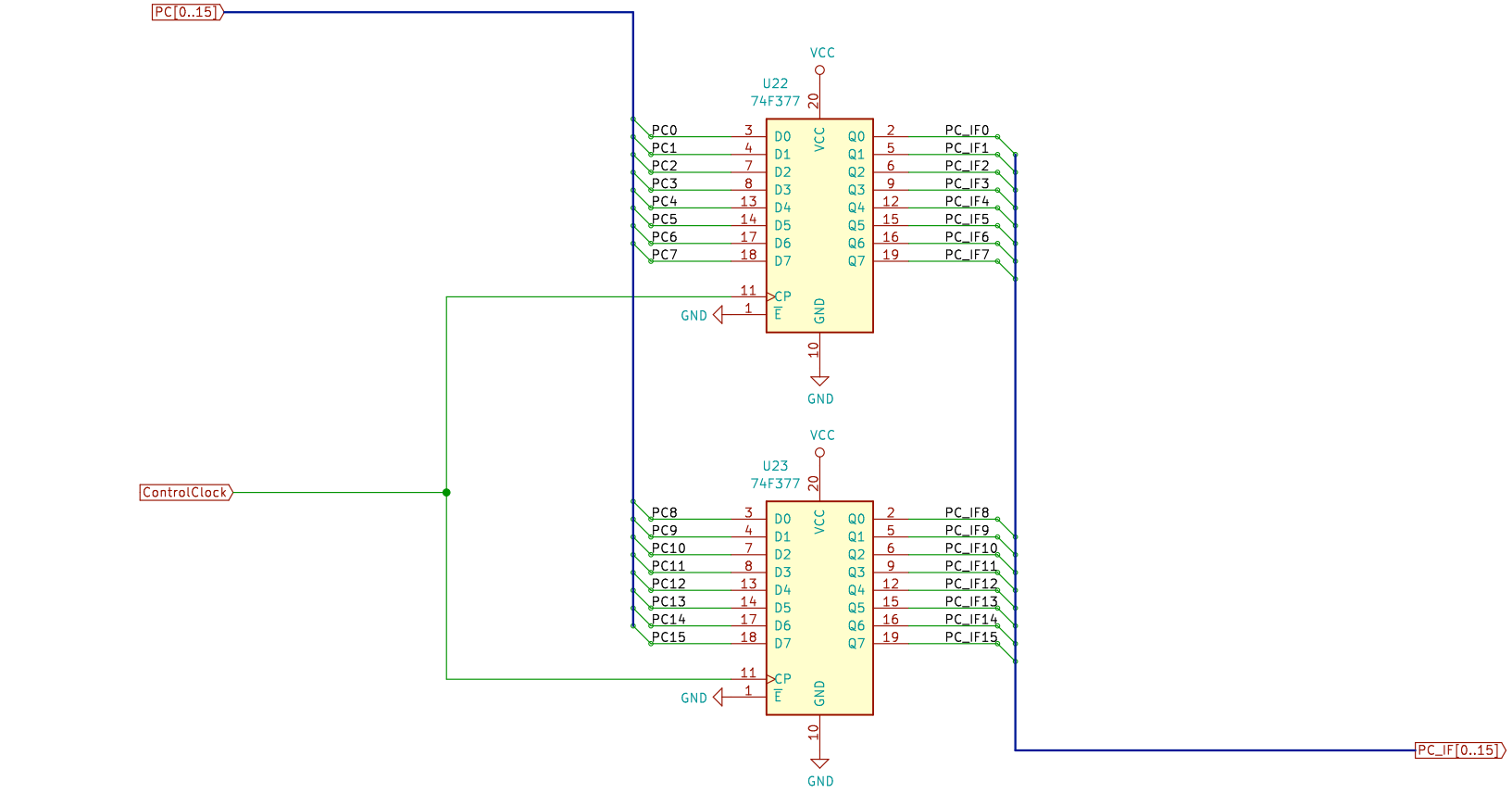
File: Instruction Register.sch

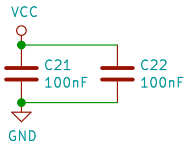
Instructions can be fetched from either Instruction ROM or Instruction RAM.
The lower 32KB of the address space is mapped to ROM, the remainder to RAM.

Sheet: /Instruction Fetch/
File: Instruction Fetch.sch

Title: Instruction Fetch

Size: A4	Date:	**Rev:**
KiCad E.D.A. kicad (5.1.0-0)		Id: 8/24



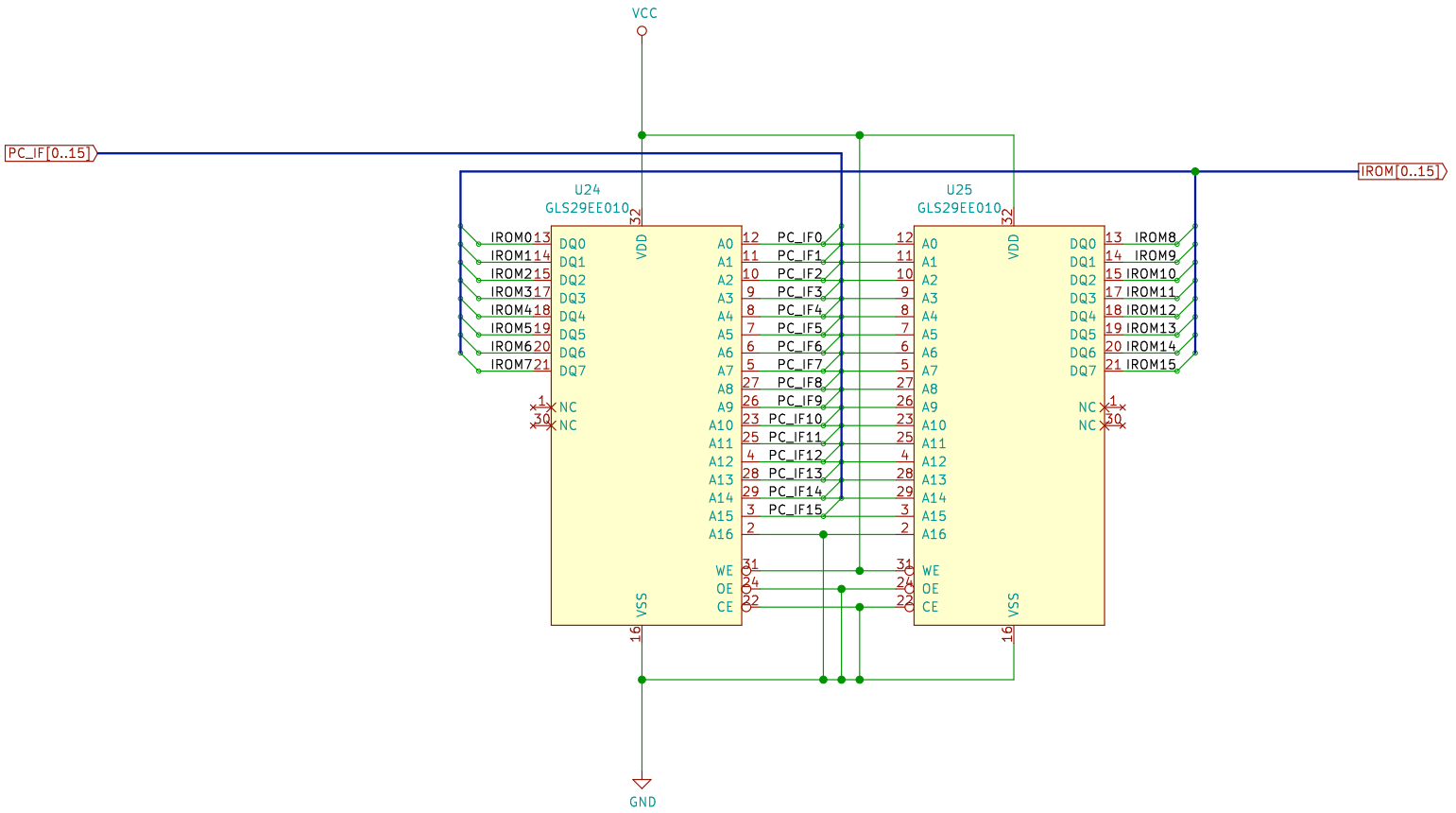


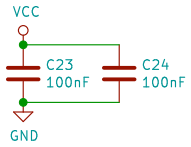
The PC/IF register sits between the program counter and the Instruction Fetch stage. This alleviates timing constraints related to the phase shift between the register clock and the control clock.

