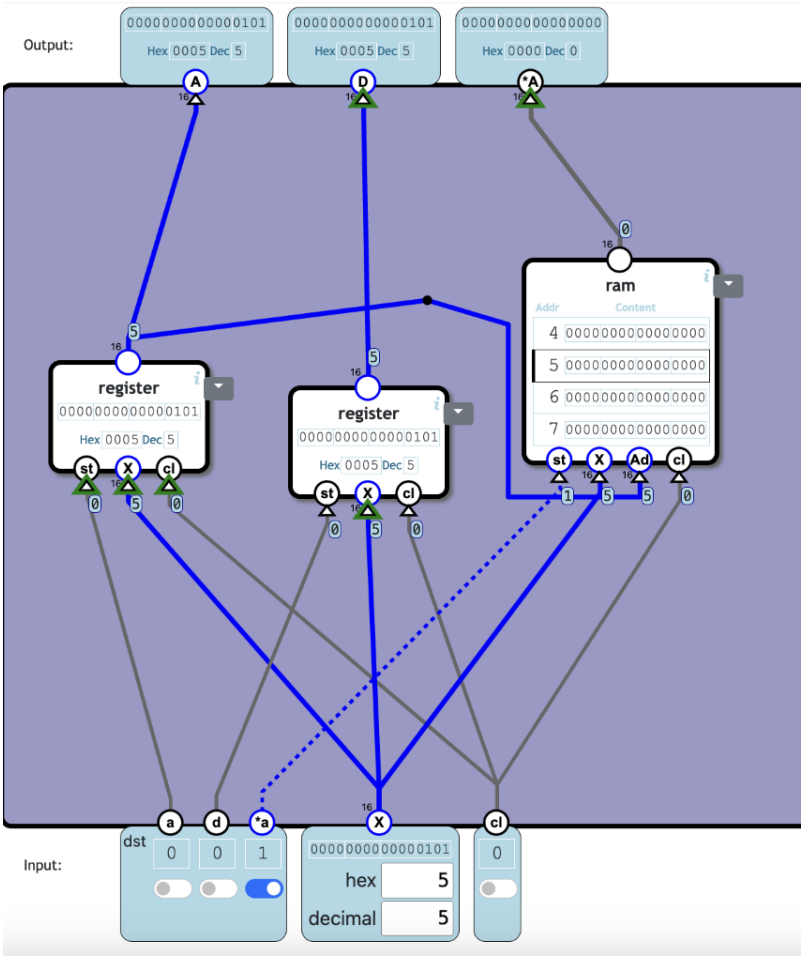
1. Combined Memory

"A processor uses both kinds of memory, registers, and RAM."
"Registers are directly accessible by the processor and used for intermediate values and calculations. RAM can store a large amount of data, but we can read or write from only a single address at a time."
"In this processor we have two registers called A and D and one RAM bank."

