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CS24BTECH11047
Homework 2

1. Write equivalent machine code (in hexadecimal) for the given assembly instructions, by highlighting the various fields in the 32-bits of the instruction: [10 marks]

a. addi x15, x22, -45

Sol:

I-type instruction format
imm[11:0] rs1 funct3 rd opcode
immediate = 111111010011
rs1 = 10110
funct3 = 000
rd = 01111
opcode = 0010011
Binary = 1111 1101 0011 1011 0000 0111 1001 0011
Hexadecimal = 0xFD3B0793

b. and x23, x8, x9

Sol:

R-type instruction format
funct7 rs2 rs1 funct3 rd opcode
funct7 = 0000000

rs2 = 01001
rs1 = 01000
funct3 = 111
rd = 10111
opcode = 0110011
Binary = 0000 0000 1001 0100 0111 1011 1011 0011
Hexadecimal = 0x00947BB3

c) blt x2, x11, 240

Sol:

B-type instruction format
imm[12|10:5] rs2 rs1 funct3 imm[4:1|11] opcode
imm = 000001111000 0
rs2 = 01011
rs1 = 00010
funct3 = 100
opcode = 1100011
Binary = 0000 1110 1011 0001 0100 1000 0110 0011
Hexadecimal = 0x0EB14863

d) sd x19, -54(x1)

Solution:

S-type instruction format
imm[11:5] rs2 rs1 funct3 imm[4:0] opcode
imm = 111111001010
rs2 = 10011
rs1 = 00001
funct3 = 011
opcode = 0100011

Binary = 1111 1101 0011 0000 1011 0101 0010 0011
Hexadecimal = 0xFD30B523

e) jal x3, -10116

Sol:

J-type instruction format
imm[20|10:1|11|19:12] rd opcode
imm = 11111110110000111100
rd = 00011
opcode = 1101111
Binary = 1000 0111 1101 1111 1101 0001 1110 1111
Hexadecimal = 0x87DFD1EF

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2. For various pseudo instructions shown below, write their equivalent using a maximum of 2 real instructions. [4 marks]
Note: The instruction li represents the pseudo instruction load immediate.

a. li x5, 0xFFFFFFFFFFFFFFFF

Sol:

0xFFFFFFFFFFFFFFFF = -1 in the range of -2048 to +2047 so can be added directly
addi x5 , x0 , -1

b. li x5, 132

Sol:

132 in the range of -2048 to +2047 so can be added directly.

addi x5 , x0 , 132

c. li x5, 2134

Sol:

2134 > 2047 so we load the upper 20 bits into the register and then adjust the register with signed lower 12 bits.

lui x5 , 1
addi x5 , x5 , -1962

d. li x5, 0x000000002345abcd

Sol:

0x000000002345abcd > 2047 so we load the upper 20 bits into the register and then adjust the register with signed lower 12 bits.

lui x5 , 0x2345b
addi x5 , x5 , -1075

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3. Convert the given instructions in hex to their corresponding assembly code [6 marks]

a. 0x0019F233

Sol:

Binary = 0000000 00001 10011 111 00100 0110011
opcode = 0110011 = R-type instruction
funct7 = 0000000 = sra and sub are eliminated
funct3 = 111 = and operation
rd = 00100 = x4
rs1 = 10011 = x19
rs2 = 00001 = x1
Instruction = and x4 , x19 , x1

b. 0x06B4D763

Sol:

Binary = 0 000011 01011 01001 101 0111 0 1100011
opcode = 1100011 = B-type instruction
funct3 = 101 = bge instruction
rs1 = 01001 = x9
rs2 = 01011 = x11
imm = 0000001101110 = 110
Instruction = bge x9 , x11 , 110

c. 0x0169CF93

Sol:

Binary = 000000010110 10011 100 11111 0010011
opcode = 0010011 = I-type instruction
rd = 11111 = x31
funct3 = 100 = xori instruction
rs1 = 10011 = x19
imm = 22
Instruction = xori x31 , x19 , 22