

**COURSE TITLE: Computer Organization and Architecture**

**Project : ISA**

**SUBMITTED TO: TnR**

**COURSE CODE: CSE 332**

**SECTION 1**

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**Introduction:**

Our task is to design a new 14 bit single-cycle CPU that has separate Data and Instruction Memory.

We planned our ISA centering on the taking after three categories of programs:

a) Basic arithmetic & logic operations,

b) Programs that require checking conditions,

c) Loop type of programs.

**Design:**

We have restricted our ISA to work with 16 dedicated instructions.

* **Operand Type:** We use register type operands and memory-based operands.
* **Operands:** We are going to use 2 operands where operands are 5 bits.
* **Operations:** In our design we have decided to use 16 operations so we have dedicated 4 bits to Opcode.
* **Operation Type:** In our Design we have 5 types of operations.

1.Arithmetic: Add, Sub, Addi

2.Logical: AND, OR, NOR, Sll

3.Conditional: beq, bne, Slt, Slti

4.Data Transfer: lw ,sw ,Din ,Dout

5.Unconditional: J

* **Formats:** We use 3 types of Formats.

1. Register Type.

2. Immediate Type.

3. Jump Type.

The ISA Format of a 14 bit Vending Machine are tabulated below:

**ISA FORMAT:**

**R-Type:**

|  |  |  |
| --- | --- | --- |
| **Opcode** | **Destination Register** | **Source Register** |
| OP | RD | RS |
| 4 Bits | 5 Bits | 5Bits |

**I-Type:**

|  |  |  |
| --- | --- | --- |
| **Opcode** | **Source Register** | **IMMEDIATE** |
| OP | RS | IMM |
| 4 Bits | 5 Bits | 5 Bits |

**J-Type:**

|  |  |
| --- | --- |
| **Opcode** | **Target** |
| 4 Bits | 10 Bits |

* **Register Table:**

|  |  |  |  |
| --- | --- | --- | --- |
| **Name of the Registers** | **Register Number** | **Value Assigned (5 Bits**) | **Register purpose** |
| $zero | $0 | 00000 | Hardwired to 0 |
| $sp | $1 | 00001 | Stack Pointer |
| $v0 | $2 | 00010 | Return Values From functions |
| $v1 | $3 | 00011 | Same as before |
| $a0 | $4 | 00100 | Arguments to functions |
| $a1 | $5 | 00101 | Same as before |
| $a2 | $6 | 00110 | Same as before |
| $a3 | $7 | 00111 | Same as before |
| $s0 | $8 | 01000 | Saved registers, preserved by subprograms |
| $s1 | $9 | 01001 | Same as before |
| $s2 | $10 | 01010 | Same as before |
| $s3 | $11 | 01011 | Same as before |
| $s4 | $12 | 01100 | Same as before |
| $s5 | $13 | 01101 | Same as before |
| $s6 | $14 | 01110 | Same as before |
| $s7 | $15 | 01111 | Same as before |
| $s8 | $16 | 10000 | Same as before |
| $s9 | $17 | 10001 | Same as before |
| $t0 | $18 | 10010 | Temporary data, not preserved by subprograms |
| $t1 | $19 | 10011 | Same as before |
| $t2 | $20 | 10100 | Same as before |
| $t3 | $21 | 10101 | Same as before |
| $t4 | $22 | 10110 | Same as before |
| $t5 | $23 | 10111 | Same as before |
| $t6 | $24 | 11000 | Same as before |
| $t7 | $25 | 11001 | Same as before |
| $t8 | $26 | 11010 | Same as before |
| $t9 | $27 | 11011 | Same as before |
| $at | $28 | 11100 | Reserved for pseudo instructions |
| $k0 | $29 | 11101 | Reserved for kernel |
| $k1 | $30 | 11110 | Same as before |
| $fp | $31 | 11111 | Frame Pointer |

**Table for Operation Type, Instructions, Syntax, Format and Opcode:**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Operation Type | Instruction | Format | Syntax | Meaning | Opcode | Notes |
| Logical | AND | R | AND $S1, $S2 | $S1 = $S1 & $S2 | 0000 | AND operation between two registers. |
| OR | R | OR $S1, $S2 | $S1 = $S1 | $S2 | 0001 | OR operation between two registers. |
| NOR | R | NOR $S1, $S2 | $S1 = ($S1 | $S2)’ | 0010 | Complement of OR operation between two registers |
| Sll | I | Sll $S1, 5 | $S1 = $S1 <<5 | 0011 | Shift left |
| Arithmetic | ADD | R | ADD $S1, $S2 | $S1 = $S1 + $S2 | 0100 | Adding two registers |
| SUB | R | SUB $S1, $S2 | $S1 = $S1 - $S2 | 0101 | Subtracting two registers |
| ADDi | I | ADD $S1, 9 | $S1 = $S1 + 9 | 0110 | Adding constant to register |
| Data Transfer | LW | R | LW $S1, $S2 | $S1 = $S2 | 0111 | Loads from memory |
| SW | R | SW $S1, $S2 | $S2 = $S1 | 1000 | Stores into memory |
| Din | R | Din $S1 | $S1 = User Input | 1001 | Input taken from User |
| Dout | R | Dout $S1 | $S1 = User Output | 1010 | Output shown to User |
| Conditional | Slt | R | Slt $S1, $S2 | If($S1 < $S2)  $S1 = 1,  Else $S1 = 0 | 1011 | Comparison between two registers |
| Slti | I | Slti $S1, 5 | If($S1 < 5)  $S1 = 1,  Else $S1 = 0 | 1100 | Comparison between register and constant |
| Beq | I | Beq $S1, 6 | If($S1 == $sp)  Go to line 6 | 1101 | Equality check between registers |
| Bne | I | Bne $S1, 6 | If($S1 != $sp)  Go to line 6 | 1110 | Inequality check between registers. |
| Unconditional | Jump | J | J 7 | Jump to line 7 | 1111 | Jump to another instruction. |

**The addressing Modes we will use are given below:**

1. Register addressing.
2. Immediate addressing.
3. Base addressing.
4. Pc-relative addressing.
5. Indirect addressing.
6. Direct addressing.