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

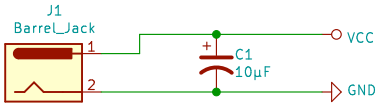
File: Register D.sch

Sheet: Bus Display

File: Bus Display.sch

Sheet: ALU

File: ALU.sch

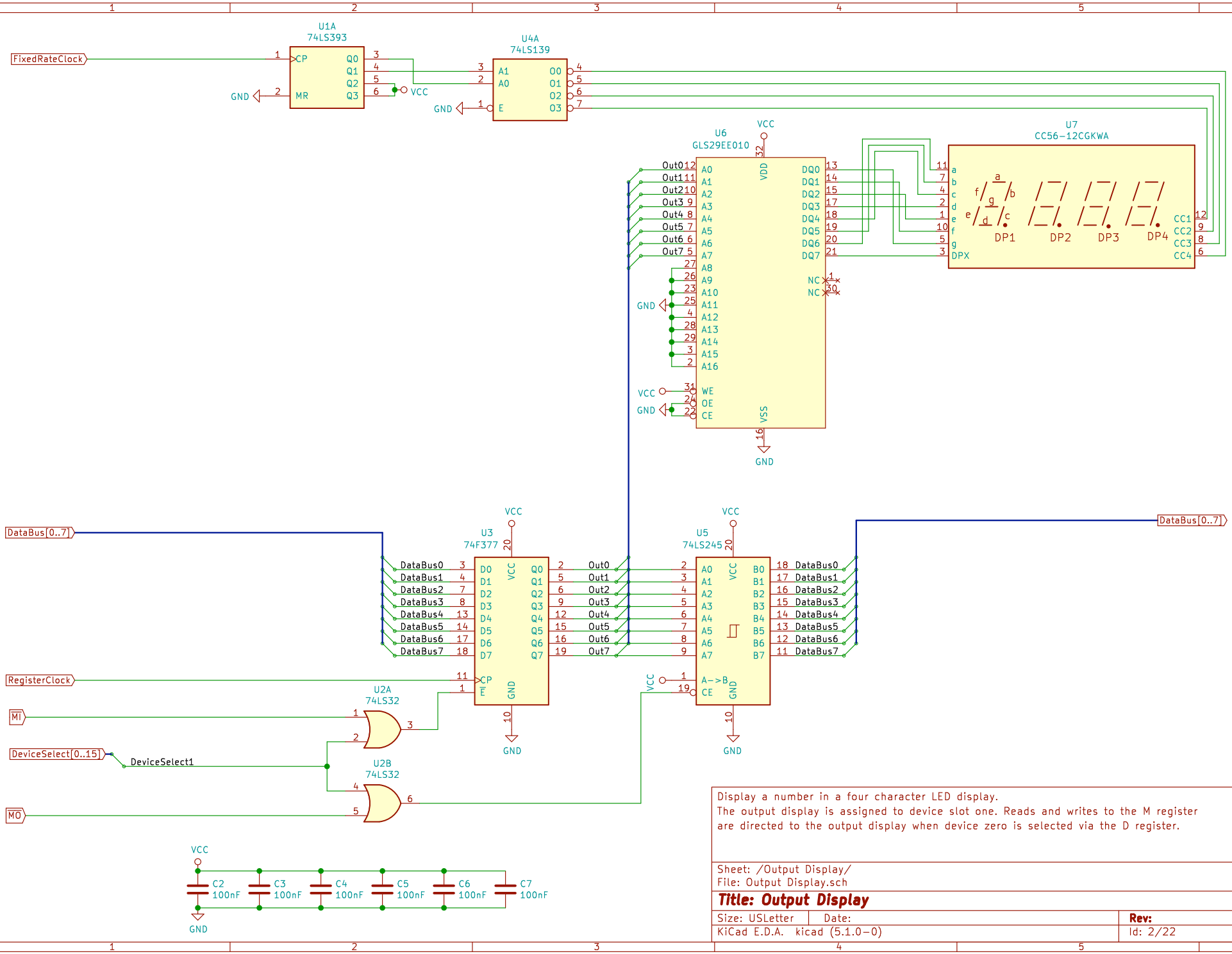


TTL microcomputer built from 74xx series logic chips.

Sheet: /
File: MainBoard.sch

Title: TurtleTTL: Main Board

Size: A	Date:	**Rev:**
KiCad E.D.A. kicad (5.1.0-0)		Id: 1/22

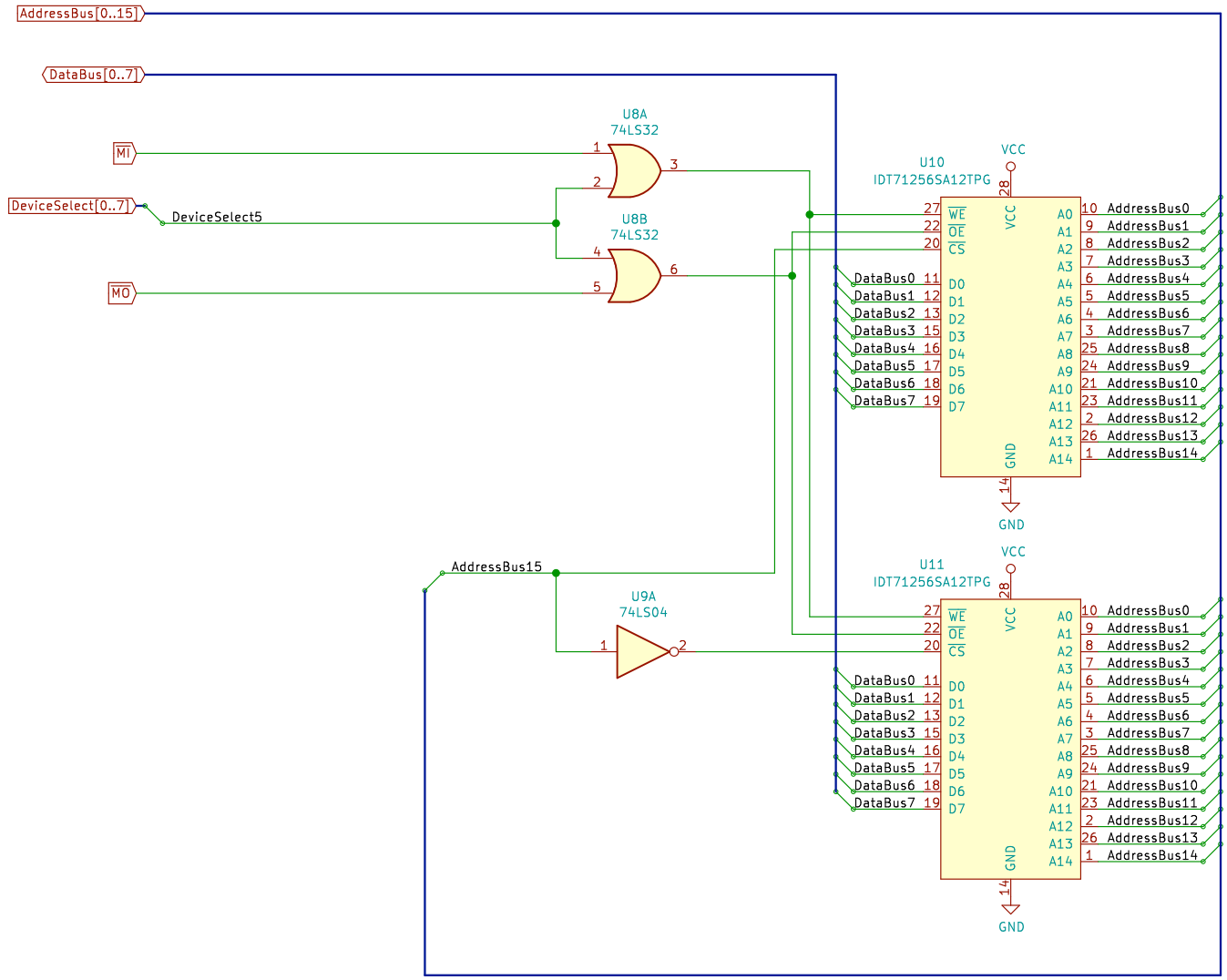


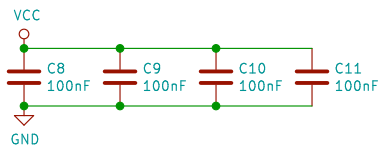
Display a number in a four character LED display.
The output display is assigned to device slot one. Reads and writes to the M register are directed to the output display when device zero is selected via the D register.