Sheet: /Instruction Fetch/PC/IF/
File: PC_IF.sch

Title: PC/IF

Size: USLetter	Date:	Rev:
KiCad E.D.A. kicad (5.1.0-0)		Id: 9/24



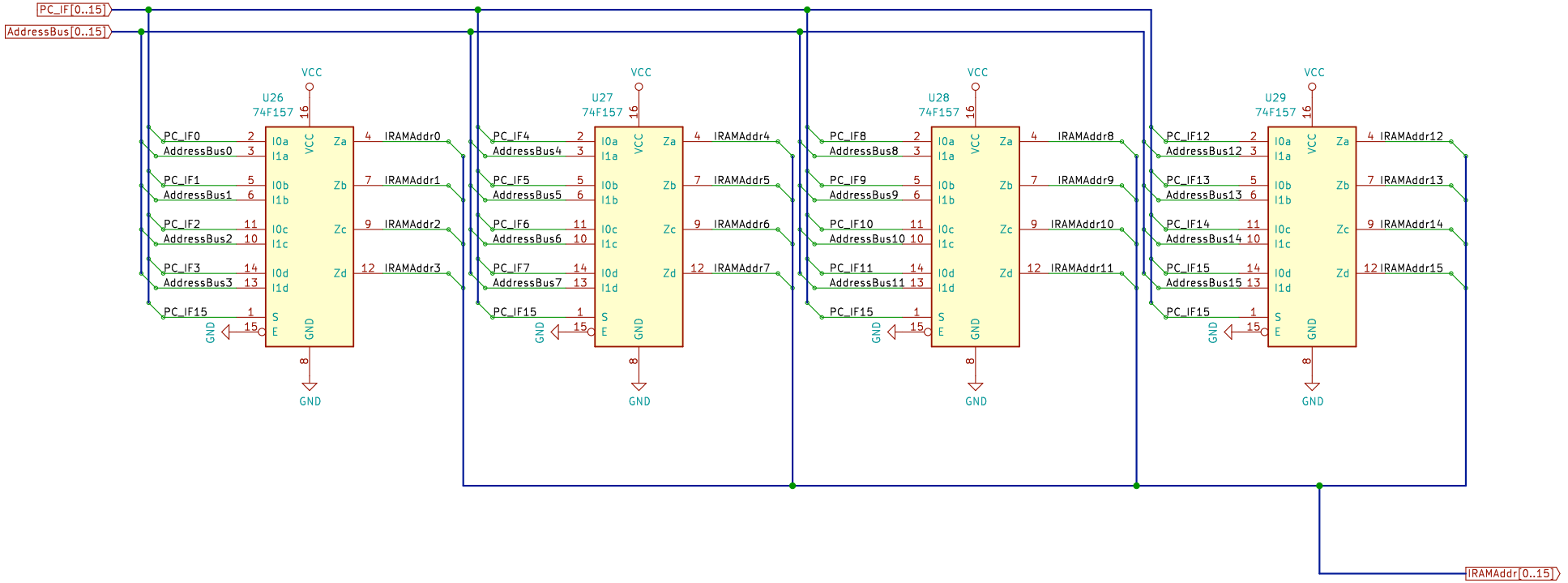


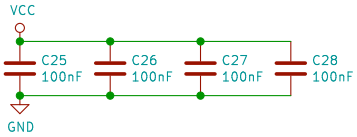
16-bit instructions are read from ROM at the address specified by the Program Counter.

Sheet: /Instruction Fetch/Instruction ROM/
File: Instruction ROM.sch

Title: Instruction ROM

Size: USLetter	Date:	Rev:
KiCad E.D.A. kicad (5.1.0-0)		Id: 10/24



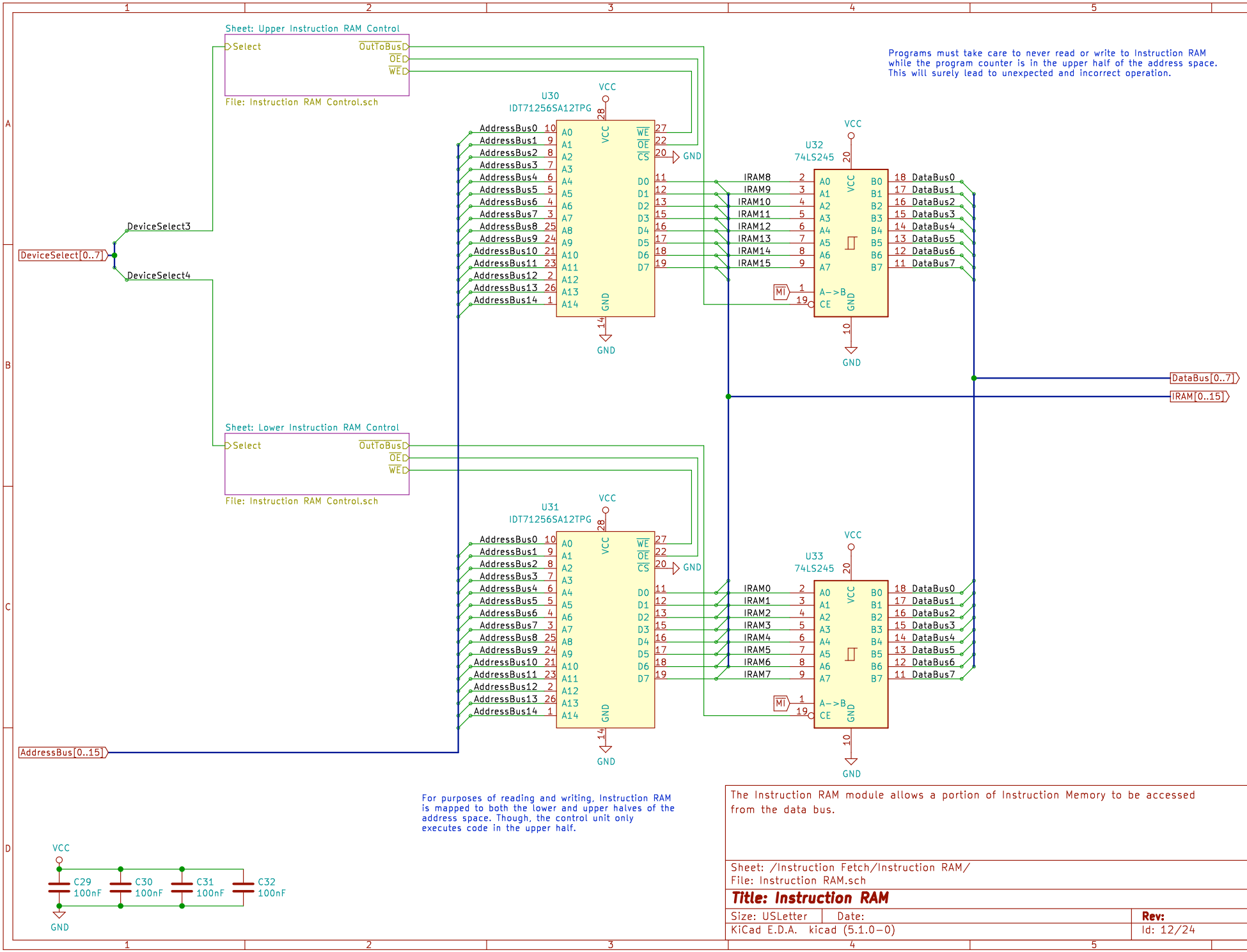


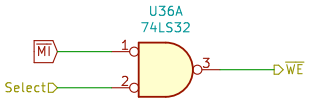
Instruction RAM uses an address from either the program counter or the address bus.
If the program counter is in the upper 32KB of the address space then use the program counter as we're running in Instruction RAM.

