ISA Design

Roll no: 1703018

Requirements:

- ✓ **Word size of CPU: 5**
- ✓ **ALU Operations: 2** (SHL, ROL)
- ✓ **No of Registers: 4**
- ✓ **Supported RAM: 7x15**
- ✓ **Types of Instructions:** ALU Instruction (Register Mode), ALU Instruction (Immediate Mode), Jump Instruction (JMP)

Answer:

Word size of RAM and ISA is 15. So, maximum size of instruction is 15 bits.
No of types of instructions is 3. So, 2 bits is for types of instruction ($2^2 = 4$). No of ALU operations is 2. So, 1 bit is for Operations ($2^1 = 2$). 0 = SHL, 1 = ROL. So, Opcode is 3 bits.

ISA format for ALU instruction (Register Mode):

No of Registers is 4. So, 2 bits are needed to address 4 registers ($2^2 = 4$).

Opcode (3 bit)		Register 1	Register 2	Unused
2 bits	1 bit	2 bits	2 bits	8 bits
Types of instruction (00)	Operations 0 = SHL 1 = ROL	Ra (00-11)	Rb (00-11)	XXXXXXXX

Size of ISA needed 7 bits.

ISA format for ALU instruction (Immediate Mode):

CPU is 5-bit, size of value will be 5 bits.

Opcode (3 bit)		Register 1	Value	Unused
2 bits	1 bit	2 bits	5 bits	5 bits
Types of instruction (01)	Operations 0 = SHL 1 = ROL	Ra (00-11)	Value (00000-11111)	XXXXX

Size of ISA needed 10 bits.

ISA format for Jump instruction (JMP):

Size of RAM 7. So, 3 bits will be taken to address all memory locations.

Opcode (3 bit)		Address	Unused
2 bits	1 bit	3 bits	9 bits
Types of instruction (10)	Operations 0 = JMP	Value (000-111)	XXXXXXXXX

Size of ISA needed 6 bits.

So, Total size of ISA will be 10 bits. Extra bits in other instructions will be unused.

ISA format for ALU instruction (Register Mode):

Opcode (3 bit)		**Register 1**	**Register 2**	**Unused**
2 bits	1 bit	2 bits	2 bits	3 bits
(00) Types of instruction	Operations 0 = SHL 1 = ROL	Ra (00-11)	Rb (00-11)	XXX

ISA format for ALU instruction (Immediate Mode):

Opcode (3 bit)		**Register 1**	**Value**
2 bits	1 bit	2 bits	5 bits
(01) Types of instruction	Operations 0 = SHL 1 = ROL	Ra (00-11)	Value (00000-11111)

ISA format for Jump instruction (JMP):

Opcode (3 bit)		Address	Unused
2 bits	1 bit	3 bits	4 bits
Types of instruction (10)	Operations 0 = JMP	Value (000-111)	XXXX

ISA Instructions:

Instruction	**Machine Code**
SHL R0, R1	00 0 00 01 000
SHL R1, 2	01 0 01 00010
ROL R0, R1	00 1 00 01 000
ROL R2, 3	01 1 10 00011
JMP 3 (LABEL)	10 0 011 0000