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

Title: Output Display

Size: USLetter	Date:	Rev:
KiCad E.D.A. kicad (5.1.0-0)		Id: 2/22



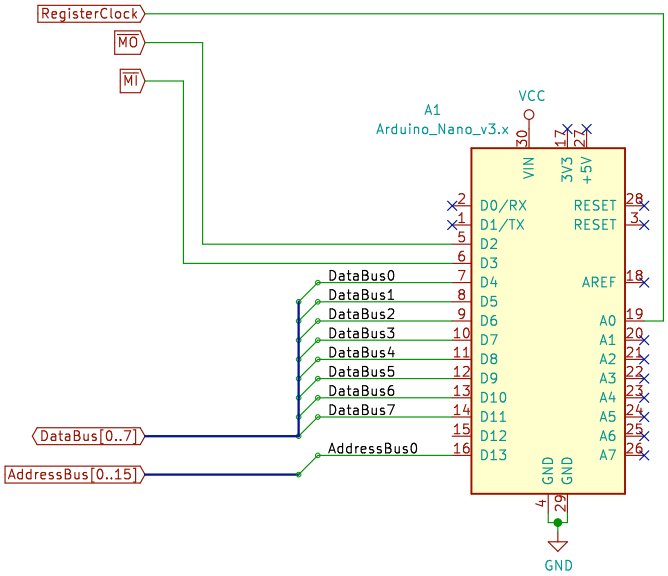


64KB Data RAM is connected to device slot five.
Reads and writes to the M register are directed to Data RAM when device 5 is selected via the D register.
The MSB of the address selects between two 32KB SRAM ICs.

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

Title: Data RAM

Size: USLetter	Date:	Rev:
KiCad E.D.A. kicad (5.1.0-0)		Id: 3/22

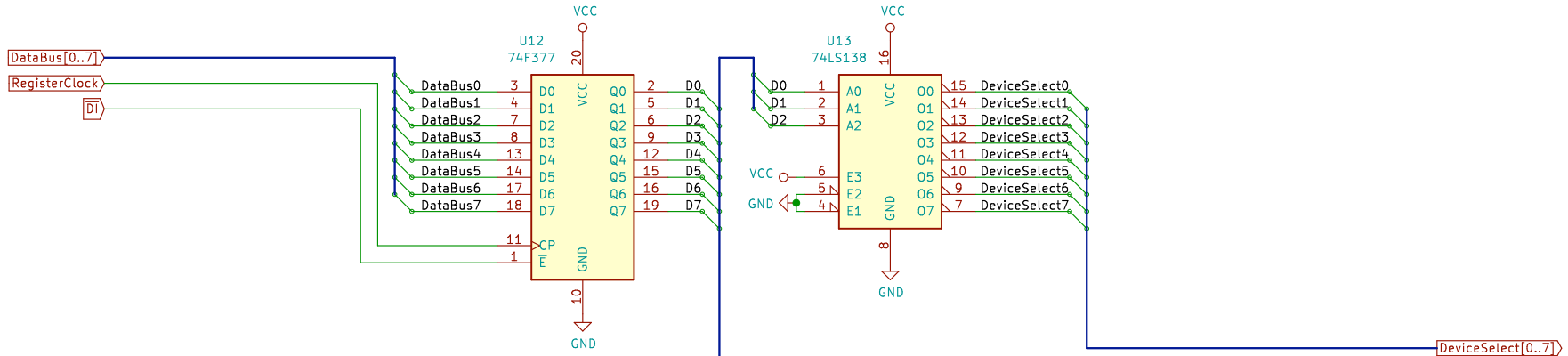


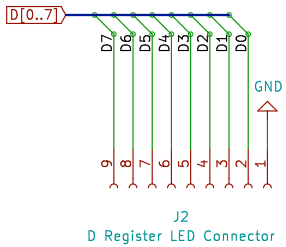
An Arduino Nano serves as a serial interface module.

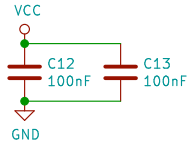
Sheet: /Serial/
File: Serial.sch

Title: Serial I/O

Size: USLetter | Date: | **Rev:**
KiCad E.D.A. kicad (5.1.0-0) | Id: 4/22





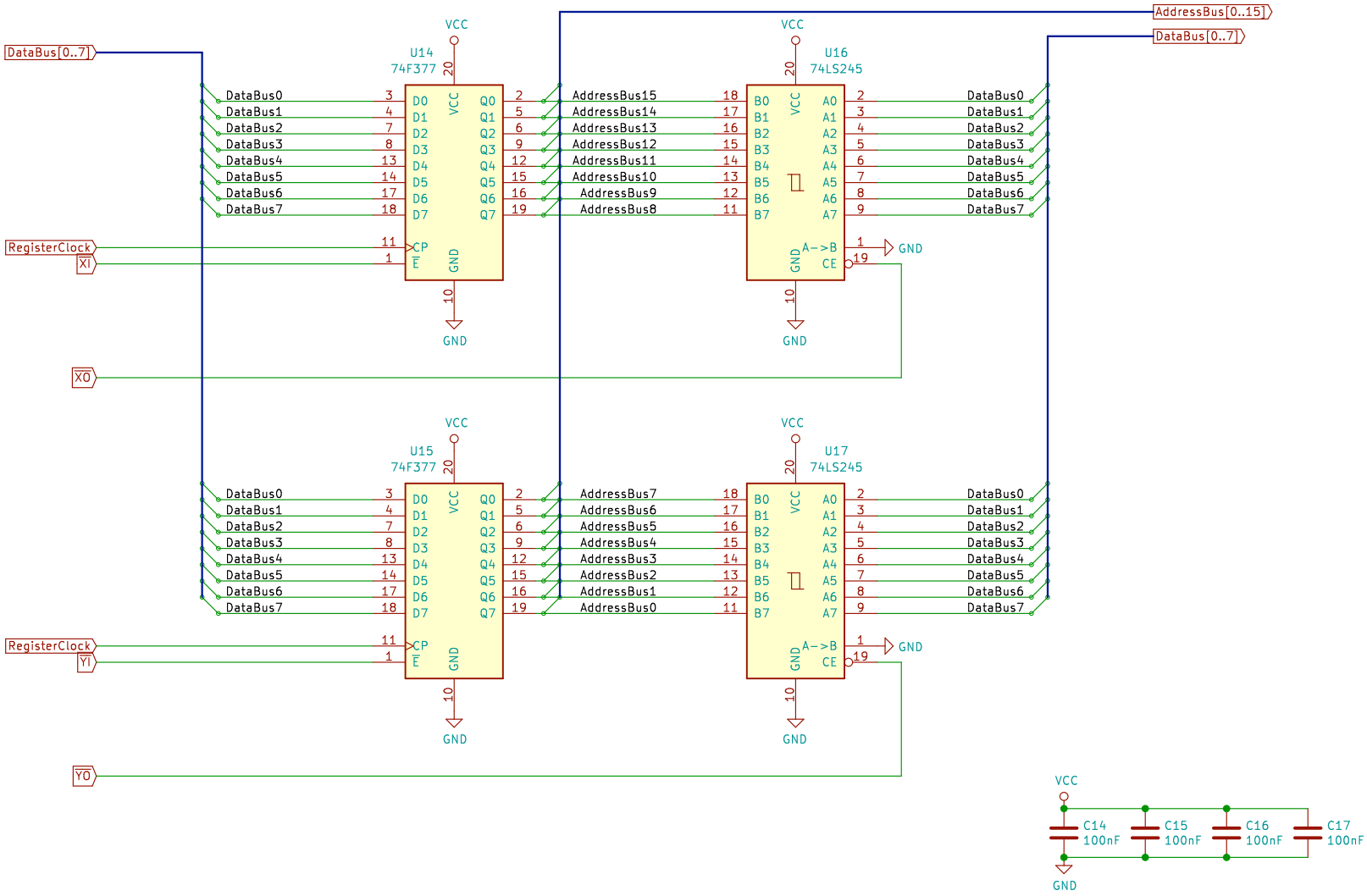


Register D controls the device select lines for peripherals and memory.