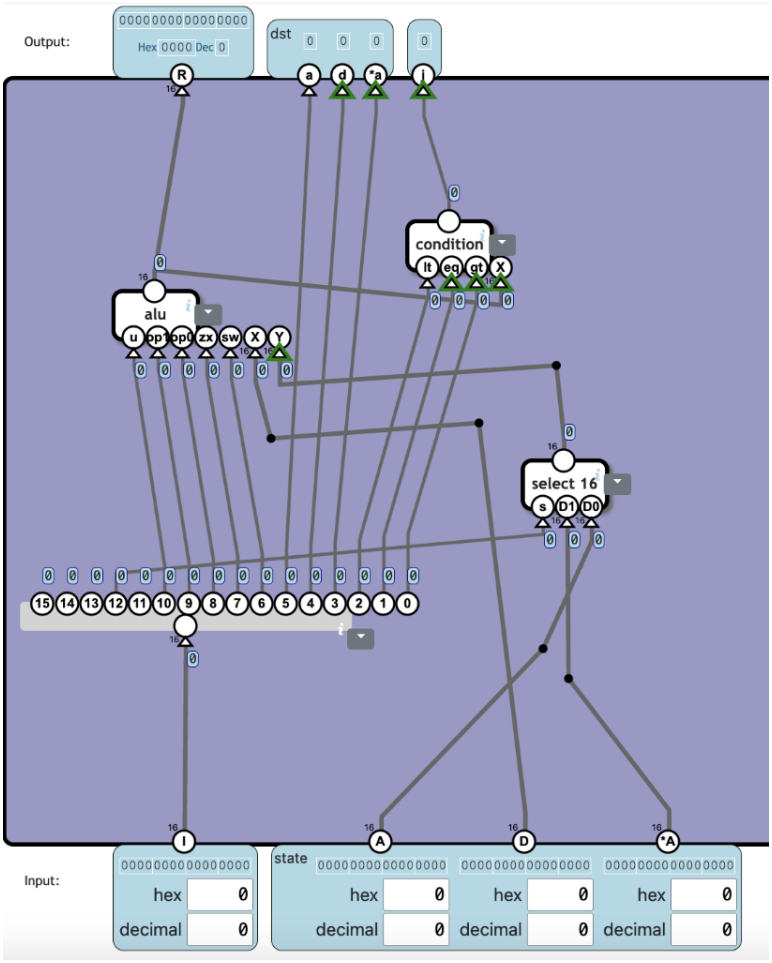


2. Instruction

"I is an instruction to the ALU and condition components. The bits direct the operation as specified:"

Input	Output	
Bit	**Group**	**flag**
10	ALU	u
9	ALU	op1
8	ALU	op0
7	ALU	zx
6	ALU	sw
5	destination	a
4	destination	d
3	destination	*a
2	condition	lt
1	condition	eq
0	condition	gt

"The A, D and *A inputs are the values of the registers"
"The X input to the ALU should be D, the Y input should be either A or *A depending on bit 12 in the instruction. If bit 12 is 0, it is A, if 1, *A."
"The R output is the result of the ALU operation."
"The j flag indicate if the ALU output conforms to the conditions specified in bit 0-2."



Input			Output
u	op1	op0	
0	0	0	X and Y
0	0	1	X or Y
0	1	0	X xor Y
0	1	1	invert X
1	0	0	X + Y
1	1	0	X - Y
1	0	1	X + 1
1	1	1	X - 1

When the sw flag is 1, the X and Y inputs are swapped.

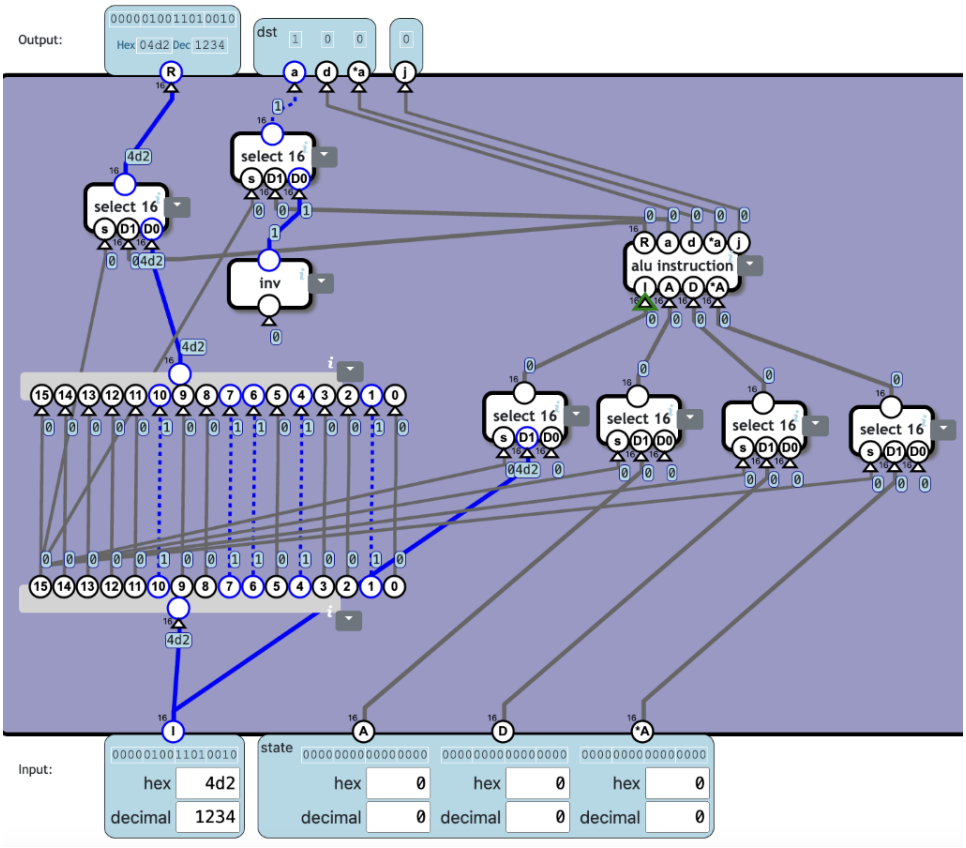
When the zx flag is 1, the left operand is replaced with 0.