Sheet: /Instruction Fetch/Instruction RAM Address/
File: Instruction RAM Address.sch

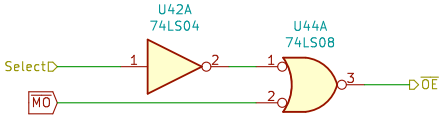
Title: Instruction RAM Address

Size: A4	Date:	Rev:
KiCad E.D.A. kicad (5.1.0-0)		Id: 11/24


Sheet: Upper Instruction RAM Control
Select
OutToBus
OE
WE
File: Instruction RAM Control.sch
Programs must take care to never read or write to Instruction RAM while the program counter is in the upper half of the address space. This will surely lead to unexpected and incorrect operation.
U30
IDT71256SA12TPG
VCC
GND
AddressBus0
AddressBus1
AddressBus2
AddressBus3
AddressBus4
AddressBus5
AddressBus6
AddressBus7
AddressBus8
AddressBus9
AddressBus10
AddressBus11
AddressBus12
AddressBus13
AddressBus14
U32
74LS245
IRAM8
IRAM9
IRAM10
IRAM11
IRAM12
IRAM13
IRAM14
IRAM15
DataBus0
DataBus1
DataBus2
DataBus3
DataBus4
DataBus5
DataBus6
DataBus7
DeviceSelect3
DeviceSelect[0..7]
DeviceSelect4
DataBus[0..7]
IRAM[0..15]
Sheet: Lower Instruction RAM Control
Select
OutToBus
OE
WE
File: Instruction RAM Control.sch
U31
IDT71256SA12TPG
U33
74LS245
IRAM0
IRAM1
IRAM2
IRAM3
IRAM4
IRAM5
IRAM6
IRAM7
AddressBus[0..15]
For purposes of reading and writing, Instruction RAM is mapped to both the lower and upper halves of the address space. Though, the control unit only executes code in the upper half.
C29 100nF
C30 100nF
C31 100nF
C32 100nF
The Instruction RAM module allows a portion of Instruction Memory to be accessed from the data bus.
Sheet: /Instruction Fetch/Instruction RAM/
File: Instruction RAM.sch
Title: Instruction RAM
Size: USLetter
Date:
Rev:
KiCad E.D.A. kicad (5.1.0-0)
Id: 12/24

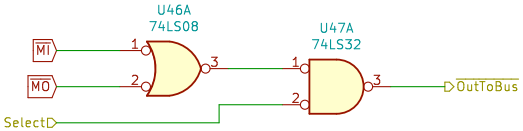


Only write to the Instruction SRAM when the MI signal is active and the appropriate plane of Instruction RAM is selected.



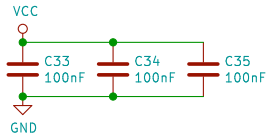
Always output from Instruction SRAM when the plane of Instruction RAM is deselected. This allows RAM to be read for use in IF.

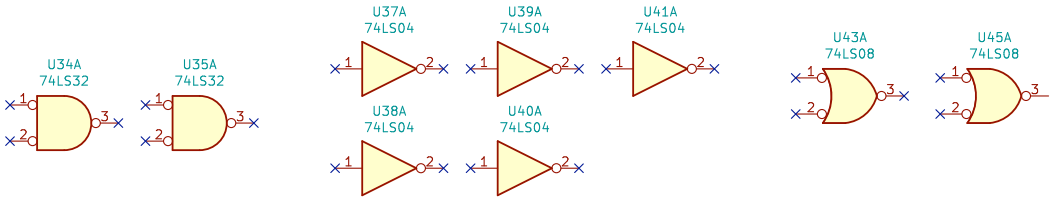
Else, if the plane is selected then only read from SRAM when the MO signal is active.



The bus transceiver should connect the Instruction SRAM to the Data Bus when the plane is selected and either MO or MI is active.

The direction of the bus transceiver must also be set appropriately. This is done elsewhere.



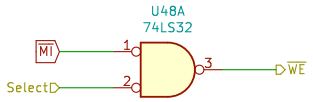


Logic for the control signals which drive Instruction RAM.

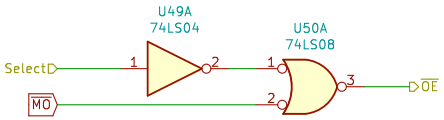
Sheet: /Instruction Fetch/Instruction RAM/Lower Instruction RAM Control/
File: Instruction RAM Control.sch

Title: Instruction RAM Control Logic

Size: A4	Date:	**Rev:**
KiCad E.D.A. kicad (5.1.0-0)		Id: 13/24

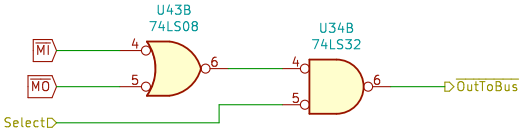


Only write to the Instruction SRAM when the MI signal is active and the appropriate plane of Instruction RAM is selected.



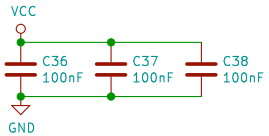
Always output from Instruction SRAM when the plane of Instruction RAM is deselected. This allows RAM to be read for use in IF.

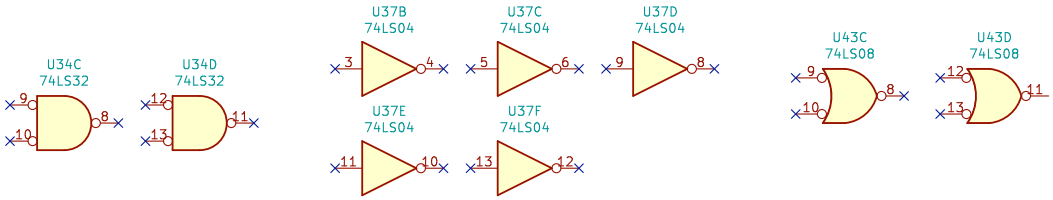
Else, if the plane is selected then only read from SRAM when the MO signal is active.



The bus transceiver should connect the Instruction SRAM to the Data Bus when the plane is selected and either MO or MI is active.

The direction of the bus transceiver must also be set appropriately. This is done elsewhere.