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

Title: Register D

Size: A | Date: | **Rev:**
KiCad E.D.A. kicad (5.1.0-0) | Id: 5/22

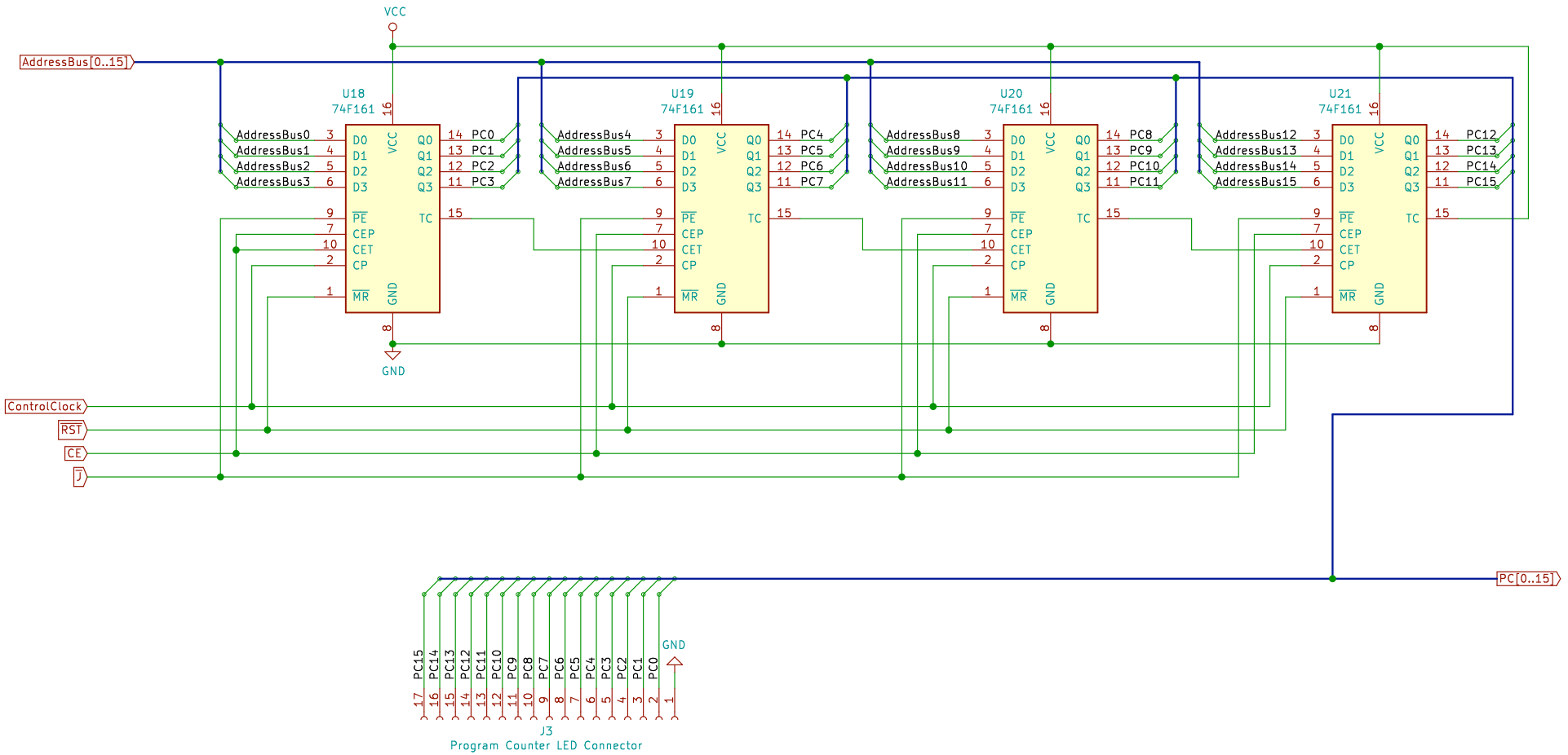


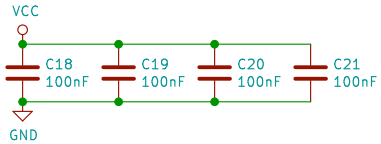
The XY register pair sets the value on the sixteen-bit Address Bus.

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: 6/22





Sheet: /Program Counter/	
File: Program Counter.sch	
Title: Program Counter	
Size: USLetter Date:	**Rev:**
KiCad E.D.A. kicad (5.1.0-0)	Id: 7/22

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

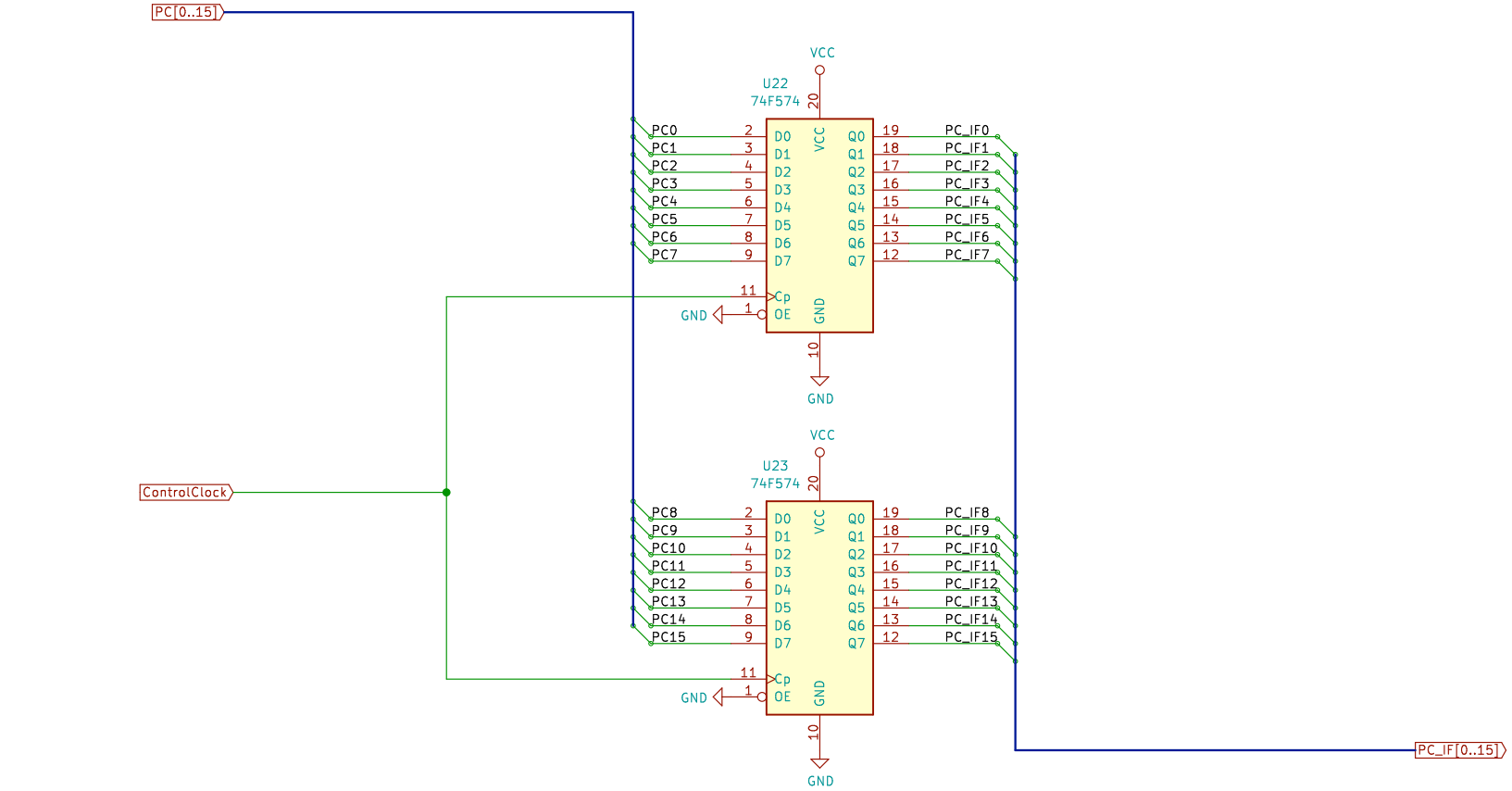
File: Instruction Register.sch

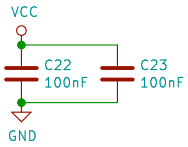
Instructions can be fetched from either Instruction ROM or Instruction RAM.
The lower 32KB of the address space is mapped to ROM, the remainder to RAM.

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

Title: Instruction Fetch

Size: A4	Date:	**Rev:**
KiCad E.D.A. kicad (5.1.0-0)		Id: 8/22



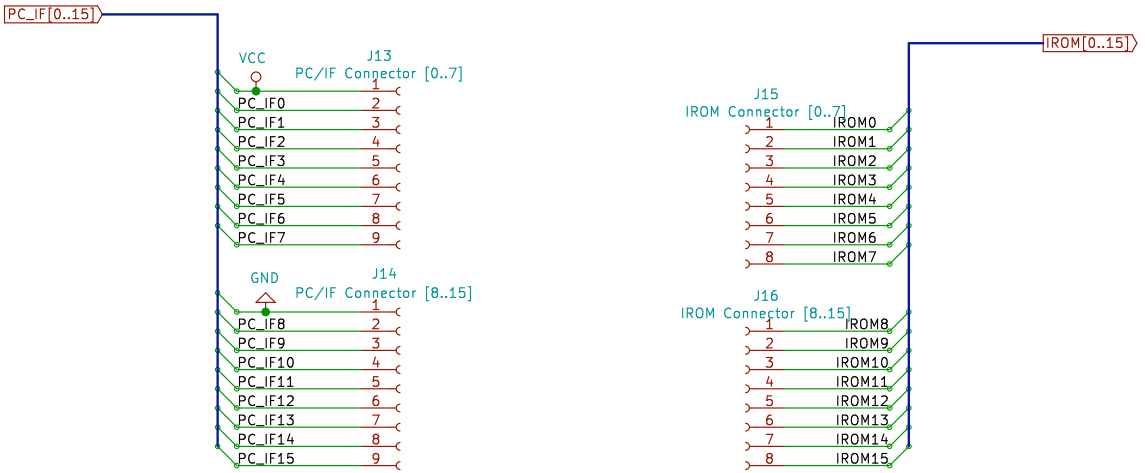


The PC/IF register sits between the program counter and the Instruction Fetch stage. This alleviates timing constraints related to the phase shift between the register clock and the control clock.

