ISA Design

Roll no: 1703018

Requirements:

- ✓ **Word size of CPU: 5**
- ✓ **ALU Operations: 2** (SHL, ROL)
- ✓ **No of Registers: 4**
- ✓ **Supported RAM: 2^7x15 or 128x15**
- ✓ **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 (0/1)	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 (0/1)	Ra (00-11)	Value (00000-11111)	XXXXX

Size of ISA needed 10 bits.

ISA format for Jump instruction (JMP):

Size of RAM 128. So, 7 bits will be taken to address all memory locations (2^7 = 128).

Opcode (3 bit)		Address	Unused
2 bits	1 bit	7 bits	5 bits
Types of instruction (10)	Operations	Value (0000000-1111111)	XXXXX

Size of ISA needed 10 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 (0/1)	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 (0/1)	Ra (00-11)	Value (00000-11111)

ISA format for Jump instruction (JMP):

Opcode (3 bit)		**Address**
2 bits	1 bit	7 bits
(10) Types of instruction	Operations	Value (0000000-1111111)

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 0000011