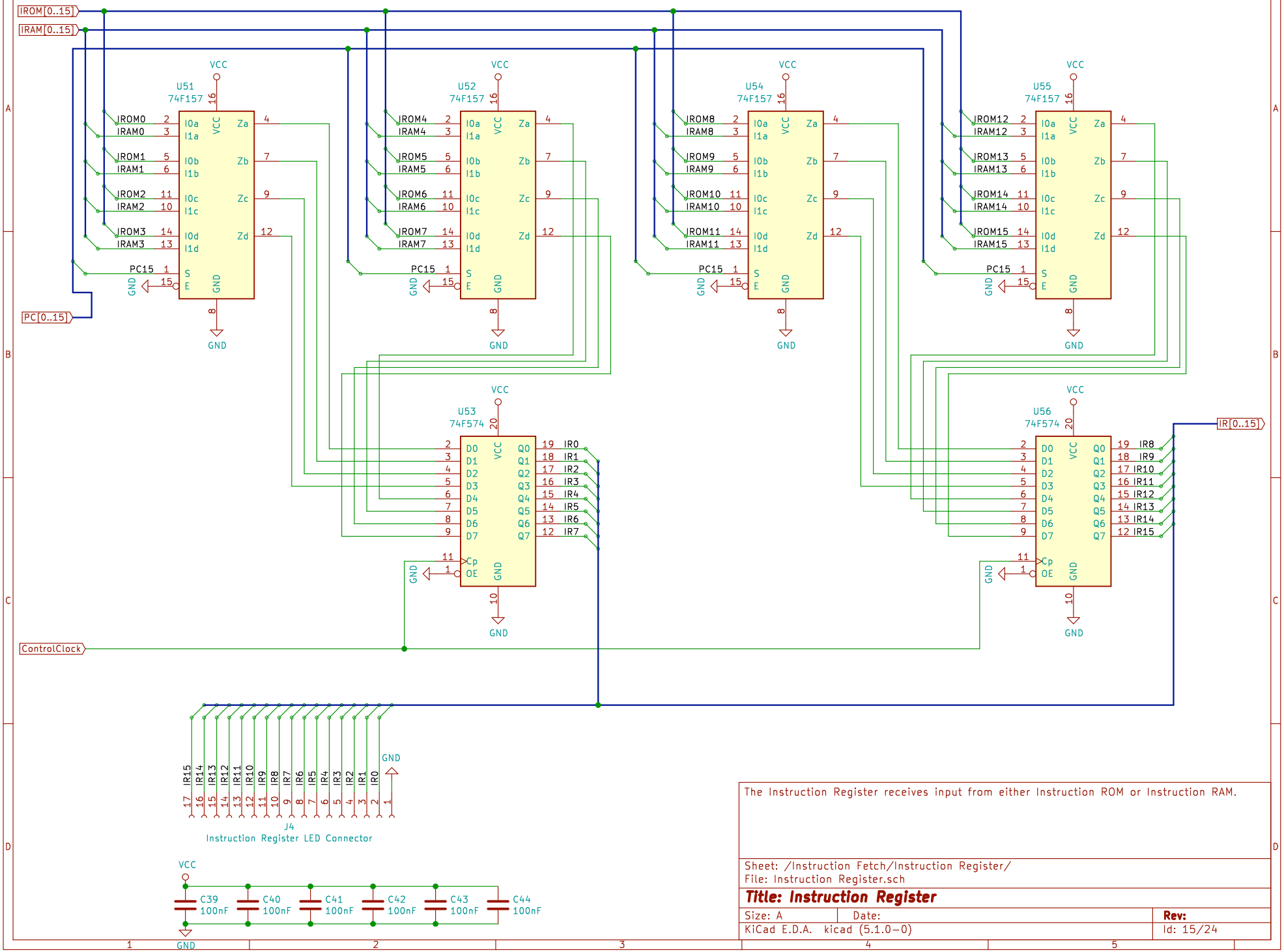


Logic for the control signals which drive Instruction RAM.

Sheet: /Instruction Fetch/Instruction RAM/Upper Instruction RAM Control/
File: Instruction RAM Control.sch

