

# Machine Language Guide

## Basic Program

The basic template of a machine language program is shown below.

```
; Program name      : XOR Implementation
;Programmer        : Jayakanth Srinivasan
;Last Modified     : Feb 18 2003

; code segment

    load R1,1        ;Load register R1 with 1
    load R2,0xff     ;Load register R2 with 11111111
    load R3,[first_number] ; move contents of location labeled
                        ; first_number into register R3
    xor  R4, R3,R2    ; flip the 0's and 1's in the first number
    store R4, [result]; store the result in location labeled result
    halt              ;halt the program.

; data segment

first_number:  db 8
result:       db 5
```

Program Header, Contains

- Program Name
- Programmer Name
- Last Modified

Start of code segment

Start of data segment

## Instruction Set

Opcode	Instruction	Operation
2 RXY	load R,XY	register[R]:=XY
1 RXY	load R,[XY]	register[R]:=memory[XY]
3 RXY	store R,[XY]	memory[XY]:=register[R]
D ORS	load R,[S]	register[R]:=memory[register[S]]
E ORS	store R,[S]	memory[register[S]]:=register[R]
4 ORS	move S,R	register[S]:=register[R]
5 RST	addi R,S,T	register[R]:=register[S]+register[T] integer add
6 RST	addf R,S,T	register[R]:=register[S]+register[T] floating-point add
7 RST	or R,S,T	register[R]:=register[S] OR register[T] bitwise OR
8 RST	and R,S,T	register[R]:=register[S] AND register[T]

			<b>bitwise AND</b>
9	RST	<b>xor</b> R,S,T	register[R]:=register[S] XOR register[T] <b>bitwise eXclusive OR</b>
A	R0X	<b>ror</b> R,X	register[R]:=register[R] ROR X <b>Rotate Right register R for X times</b>
B	RXY	<b>jmpEQ</b> R=R0,XY	PC:=XY, if R=R0
	0XY	<b>jmp</b> XY	PC:=XY
F	RXY	<b>jmpLE</b> R<=R0,X	PC:=XY, if R<=R0
C	000	<b>halt</b>	halt program

The opcode is the first nibble (higher four bits of the first byte) and the three parts of the operand are the second, third and fourth nibble.

## Assembler Syntax

### Label

A label is a sequence of letters, decimal digits and special characters, but it may not start with a digit.

### Instruction

An instruction starts with a mnemonic, followed by the operands. It has to be one of the 16 instructions listed in the previous section.

### Comment

A comment starts after a semicolon ';' and ends at the end of the line. Any character is allowed after the ';'.

### Numbers

A number can be a decimal number, a binary number or a hexadecimal number.

- A decimal number is a sequence of decimal digits ('0' up to '9'). It may start with a '-' to indicate the number is negative. It may end with a 'd' to emphasize that the number is decimal.
- A binary number is a sequence of binary digits ('0' and '1') and ending with a 'b'.

- A hexadecimal number can be written in 3 ways:
  - C-style: The number starts with '0x', followed by a sequence of hexadecimal digits ('0' up to '9' and 'A' up to 'F').
  - Pascal-style: The number starts with '\$', followed by a sequence of hexadecimal digits ('0' up to '9' and 'A' up to 'F').
  - Assembler-style: The number is a sequence of hexadecimal digits ('0' up to '9' and 'A' up to 'F'), but it may not start with a letter. This sequence is followed by an 'h'. A number can always be made to start with a decimal digit by prefixing the number with a '0', so ABh is written as 0ABh.
- Spaces are not allowed within a number.

## Remarks

All identifiers (labels and mnemonics) and (hexadecimal) numbers are case-insensitive. This means that load, Load, LOAD and lOaD are all the same and so are 0xAB, 0Xab and 0XAB.

This editor uses syntax-highlighting:

- keywords: `load, store, addi`
- numbers: `-123, 0x10, 11001011b`
- comments: `;this is a comment`
- syntax errors: `12A3, -0x10, 1+1`

## Mnemonics and operand combinations

### *data byte*

```
db    dataitem_1, dataitem_2, ..., dataitem_n
```

- Puts data directly into the memory.
- A dataitem can be either a number or a string.
- An unlimited number of dataitems can be specified.

Examples:

```
db    1,4,9,16,25,36
db    "Hello world",0
```

### *origin*

```
org    adr
```

- The next code starts at address adr.
- Address adr must be a number.

- Different fragments of code are not allowed to overlap.

Examples:

```
org    60h
load   R0,2 ;put this instruction at address $60
```

### *immediate load*

```
load   reg,number
load   reg,label
```

- Assign the immediate value (number or address of label) to register reg.

Examples:

```
load   R4,8
load   R9,Label_of_something
```

### *direct load*

```
load   reg,[adr]
```

- Assign the memory contents at address adr to register reg.
- Address adr can be a number or a label.

Examples:

```
load   R4,[8]
load   R9,[Label_of_something]
```

### *indirect load*

```
load   reg1,[reg2]
```

- Assign the memory contents of which register reg2 holds the address to register reg1.

Example:

```
load   R4,[R8]
```

### *direct store*

```
store  reg,[adr]
```

- Put the value of register reg at memory location adr.
- Address adr can be a number or a label.

Examples:

```
store  R4,[8]
store  R9,[Label_of_something]
```

### *indirect store*

```
store  reg1,[reg2]
```

- Put the value of register reg1 at memory location of which register reg2 holds the address.

Example:

```
store  R4,[R8]
```

### *move*

```
move   reg1,reg2
```

- Assign the value of register reg2 to register reg1.

Example:

```
move   R4,R8
```

### *integer addition*

```
addi   reg1,reg2,reg3
```

- Assign the integer, 2-complement sum of register reg2 and register reg3 to register reg1.

Example:

```
addi    R7,R1,R2
```

#### **floating point addition**

```
addf    reg1,reg2,reg3
```

- Assign the floating-point sum of register reg2 and register reg3 to register reg1.

Example:

```
addf    R7,R1,R2
```

#### **bitwise or**

```
or       reg1,reg2,reg3
```

- reg1 := reg2 OR reg3

Example:

```
OR      R7,R1,R2
```

#### **bitwise and**

```
and      reg1,reg2,reg3
```

- reg1 := reg2 AND reg3

Example:

```
AND     R7,R1,R2
```

#### **bitwise exclusive or**

```
xor      reg1,reg2,reg3
```

- reg1 := reg2 XOR reg3

Example:

```
XOR     R7,R1,R2
```

#### **rotate right**

```
ror      reg,num
```

- Rotate register reg to the right for num number of times.

Example:

```
ror      RC,3
```

#### **jump when equal**

```
jmpEQ    reg=R0,adr
```

- Jump to address adr when register reg is equal to register R0.
- Address adr can be a number or a label.

Examples:

```
jmpEQ    R7=R0,42h
jmpEQ    R2=R0,Label_to_some_code
```

#### **jump when less or equal**

```
jmpLE    reg<=R0,adr
```

- Jump to address adr when register reg is less than or equal to register R0.
- Address adr can be a number or a label.

Examples:

```
jmpLE    R7<=R0,42h
jmpLE    R2<=R0,Label_to_some_code
```

#### **unconditional jump**

```
jmp      adr
```

- Jump to address adr.
- Address adr can be a number or a label.

Examples:

```
jmp      42h
jmp      Label_to_some_code
```

#### **stop program**

```
halt
```

- Stop the execution of the program.

Notes:

This handout was put together with information from the help section of the Simple Simulator developed at <http://wwwes.cs.utwente.nl/software/simpsim/>