

## INSTRUCTIONS: 4-bit single cycle CPU

This CPU uses fixed length instructions. This CPU also has two types of instruction formats: R-type and I-type. In R-type instructions both operands come from registers. In I-type instructions, the first operand comes from a register and the second will be contained within the instruction.

### R-Type

Name	Bits	Description
OpCode	15 - 12	Determines what operation should be performed
C	11 - 8	The destination register. The C in $\text{Reg}_C = \text{Reg}_A \text{ OP } \text{Reg}_B$
A	7 - 4	The first source register. The A in $\text{Reg}_C = \text{Reg}_A \text{ OP } \text{Reg}_B$
B	3 - 0	The second source register. The B in $\text{Reg}_C = \text{Reg}_A \text{ OP } \text{Reg}_B$

### I-Type

Name	Bits	Description
OpCode	15 - 12	Determines what operation should be performed
C	11 - 8	The destination register. The C in $\text{Reg}_C = \text{Reg}_A \text{ OP } \text{Imm}$
A	7 - 4	The first source register. The A in $\text{Reg}_C = \text{Reg}_A \text{ OP } \text{Imm}$
Immediate	3 - 0	The second source register. The Imm in $\text{Reg}_C = \text{Reg}_A \text{ OP } \text{Imm}$

### Instructions

Operation	Encoding (The value in the OpCodeField)	Description
STOP	0000	The CPU ceases execution
NOP	0001	Do nothing
LOAD	0010	$\text{Reg}_C = \text{Immediate}$
MOVE	0011	$\text{Reg}_C = \text{Reg}_A$

ANDR	0100	$\text{Reg}_C = \text{Reg}_A \text{ AND } \text{Reg}_B$
ANDI	0101	$\text{Reg}_C = \text{Reg}_A \text{ AND Immediate}$
ORR	0110	$\text{Reg}_C = \text{Reg}_A \text{ OR } \text{Reg}_B$
ORI	0111	$\text{Reg}_C = \text{Reg}_A \text{ OR Immediate}$
XORR	1000	$\text{Reg}_C = \text{Reg}_A \text{ XOR } \text{Reg}_B$
XORI	1001	$\text{Reg}_C = \text{Reg}_A \text{ XOR Immediate}$
NOT	1010	$\text{Reg}_C = \text{NOT } \text{Reg}_A$
NEGATE	1011	$\text{Reg}_C = -\text{Reg}_A$
ADDR	1100	$\text{Reg}_C = \text{Reg}_A + \text{Reg}_B$
ADDI	1101	$\text{Reg}_C = \text{Reg}_A + \text{Immediate}$
SUBR	1110	$\text{Reg}_C = \text{Reg}_A - \text{Reg}_B$
SUBI	1111	$\text{Reg}_C = \text{Reg}_A - \text{Immediate}$

## Inputs

Pin	Size (in bits)	Explanation
Instruction	16	The instruction located at instruction_Address
ClkIn	1	The Clock. Connect this to the clock ports of your registers and flip-flops. Do nothing else with this.

## Outputs

Pin	Size (in bits)	Explanation
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Instruction_Address_Out	5	The address of the instruction you want to execute
Reg0-15	4	The values in the register file. This has already been connected.

## Restrictions

For the CPU, I only could use:

- All of the components under Wiring
- All of the components under Gates **EXCEPT** for Controlled Buffer, Controlled Inverter, PLA
- All of the components under Plexers
- All of the components under Arithmetic
- All of the components under Memory **EXCEPT** for **RAM**, **ROM**, and **Random** Generator