EE20021 HighRisc processor instruction set definition

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Introduction

This document describes the instruction set architecture (ISA) of the HighRisc processor that you are developing for your coursework.

Instruction formats

The ISA has three instruction formats (R-type, J-type and I-type) shown in the following tables.

Table 1. R-type instruction format

Section	Opcode				Destination (Dest)						Source (Src) / Immediate					
Value	1 to 15				0 to 63						0 to 63					
Bit	15			12	11					6	5					0

Table 2. J-type instruction format

Section	Opcode				Condition			Offset								
Value	0				See Flags			-256 to 255								
Bit	15			12	11		9	8								0

Table 3. I-type instruction format

Opcode	Imm[5]	Dest														
LIU	1	Imm[4:0]					Unchanged									
LIU	0	Sign Extend					Imm[4:0]					Unchanged				
LIL	X	Sign Extend										Imm				
	Bit	15				11	10				6	5					0

Registers

The system has 62 general purpose registers (R0 to R61). Each is 16 bits in size. There are also two special registers as described below.

Special register: Flags

Register 62 is the Flags register (FL). This is a 5 bit register containing the ALU result flags described in table 2. Three conditions are also described in the table that are derived from the flags but not stored in the register.

Table 4. Flags and conditions

Bit	Condition	Code	Description	Essential
0	Carry	C	Set when an arithmetic function produces a carry (or borrow). Also used as an extra register bit in rotate operations	Yes
1	Zero	Z	Set when the result of an ALU operation is zero	Yes
2	Negative	N	Set when the result of an ALU operation is negative	Yes
3	Parity	P	Set when the number of 1 bits in the result of an ALU operation is even (including when no bits are set to 1)	Yes

4	Overflow	V	Set when an ALU addition or subtraction operation overflows. The conditions in which this is deemed to have occurred are shown in table 5	Yes
-	No carry	NC	Set when an arithmetic function doesn't produce a carry (or borrow). Rotate operations affect this flag	
-	Not zero	NZ	Set when the result of an ALU operation is not zero	
-	Always	A	Always set	

Table 5. Overflow flag conditions based on the most significant bit (MSB) of each or the ALU inputs and outputs

Addition			
Dest MSB	Src MSB	Result MSB	V flag
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	0
1	0	0	0
1	0	1	0
1	1	0	1
1	1	1	0

Subtraction			
Dest MSB	Src MSB	Result MSB	V flag
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	1
1	0	1	0
1	1	0	0
1	1	1	0

Special register: Program Counter
Register 63 is the Program Counter (PC) which stores the address of the currently executing instruction.

Instructions
The list of instructions that can be executed by the HighRisc processor are shown in Table 6.

Table 6. Instructions of the HighRisc processor

Opcode Value	Name	Description	Flags Affected	ALU operation?
0	JR	Changes the PC by the *offset* if the *condition* flag is set		No
1	LOAD	Loads register *Dest* with the value at the address in data memory given by register *Src*.		No
2	STORE	Copies the value in register *Src* to the address in data memory given by register *Dest*.		No
3	MOVE	Copies the content of register *Src* to register *Dest.*		Yes
4	NAND	Sets register *Dest* to the bitwise logical NAND of the contents of registers *Dest* and *Src*.		Yes
5	NOR	Sets register *Dest* to the bitwise logical NOR of the contents of registers *Dest* and *Src*.		Yes

6	ROL	Sets register *Dest* to the contents of register *Src* having first shifted the value left by 1 bit and sets the least significant bit of *Dest* to the value in the *C* flag. Following this operation, the *C* flag contains the most significant bit of *Src*.	C	Yes
7	ROR	Sets register *Dest* to the contents of register *Src* having first shifted the value right by 1 bit and sets the most significant bit of *Dest* to the value in the *C* flag. Following this operation, the *C* flag contains the least significant bit of *Src*.	C	Yes
8	LIL	Sets the contents of register *Dest* to a sign extended copy of the immediate value.		Yes
9	LIU	Sets the upper bits of register *Dest* based upon the immediate value as shown in table 5.		Yes
10	ADC	Sets the value of register *Dest* to be the sum of *Src*, *Dest* and the *C* flag. All flags are set according to the result.	CZN VP	Yes
11	SUB	Sets the value of register *Dest* to *Dest* – (*Src* + *C)* flag. All flags are set according to the result.	CZN VP	Yes
12	DIV	Sets the value of register *Dest* to the result of a signed integer division *Dest* / *Src*.	ZNP	Yes
13	MOD	Sets the value of register *Dest* to the remainder of the signed integer division *Dest* / *Src*.	ZNP	Yes
14	MUL	Sets the value of register *Dest* to the low half of the signed integer product *Dest* x *Src*.	ZNP	Yes
15	MUH	Sets the value of register *Dest* to the high half of the signed integer product *Dest* x *Src*.	ZNP	Yes