3. Control Unit

"In addition to the ALU instructions, the computer should also support data instructions. In a data instruction, the instruction value is directly written to the A register.
Create a control unit which execute either a data- or ALU instruction, depending on the high-bit of the instruction I:"

Bit 15	
0	Data instruction
1	ALU instruction

"For a data instruction, the output R should be the I input, and destination should be the A register. I.e. a should be 1 and d, a*, and j flags should be 0"

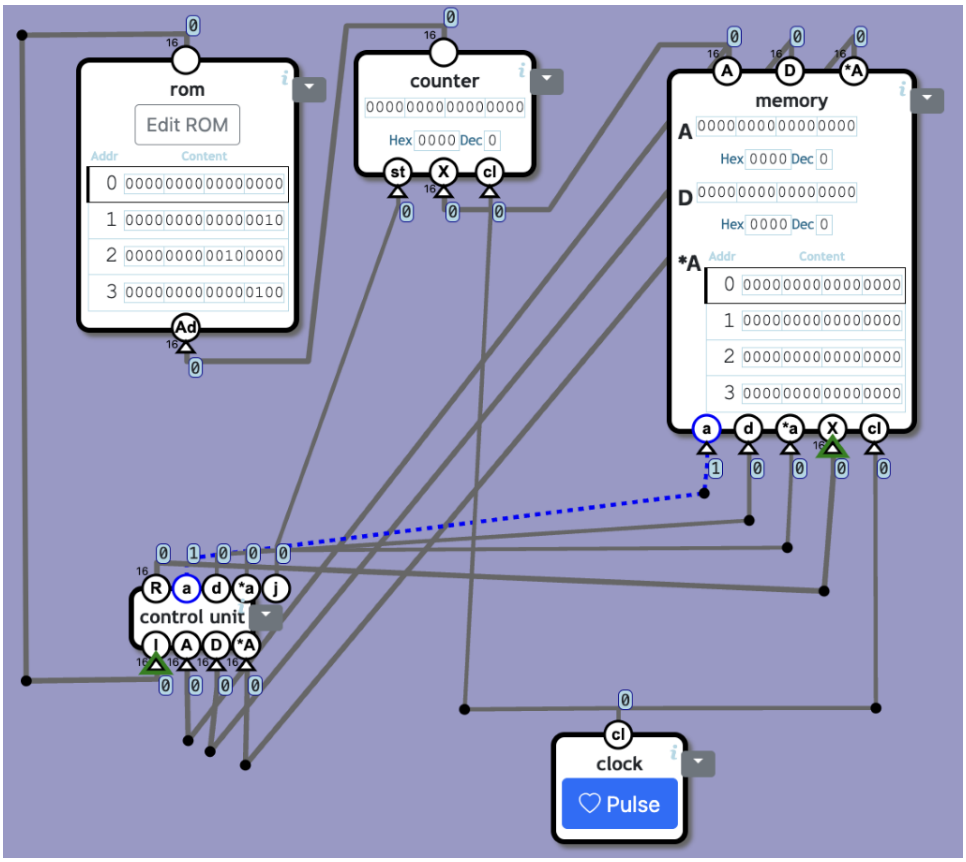


4. Computer

"Build a computer by combining:

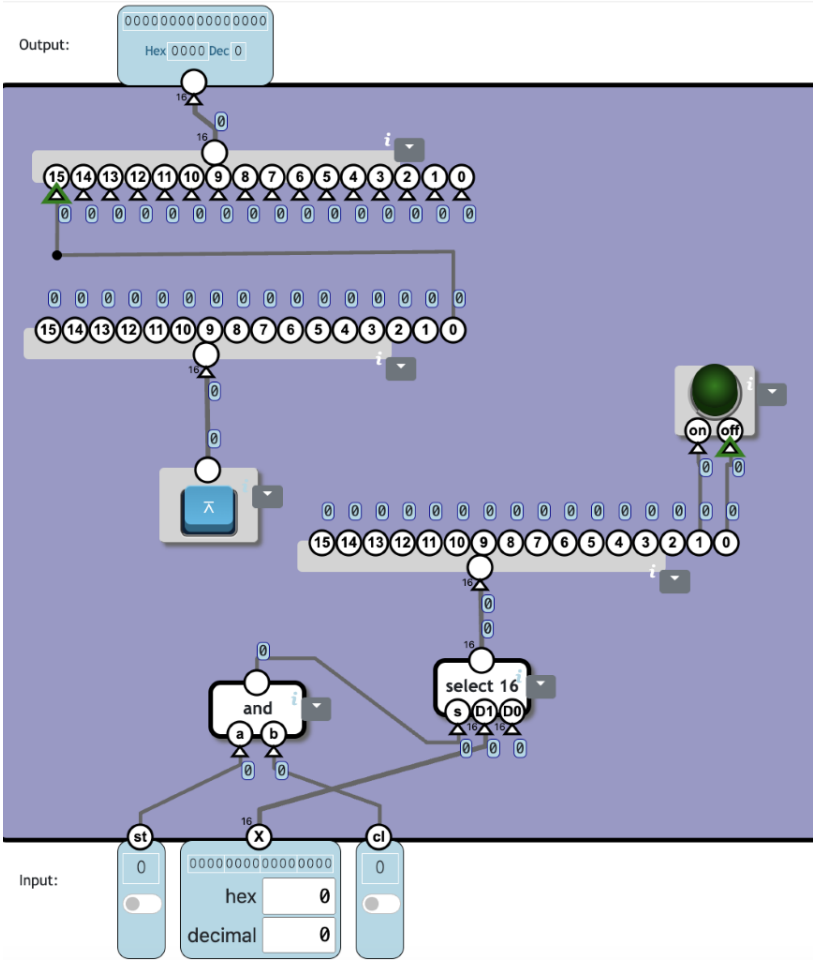
- A control unit
- Storage memory (RAM and registers)
- A program memory unit (ROM).
- A counter which keeps track of the current instruction address (called the "program counter" or PC).
- A clock unit

The word at the PC address in the program memory is the I input to the control unit.
Each clock cycle changes the program counter depending on j:
If j=0, the program counter should advance with 1.
If j=1, the PC should be set to the value on A."



5. Input/Output

Simple input/output exercise using bits


Output:
Hex 0000 Dec 0
15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0
on
off
and
a
b
select 16
s
D1
D0
st
X
cl
Input:
hex
decimal