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: 9/22

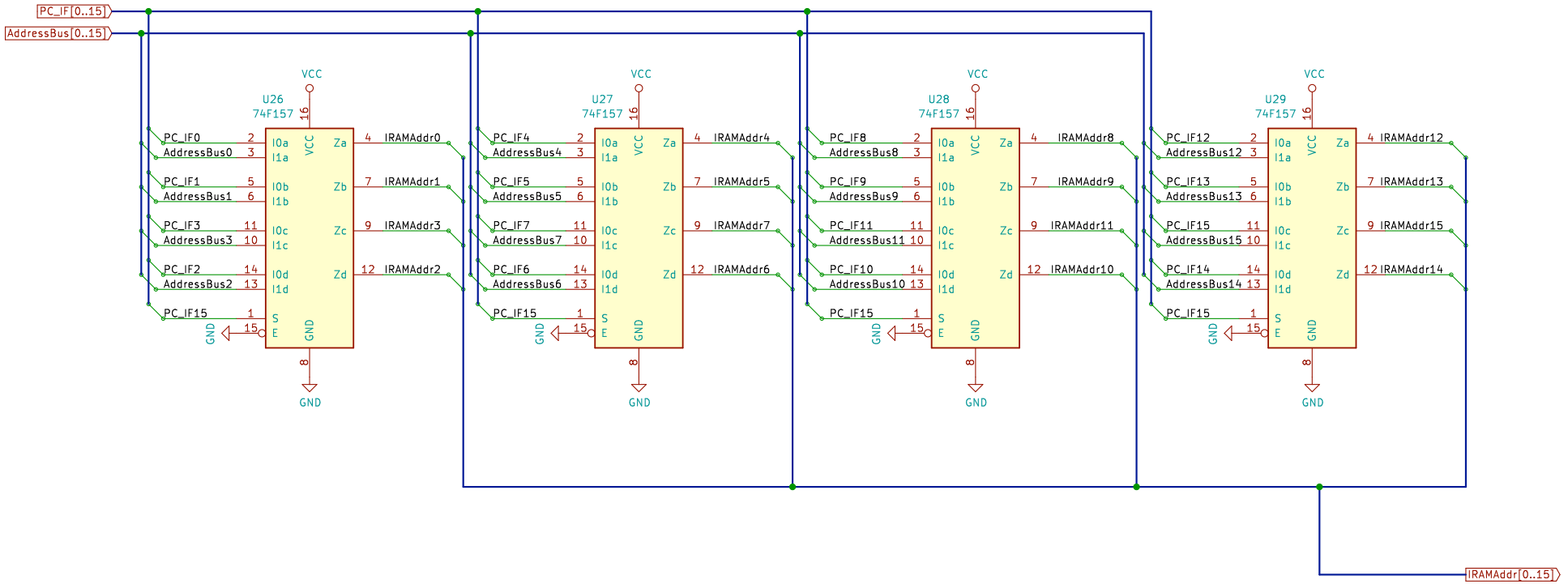


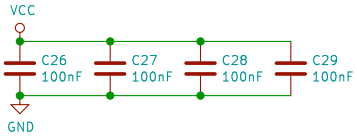
Instruction ROM is located on a daughter board.
This schematic describes the connectors by attach it to the main board.