Title: Instruction RAM Control Logic

Size: A4	Date:	Rev:
KiCad E.D.A. kicad (5.1.0-0)		Id: 14/24

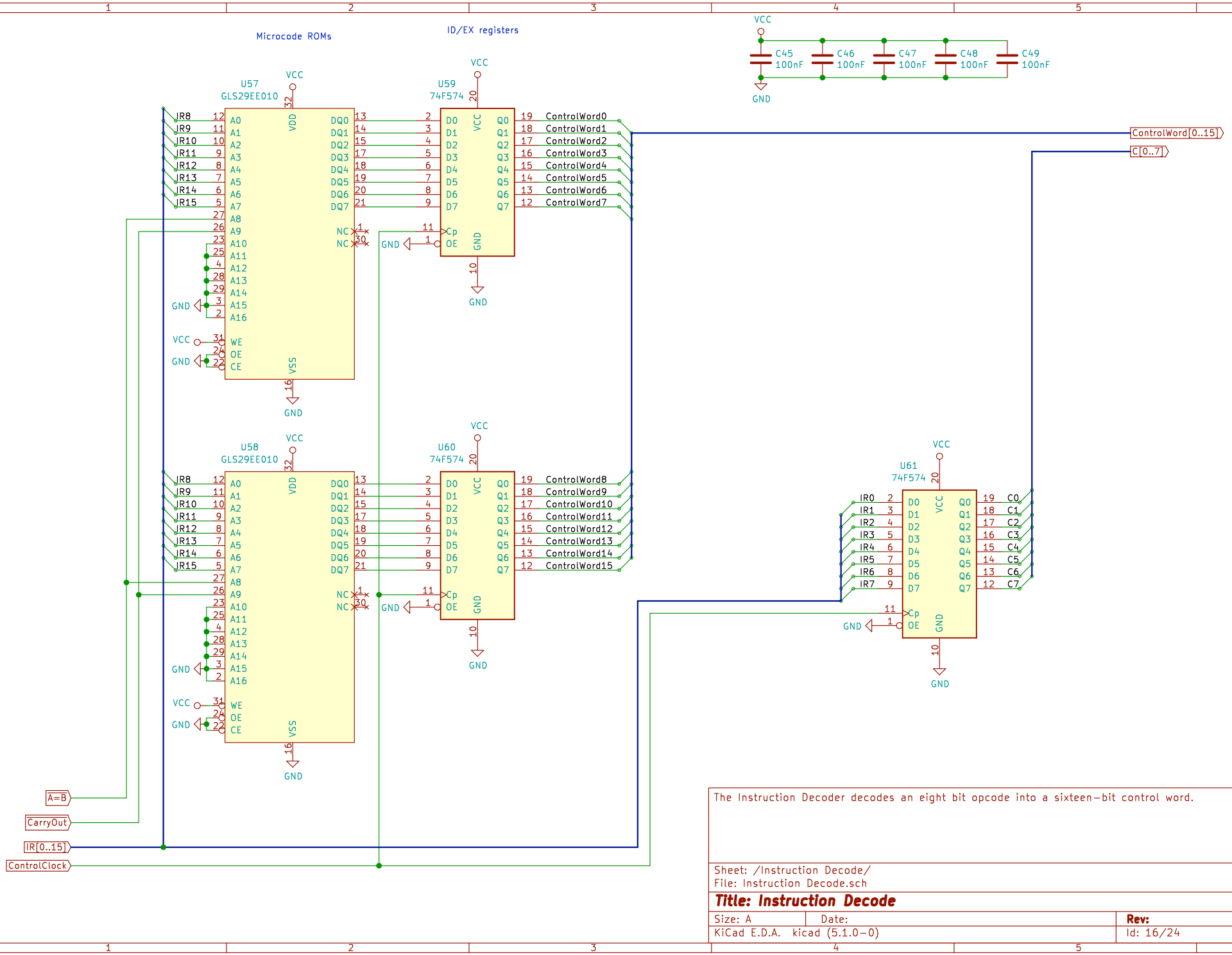


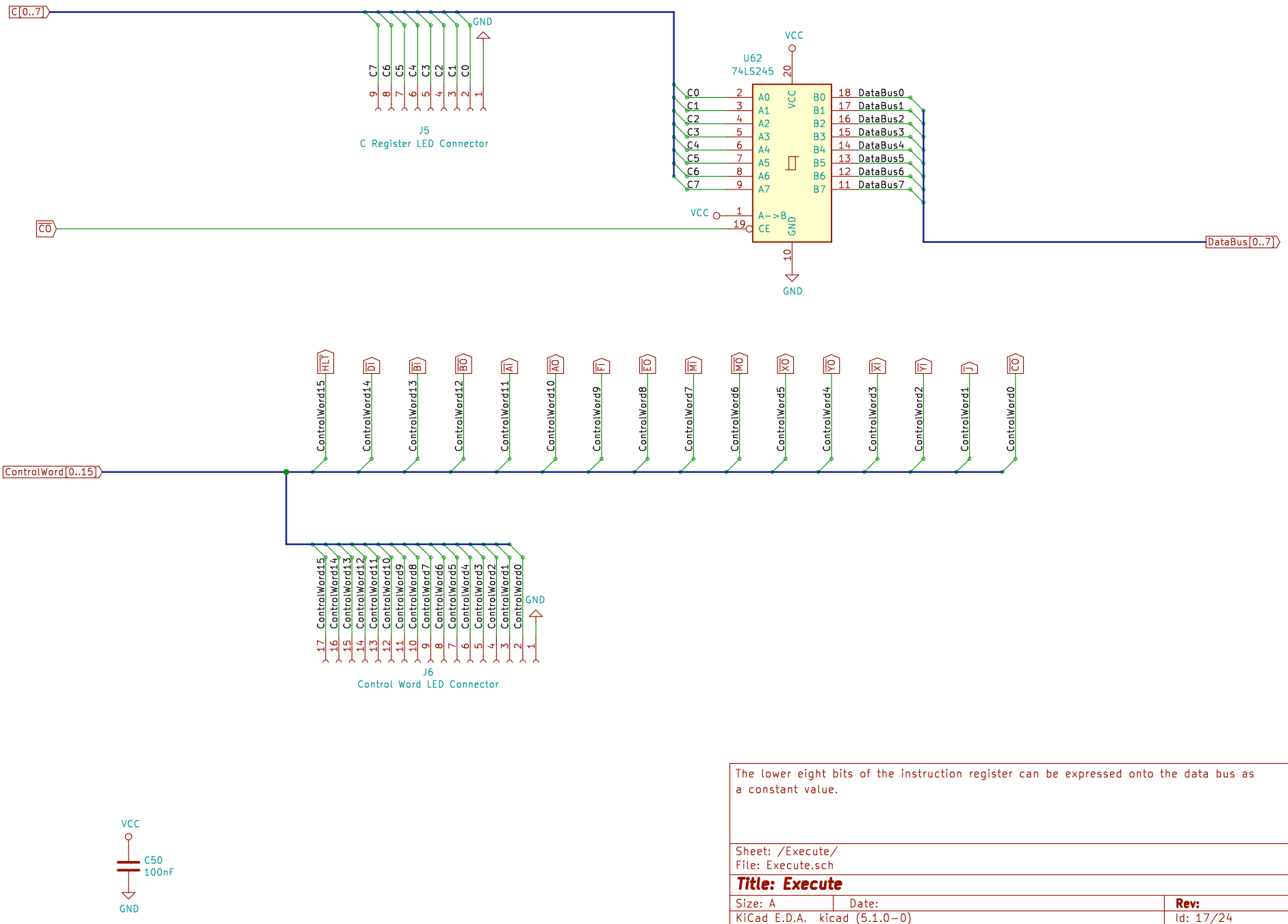
The Instruction Register receives input from either Instruction ROM or Instruction RAM.

Sheet: /Instruction Fetch/Instruction Register/
File: Instruction Register.sch

Title: Instruction Register

Size: A	Date:	Rev:
KiCad E.D.A. kicad (5.1.0-0)		Id: 15/24


Microcode ROMs
ID/EX registers
U57
GLS29EE010
U58
GLS29EE010
U59
74F574
U60
74F574
U61
74F574
C45 100nF
C46 100nF
C47 100nF
C48 100nF
C49 100nF
VCC
GND
IR8
IR9
IR10
IR11
IR12
IR13
IR14
IR15
ControlWord0
ControlWord1
ControlWord2
ControlWord3
ControlWord4
ControlWord5
ControlWord6
ControlWord7
ControlWord8
ControlWord9
ControlWord10
ControlWord11
ControlWord12
ControlWord13
ControlWord14
ControlWord15
ControlWord[0..15]
C[0..7]
A=B
CarryOut
IR[0..15]
ControlClock
The Instruction Decoder decodes an eight bit opcode into a sixteen-bit control word.
Sheet: /Instruction Decode/
File: Instruction Decode.sch
Title: Instruction Decode
Size: A
Date:
Rev:
KiCad E.D.A. kicad (5.1.0-0)
Id: 16/24