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: 10/22



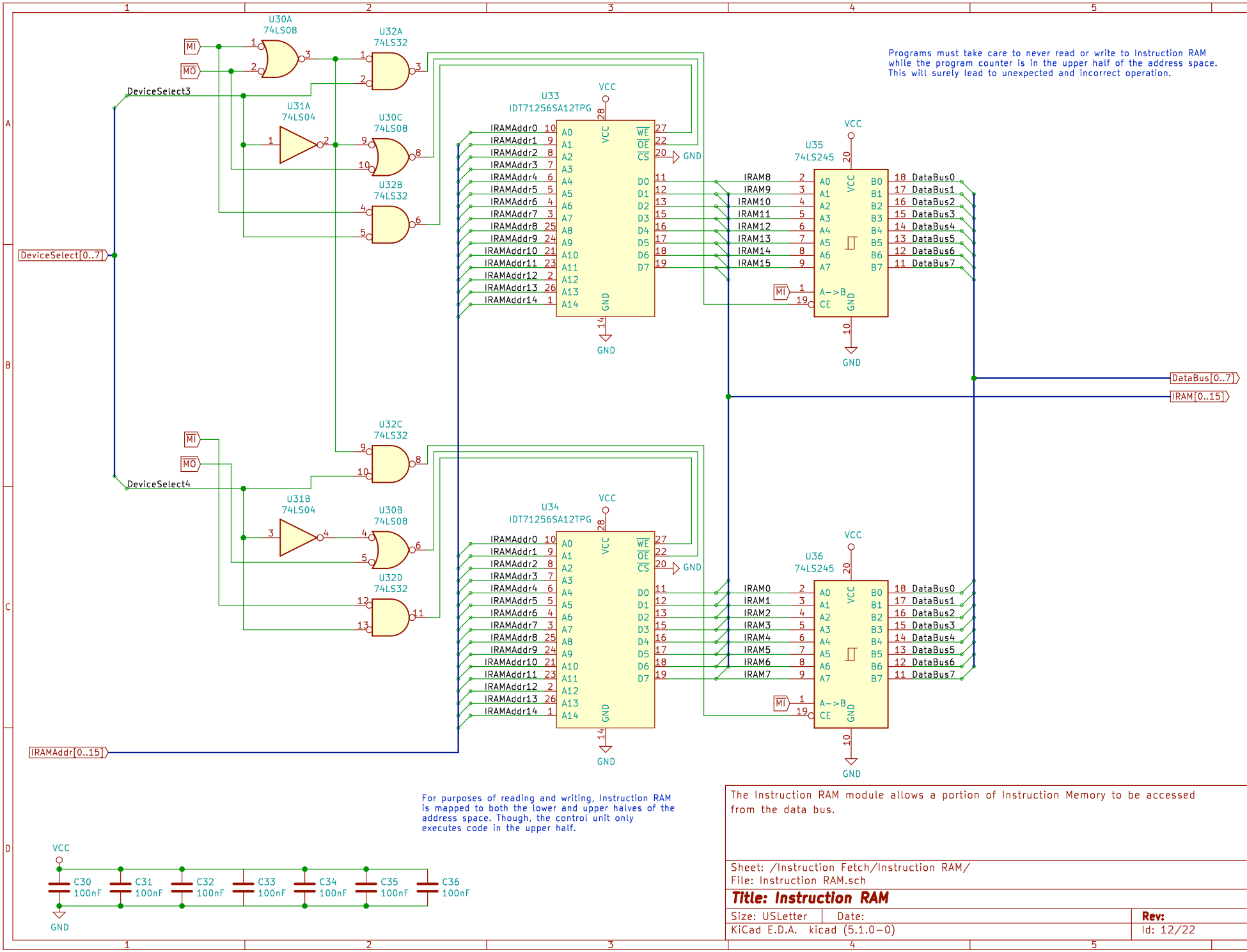


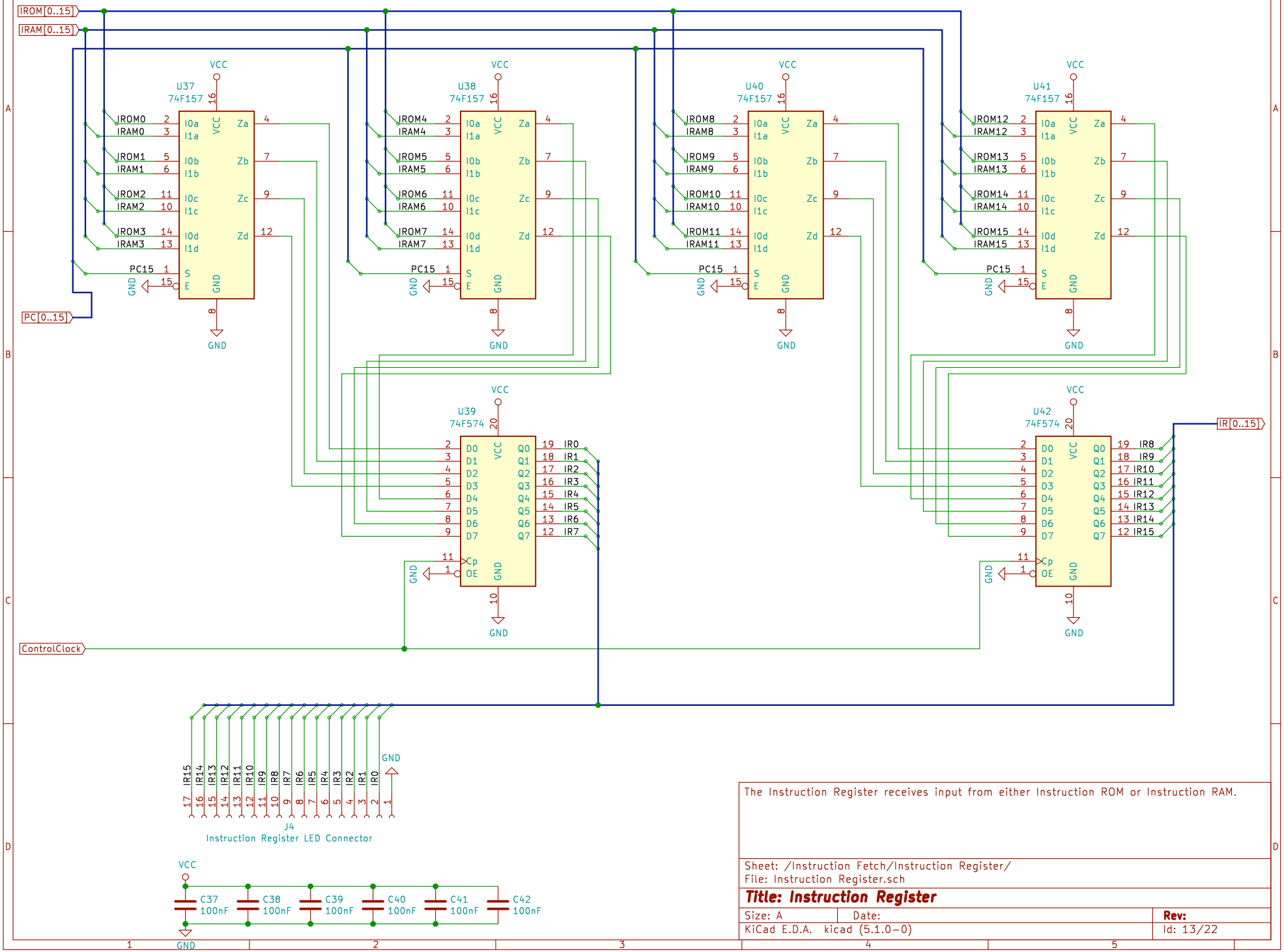
Instruction RAM uses an address from either the program counter or the address bus.
If the program counter is in the upper 32KB of the address space then use the program counter as we're running in Instruction RAM.

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: 11/22


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.
U30A 74LS08
U32A 74LS32
U31A 74LS04
U30C 74LS08
U32B 74LS32
U32C 74LS32
U31B 74LS04
U30B 74LS08
U32D 74LS32
MI
MO
DeviceSelect3
DeviceSelect4
DeviceSelect[0..7]
U33 IDT71256SA12TPG
U34 IDT71256SA12TPG
IRAMAddr0
IRAMAddr1
IRAMAddr2
IRAMAddr3
IRAMAddr4
IRAMAddr5
IRAMAddr6
IRAMAddr7
IRAMAddr8
IRAMAddr9
IRAMAddr10
IRAMAddr11
IRAMAddr12
IRAMAddr13
IRAMAddr14
IRAMAddr[0..15]
VCC
GND
U35 74LS245
U36 74LS245
IRAM8
IRAM9
IRAM10
IRAM11
IRAM12
IRAM13
IRAM14
IRAM15
IRAM0
IRAM1
IRAM2
IRAM3
IRAM4
IRAM5
IRAM6
IRAM7
DataBus0
DataBus1
DataBus2
DataBus3
DataBus4
DataBus5
DataBus6
DataBus7
DataBus[0..7]
IRAM[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.
C30 100nF
C31 100nF
C32 100nF
C33 100nF
C34 100nF
C35 100nF
C36 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: 12/22

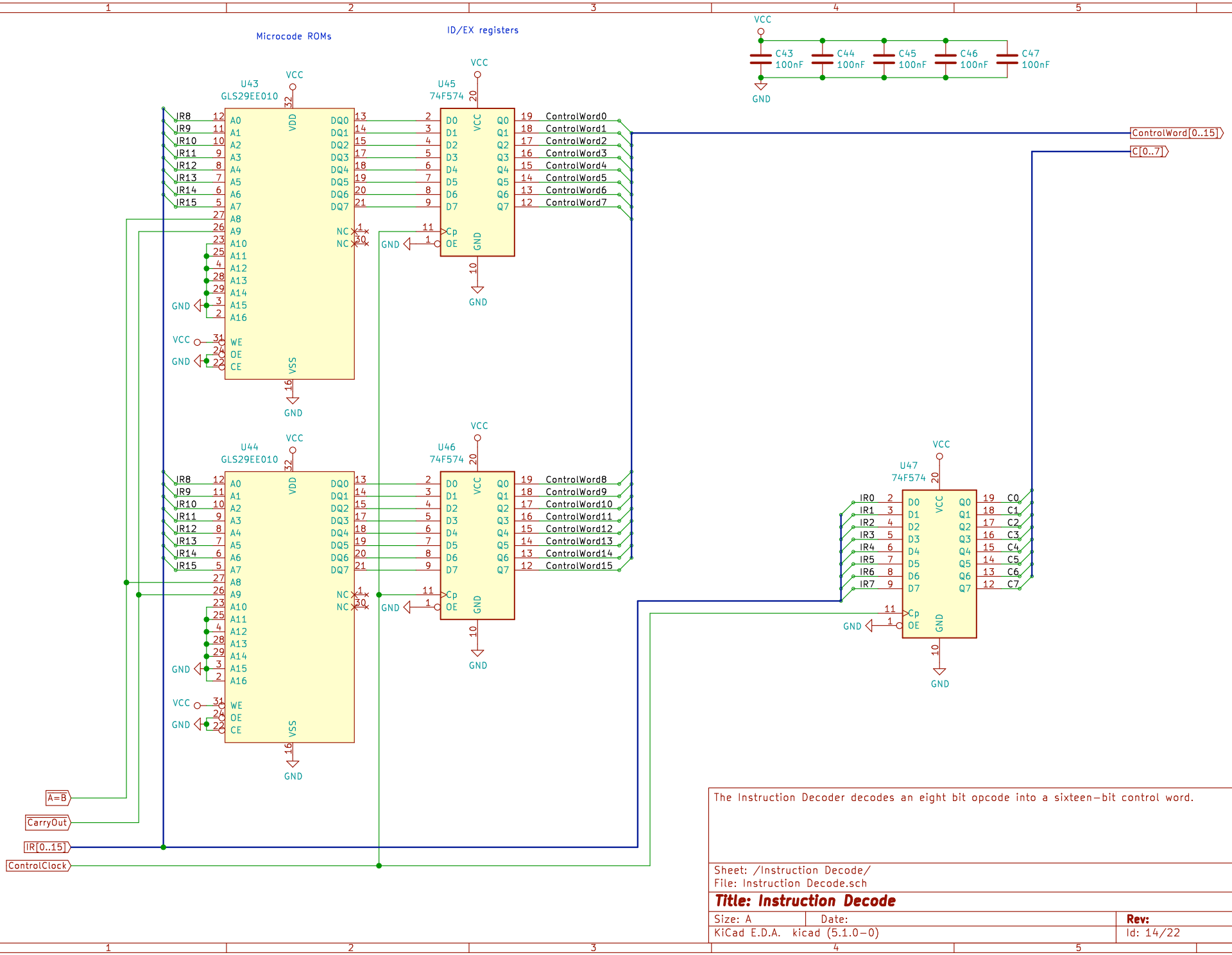


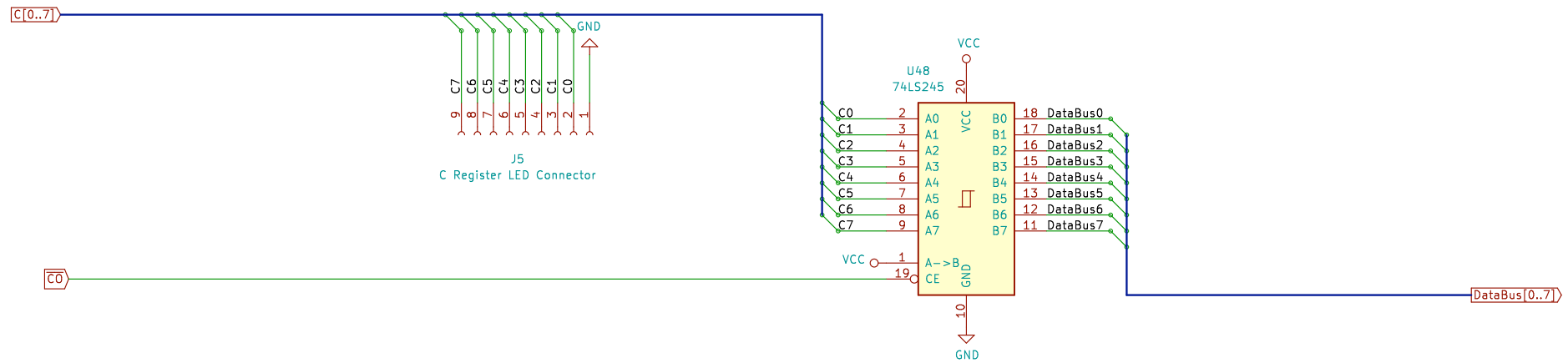
The Instruction Register receives input from either Instruction ROM or Instruction RAM.

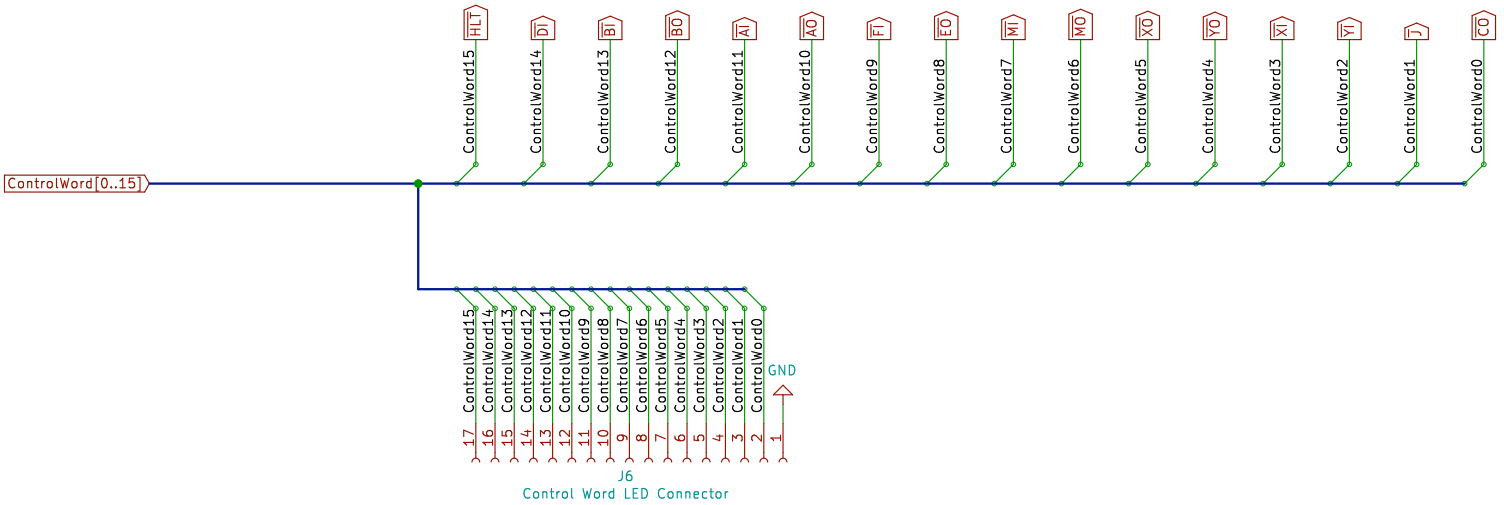
Sheet: /Instruction Fetch/Instruction Register/
File: Instruction Register.sch

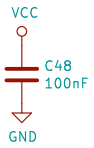
Title: Instruction Register

Size: A	Date:	Rev:
KiCad E.D.A. kicad (5.1.0-0)		Id: 13/22


Microcode ROMs
ID/EX registers
U43
GLS29EE010
U44
GLS29EE010
U45
74F574
U46
74F574
U47
74F574
C43 100nF
C44 100nF
C45 100nF
C46 100nF
C47 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: 14/22