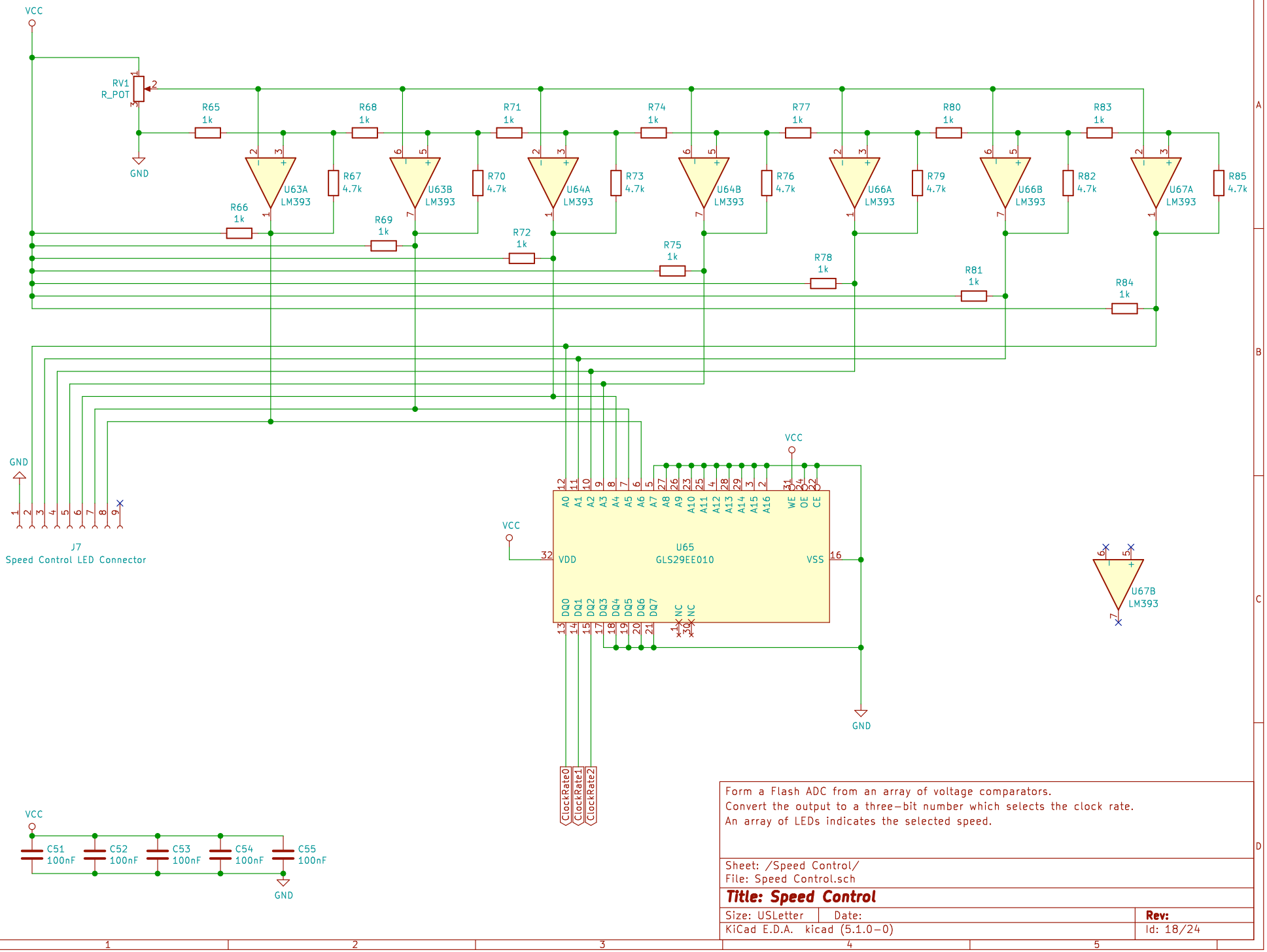


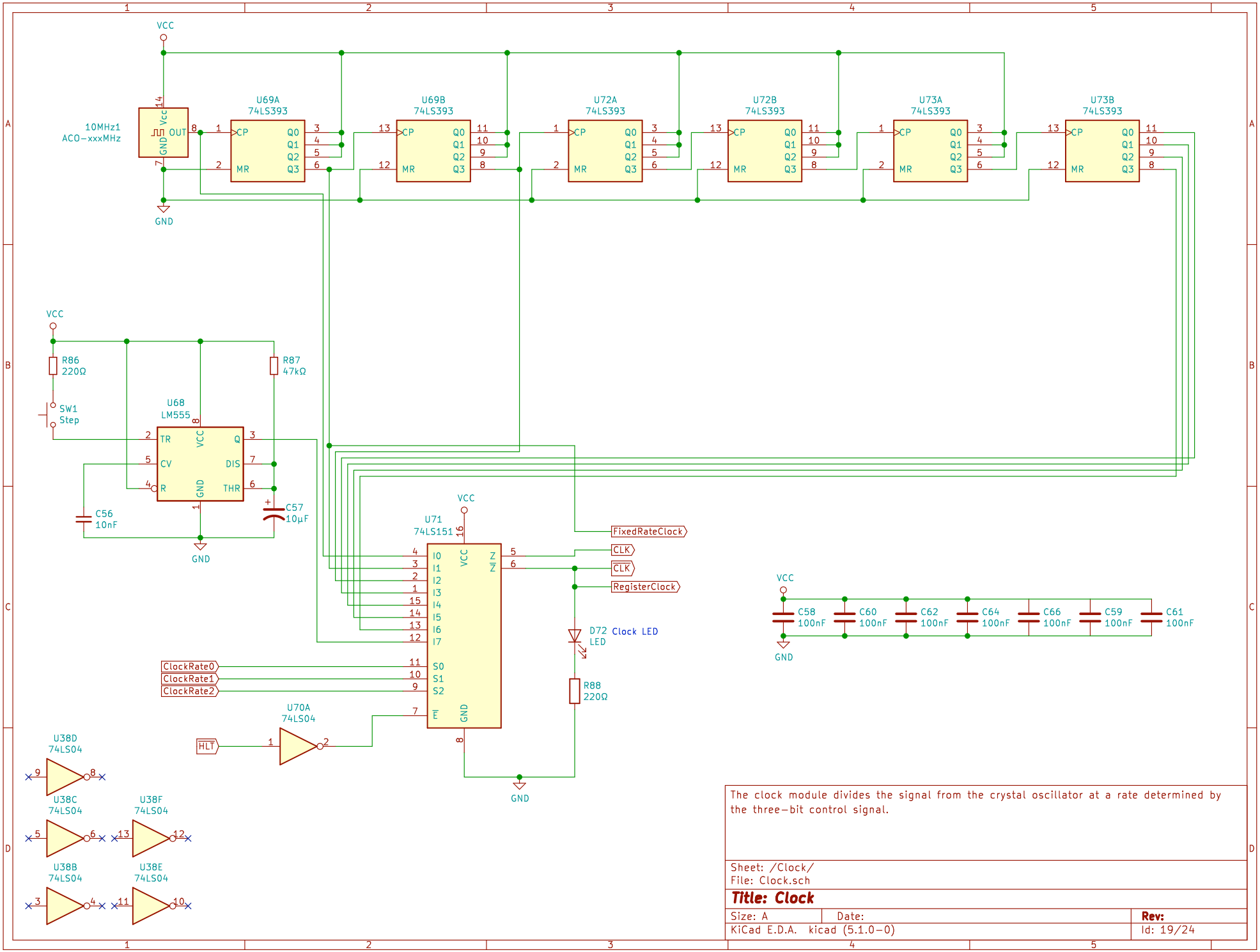
The lower eight bits of the instruction register can be expressed onto the data bus as a constant value.

Sheet: /Execute/
File: Execute.sch

Title: Execute

Size: A	Date:	Rev:
KiCad E.D.A. kicad (5.1.0-0)		Id: 17/24


VCC
RV1
R_POT
GND
R65
1k
R68
1k
R71
1k
R74
1k
R77
1k
R80
1k
R83
1k
U63A
LM393
U63B
LM393
U64A
LM393
U64B
LM393
U66A
LM393
U66B
LM393
U67A
LM393
R66
1k
R67
4.7k
R69
1k
R70
4.7k
R72
1k
R73
4.7k
R75
1k
R76
4.7k
R78
1k
R79
4.7k
R81
1k
R82
4.7k
R84
1k
R85
4.7k
J7
Speed Control LED Connector
U65
GLS29EE010
VDD
VSS
WE
OE
CE
NC
U67B
LM393
ClockRate0
ClockRate1
ClockRate2
C51
100nF
C52
100nF
C53
100nF
C54
100nF
C55
100nF
Form a Flash ADC from an array of voltage comparators.
Convert the output to a three-bit number which selects the clock rate.
An array of LEDs indicates the selected speed.
Sheet: /Speed Control/
File: Speed Control.sch
Title: Speed Control
Size: USLetter
Date:
Rev:
KiCad E.D.A. kicad (5.1.0-0)
Id: 18/24

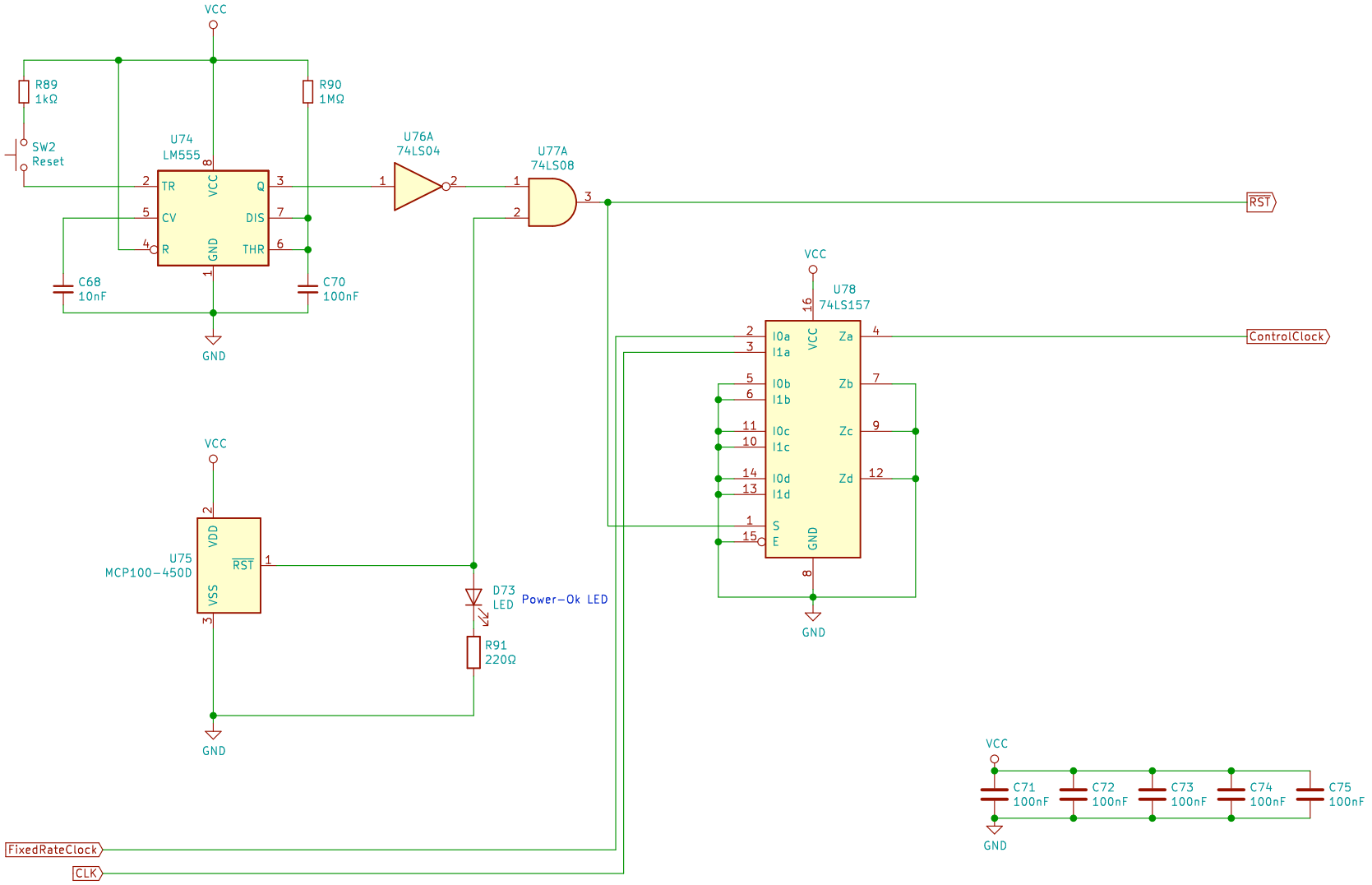


The clock module divides the signal from the crystal oscillator at a rate determined by the three-bit control signal.

Sheet: /Clock/
File: Clock.sch

Title: Clock

Size: A	Date:	Rev:
KiCad E.D.A. kicad (5.1.0-0)		Id: 19/24

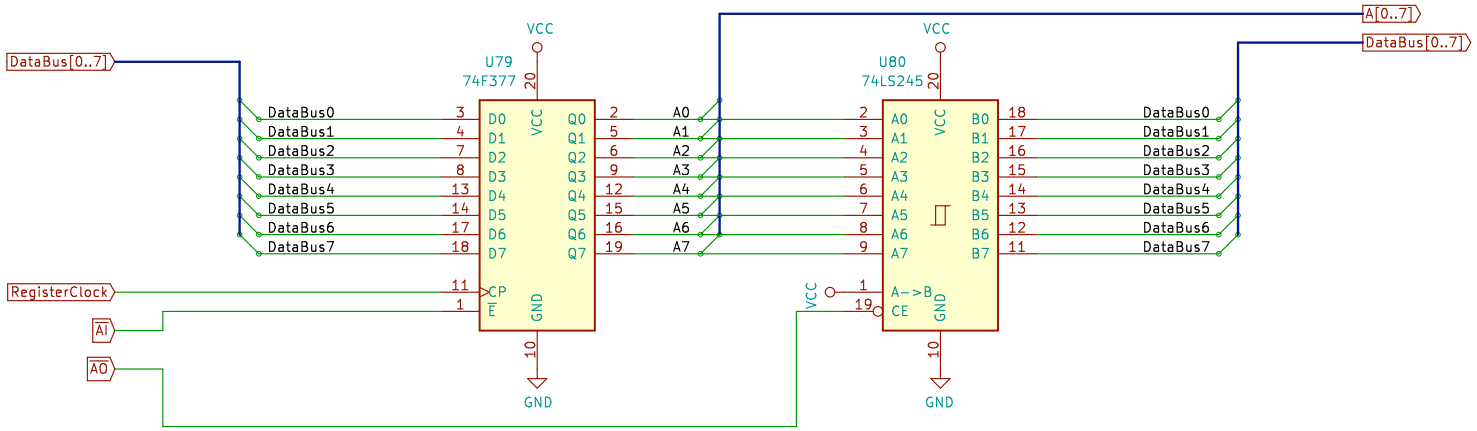


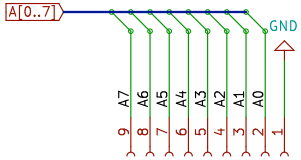
The MCP100 provides Power-on Reset functionality.
A button is also provided to manually reset the machine.
During reset, the control clock is pulsed repeatedly to flush the pipeline.

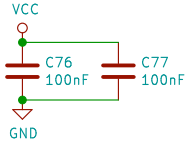
Sheet: /Power-on Reset/
File: Power-on Reset.sch

Title: Power-on Reset

Size: A	Date:	Rev:
KiCad E.D.A. kicad (5.1.0-0)		Id: 20/24





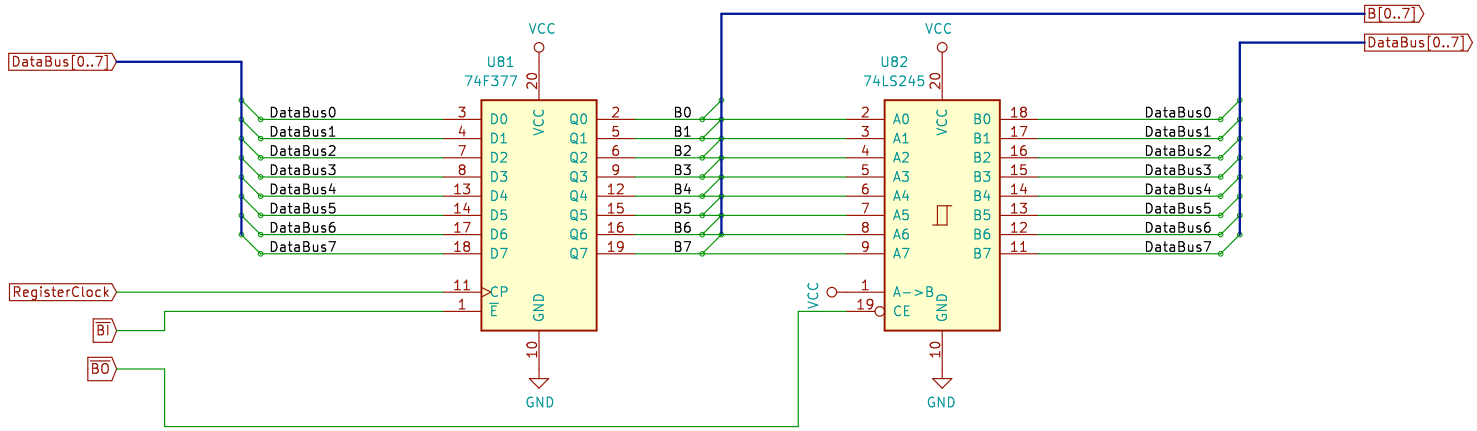


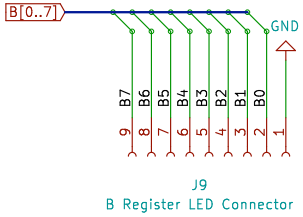
Register A is wired to the ALU's A operand.