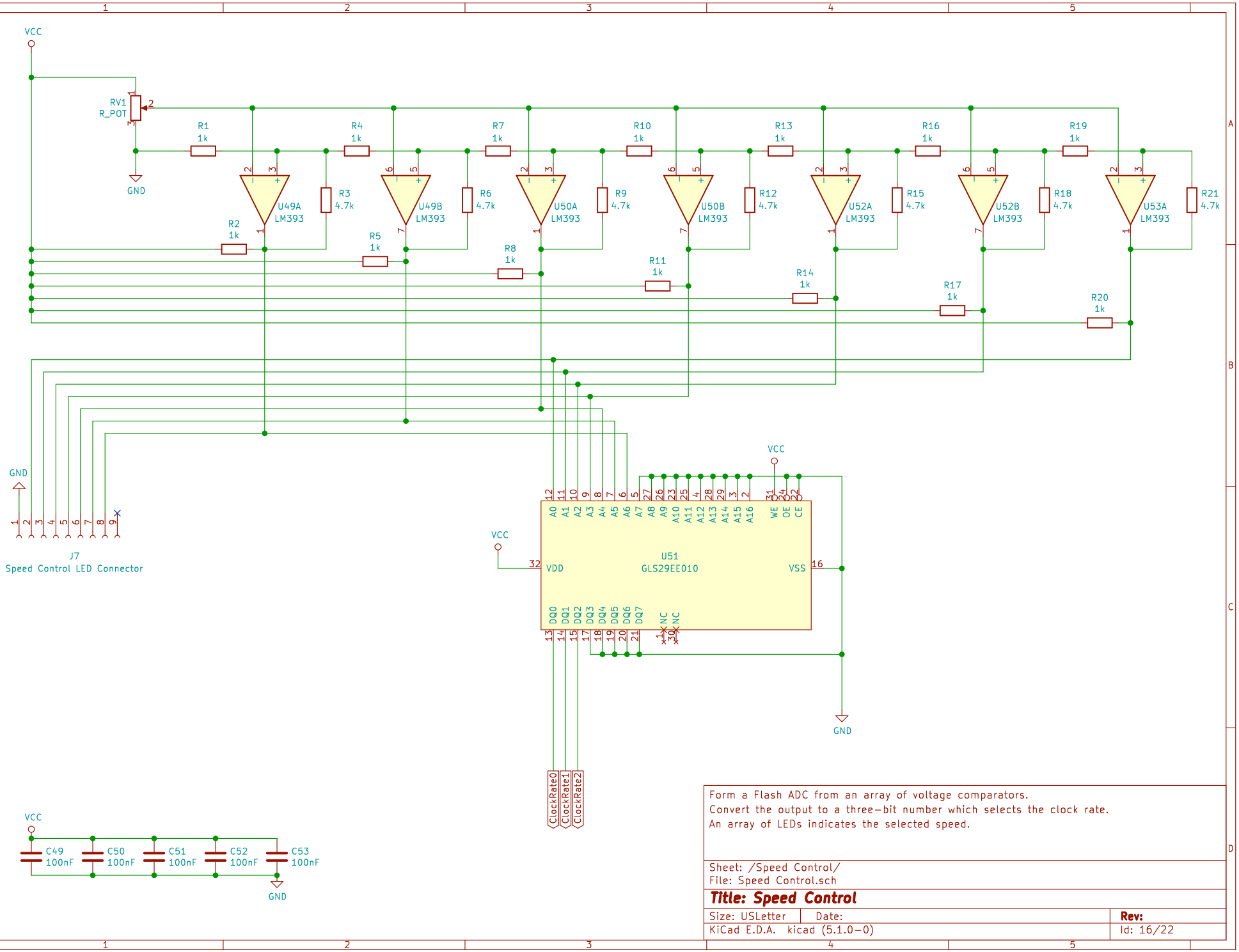


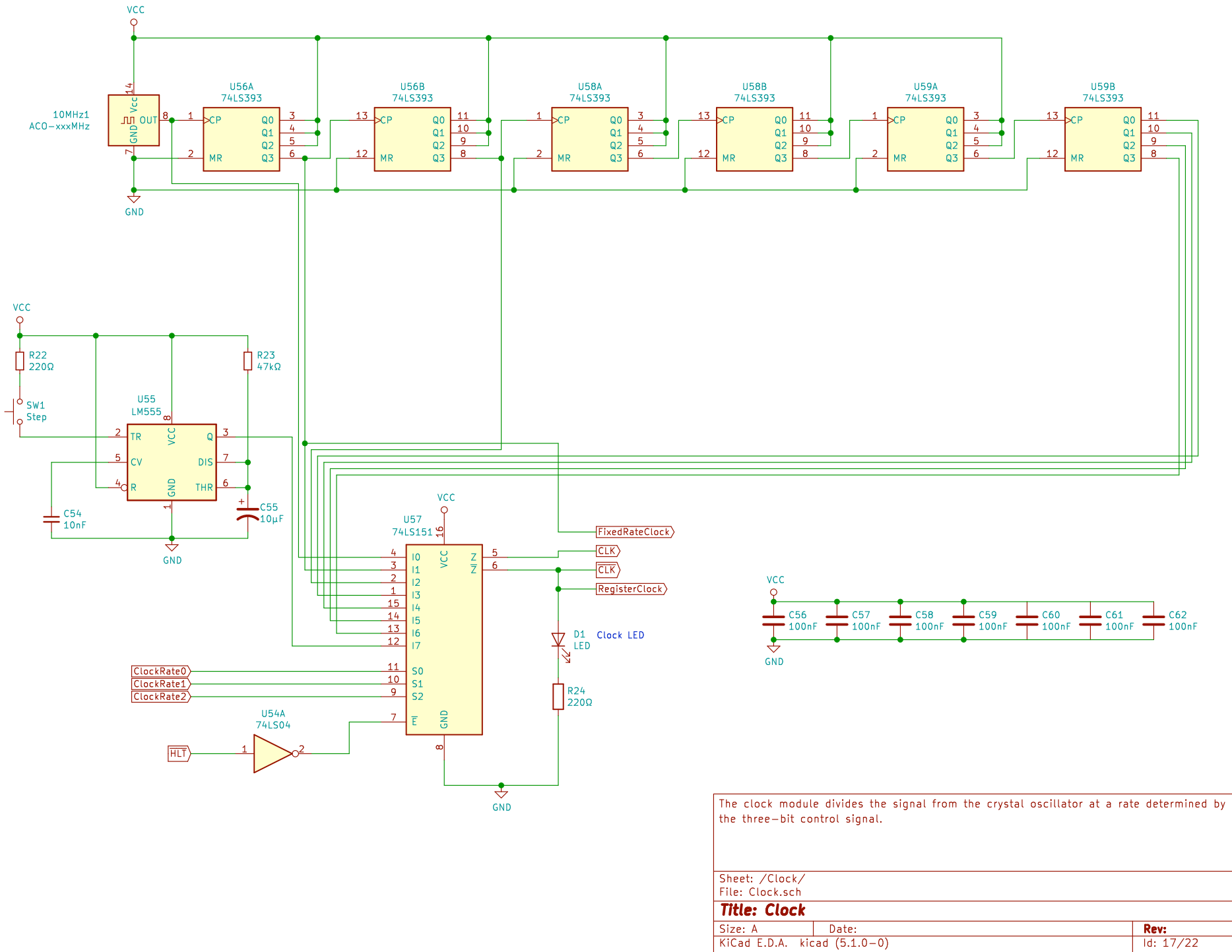
The lower eight bits of the instruction register can be expressed onto the data bus as a constant value.

Sheet: /Execute/
File: Execute.sch

Title: Execute

Size: A	Date:	Rev:
KiCad E.D.A. kicad (5.1.0-0)		Id: 15/22


VCC
RV1
R_POT
GND
R1 1k
R2 1k
R3 4.7k
R4 1k
R5 1k
R6 4.7k
R7 1k
R8 1k
R9 4.7k
R10 1k
R11 1k
R12 4.7k
R13 1k
R14 1k
R15 4.7k
R16 1k
R17 1k
R18 4.7k
R19 1k
R20 1k
R21 4.7k
U49A LM393
U49B LM393
U50A LM393
U50B LM393
U52A LM393
U52B LM393
U53A LM393
J7
Speed Control LED Connector
U51
GLS29EE010
VDD
VSS
WE
OE
CE
NC
ClockRate0
ClockRate1
ClockRate2
C49 100nF
C50 100nF
C51 100nF
C52 100nF
C53 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: 16/22



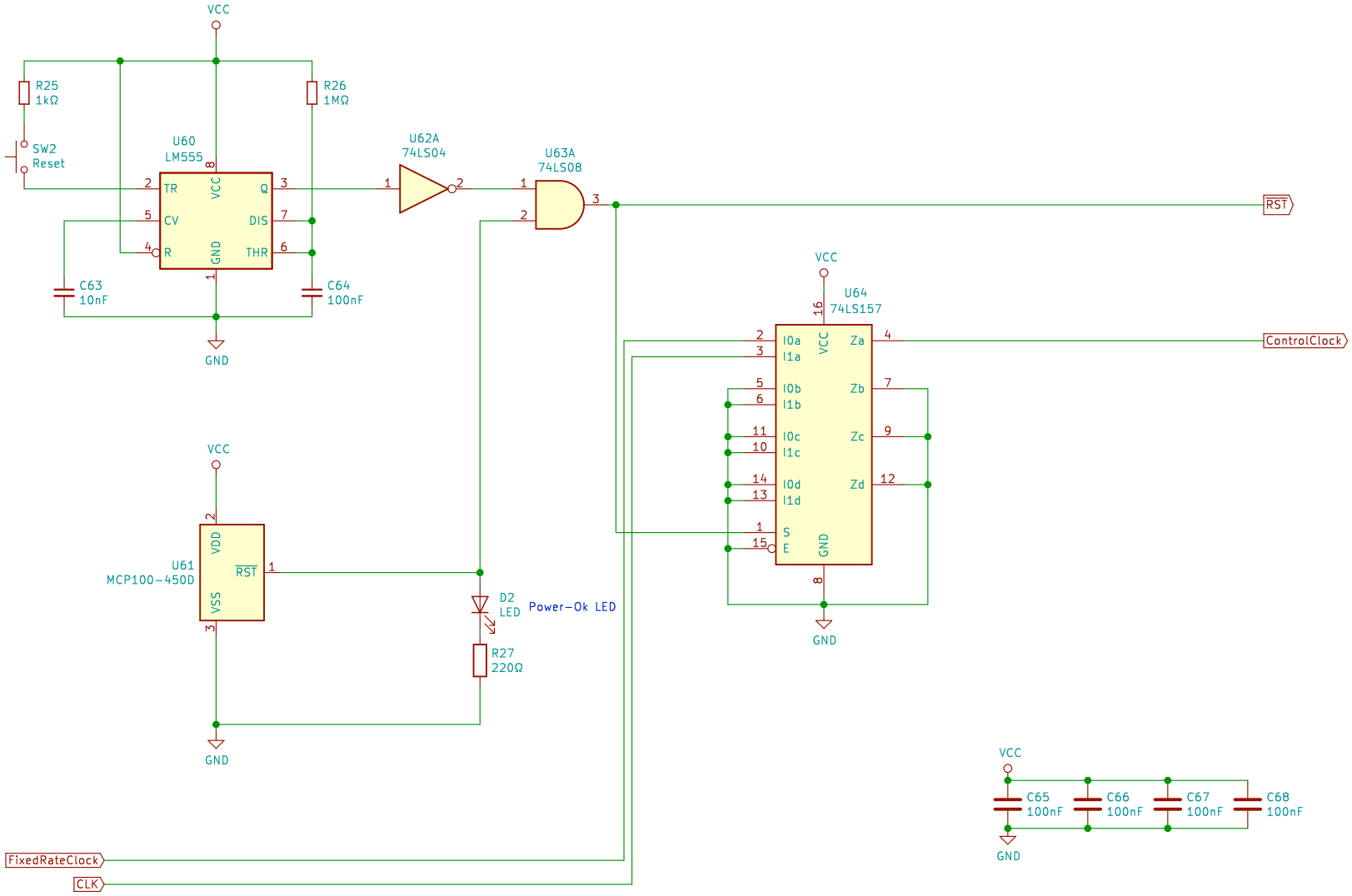
The clock module divides the signal from the crystal oscillator at a rate determined by the three-bit control signal.

Sheet: /Clock/
File: Clock.sch

Title: Clock

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

KiCad E.D.A. kicad (5.1.0-0) | Id: 17/22

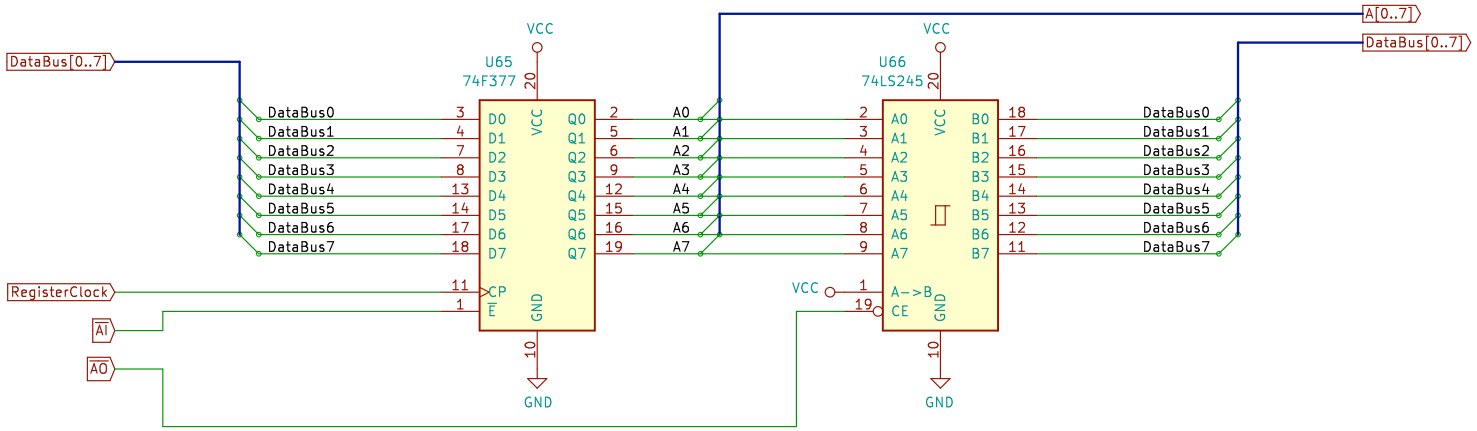


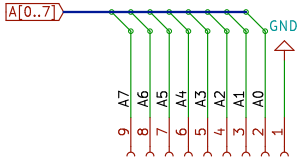
The MCP100 provides Power-on Reset functionality.
A button is also provided to manually reset the machine.
During reset, the control clock is pulsed repeatedly to flush the pipeline.