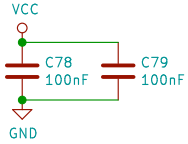
Sheet: /Register A/
File: Register A.sch

Title: Register A

Size: A	Date:	**Rev:**
KiCad E.D.A. kicad (5.1.0-0)		Id: 21/24





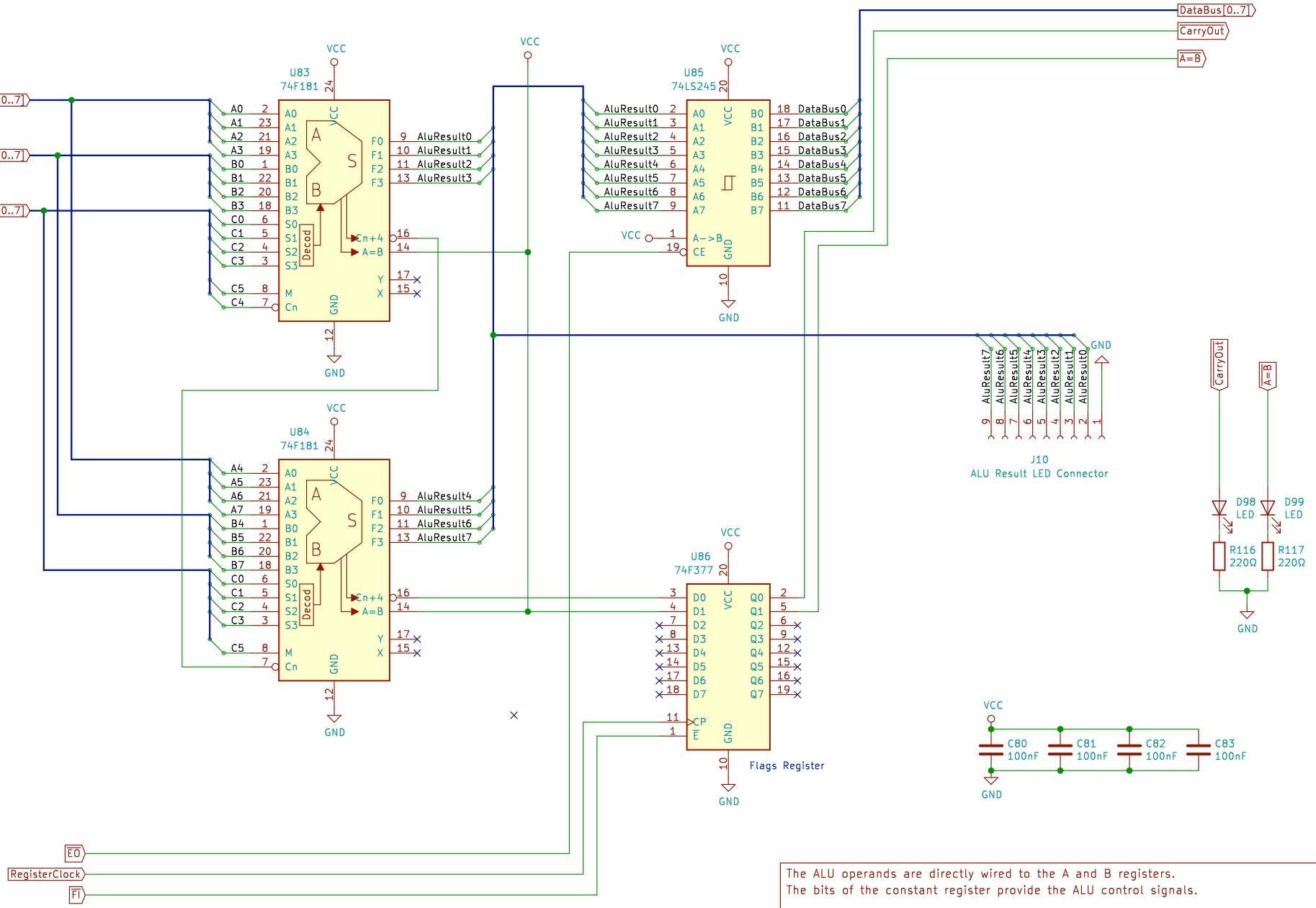


Register B is wired to the ALU's B operand.

Sheet: /Register B/
File: Register B.sch

Title: Register B

Size: A	Date:	**Rev:**
KiCad E.D.A. kicad (5.1.0-0)		Id: 22/24

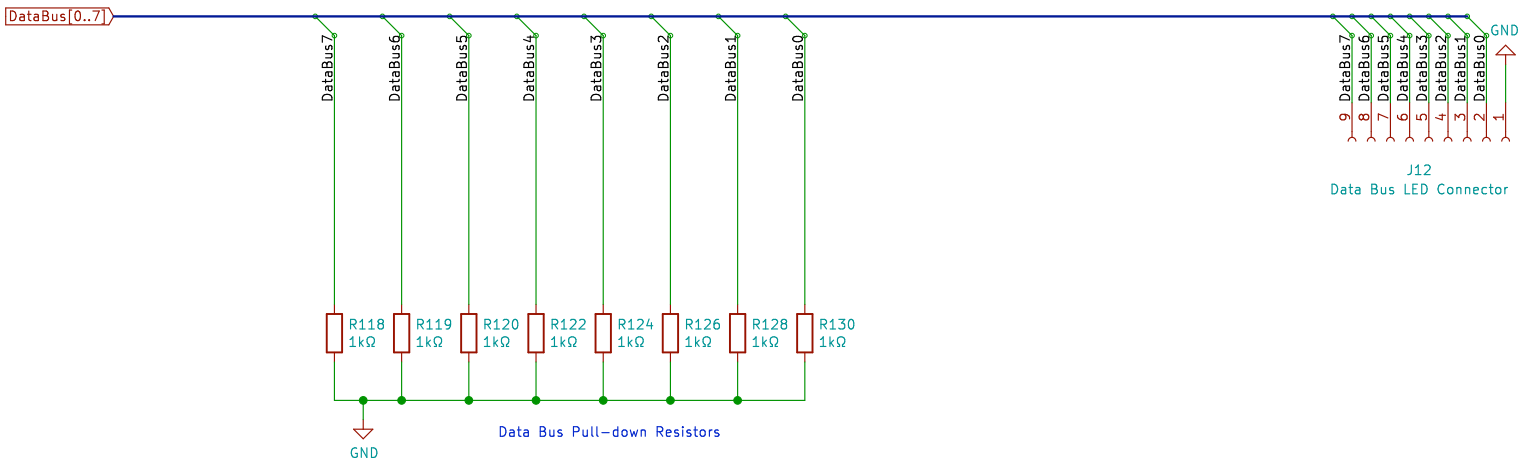


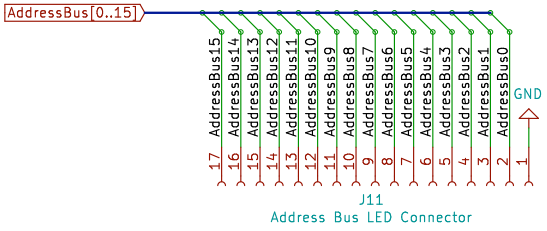
The ALU operands are directly wired to the A and B registers.
The bits of the constant register provide the ALU control signals.

Sheet: /ALU/
File: ALU.sch

Title: ALU

Size: A	Date:	**Rev:**
KiCad E.D.A. kicad (5.1.0-0)		Id: 23/24





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

Title: Bus Display

Size: A	Date:	**Rev:**
KiCad E.D.A. kicad (5.1.0-0)		Id: 24/24