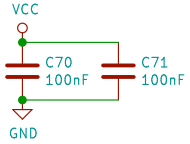
Sheet: /Power-on Reset/
File: Power-on Reset.sch

Title: Power-on Reset

Size: A	Date:	Rev:
KiCad E.D.A. kicad (5.1.0-0)		Id: 18/22





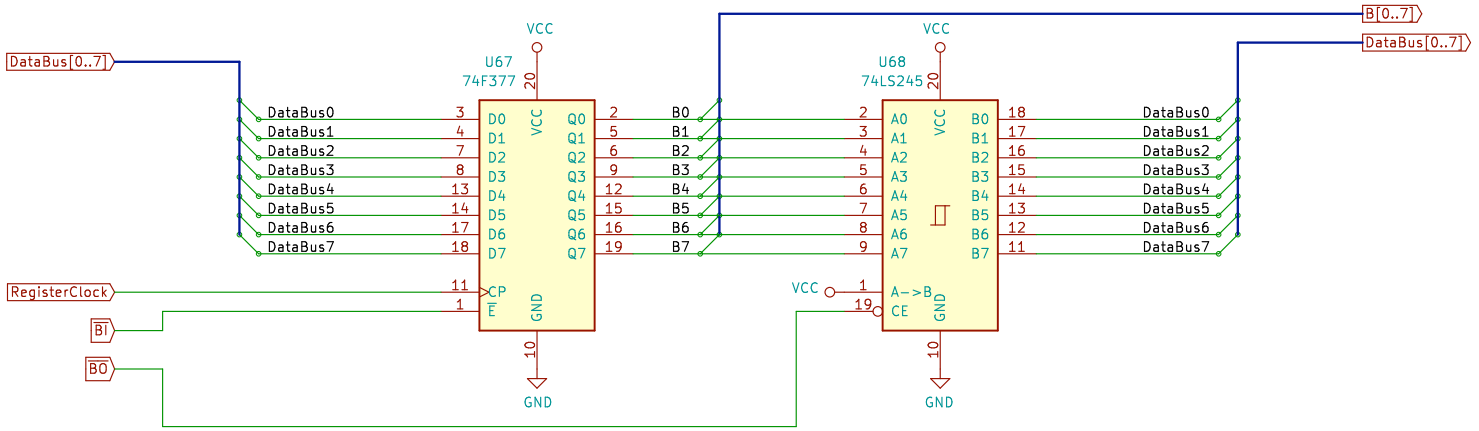


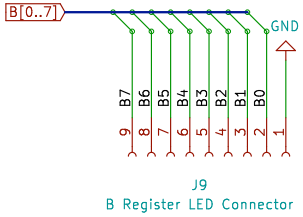
Register A is wired to the ALU's A operand.

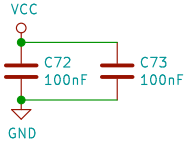
Sheet: /Register A/
File: Register A.sch

Title: Register A

Size: A	Date:	**Rev:**
KiCad E.D.A. kicad (5.1.0-0)		Id: 19/22





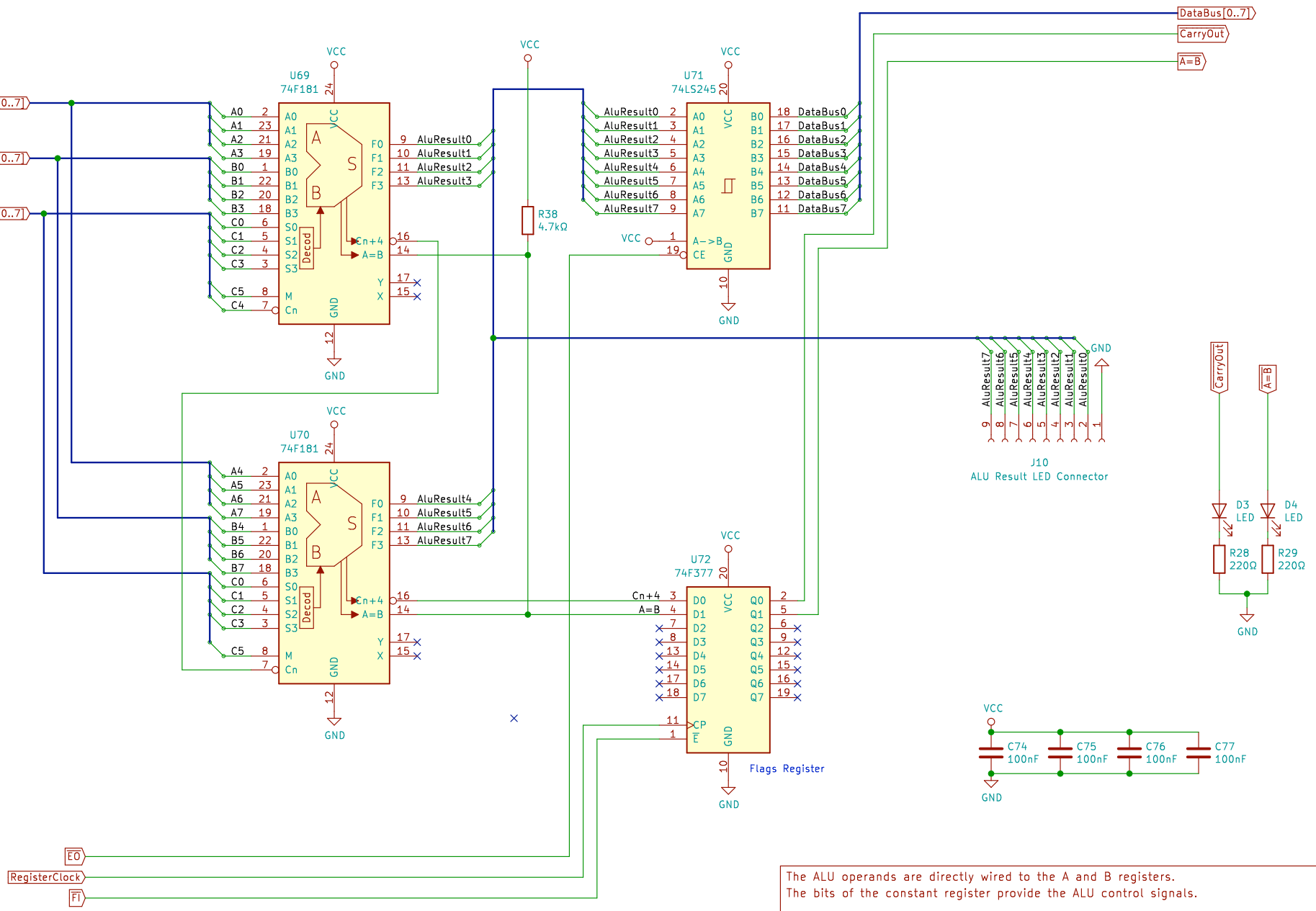


Register B is wired to the ALU's B operand.

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

Title: Register B

Size: A	Date:	**Rev:**
KiCad E.D.A. kicad (5.1.0-0)		Id: 20/22

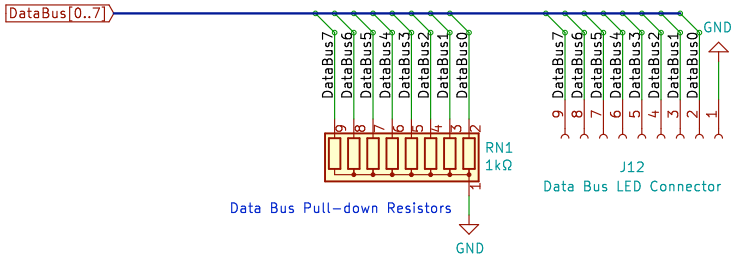


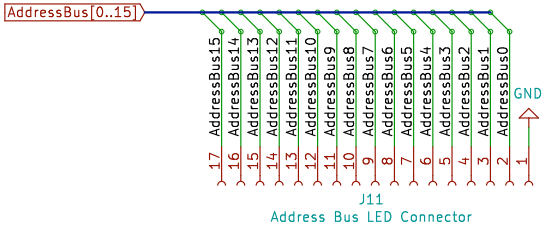
The ALU operands are directly wired to the A and B registers.
The bits of the constant register provide the ALU control signals.

Sheet: /ALU/
File: ALU.sch

Title: ALU

Size: A	Date:	Rev:
KiCad E.D.A. kicad (5.1.0-0)		Id: 21/22





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