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Tutorial: Beta ISA

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4/4 points (ungraded)

In this problem, you will consider a number of plausible hardware faults in an otherwise working Beta processor. Each of the faults involves changing a particular output of the control logic to some new (incorrect) constant value. In each case, you are to evaluate the impact of the fault on each of the following Beta instructions:

```
I1: ST(R0, 0x100, R1)
I2: JMP(LP, R31)
I3: BEQ(R31, .+4, R0)
I4: SUB(R1, R0, R0)
```

For each of the following faults, identify which (if any) of the above instructions will fail to work properly – that is, if the fault might effect the processor state (register and PC values) after the execution of the instruction. Be careful: some of these are tricky!

1. ALUFN stuck at code for "-" (32-bit SUBTRACT)
   Which instruction(s) fail? Select all that apply.
   - [x] I1
   - [ ] I2
   - [ ] I3
   - [ ] I4
   - [ ] None

   ✔

   Explanation
   I1, The **ST** instruction is the only one that needs to make use of the ALU in order to add **R0 + 0×100**. It won't produce the proper address if the alu is stuck executing subtraction.

2. RA2SEL stuck at 1
   Which instruction(s) fail? Select all that apply.
   - [ ] I1
   - [ ] I2
   - [ ] I3
   - [ ] I4
   - [x] None

   ✔

   Explanation
   RA2SEL stuck at 1 means that the register read by the B terminal of the register file is Rc instead of Rb. Instructions I1-I3 don't use Rb so they are not affected by this. Instruction I4, the **SUB** does use Rb, however, since in I4 Rc = Rb = R0 then the instruction is still going to be executed correctly even if RA2SEL is stuck at 1.

3. WERF stuck at 0
   Which instruction(s) fail? Select all that apply.
   - [ ] I1

- [ ] None

✔

Explanation
WERF stuck at 0 means that we cannot write to the register file. I1, the **ST** does not write to the register file. I2, the **JMP** is not storing the return address because its using register R31 which cannot be written to. I3, the **BEQ** and I4, the **SUB** are both supposed to write something to the register file, so they will not work correctly.

4. BSEL stuck at code 0
Which instruction(s) fail? Select all that apply.

- [x] I1
- [ ] I2
- [ ] I3
- [ ] I4
- [ ] None

✔

Explanation
BSEL stuck at 0 means that the B input to the ALU will always be the value of the second read port and never the sign extended literal. This means that I1, the **ST**, instruction will not work correctly.

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Answers are displayed within the problem

Beta ISA: 2

40 points possible (ungraded)
Marketing has asked for the following instructions to be added to an Extended Beta instruction set, for implementation on a Beta as implemented in Lecture and in the lab.

```
CLEAR2(Rx, Ry)          // Clear two registers
    Reg[Rx] ← 0
    Reg[Ry] ← 0
    PC ← PC + 4

NOR(Rx, Ry, Rz)         // Bitwise NOR: Rz[i] = NOR(Rx[i], Ry[i])
    Reg[Rz] ← bitwise NOR of Reg[Rx], Reg[Ry]
    PC ← PC + 4

LDRADR(C, Rx )          // Load Relative Address
    Reg[Rx] ← PC+4+4*SEXT(C)
    PC ← PC + 4

LDINCR(Rx,C, Ry )       // Load Incremented
    EA ← Reg[Rx]+SEXT(C)
    Reg[Ry] = Mem[EA] + 1
```

For each instruction select the appropriate values for the control signals in the table below. Select "None" for all entries in a row if the instruction cannot be implemented using the existing Beta datapath. Select "--" to indicate a "don't care" value for a control signal.

Instr	ALUFN	WERF	BSEL	WDSEL	MOE	MWR
CLEAR2	Select an option	Select an option	Select an option	Select an option	Select an option	Selec
NOR	Select an option	Select an option	Select an option	Select an option	Select an option	Selec
LDRADR	Select an option	Select an option	Select an option	Select an option	Select an option	Selec
LDINCR	Select an option	Select an option	Select an option	Select an option	Select an option	Selec

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Beta ISA: 3

1 point possible (ungraded)

You modify a working BETA by connecting the **JT** input to the PCSEL MUX to the constant 0, rather than to its proper logic. Which instructions, if any, are effected by this change?

Instruction(s) effected (select all that apply):

- [ ] BNE
- [ ] JMP
- [ ] ADD
- [ ] ST
- [ ] None

Submit

Beta ISA: 4

3 points possible (ungraded)

For the Beta instruction sequence shown below, indicate the values of the specified quantities after the sequence has been executed.

```
      .=0
      CMOVE(0x6000, SP)
      PUSH(SP)
      HALT()
```

Value left in SP (HEX): 0x

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Beta ISA: 5

11 points possible (ungraded)

Many problems, like sorting, require swapping data in two memory locations. The following assembly code swaps the contents of two words in memory, with addresses stored in R0 and R1:

```
LD(R0, 0, R2)
LD(R1, 0, R3)
ST(R2, 0, R1)
ST(R3, 0, R0)
```

1. Suppose we add a SWAP instruction to the Beta. SWAP swaps the contents of a register and a memory location:

```
SWAP(Ra, literal, Rc)       // Swap register contents with memory
    EA ← Reg[Ra] + SEXT(literal)
    tmp ← Mem[EA]
    Mem[EA] ← Reg[Rc]
    Reg[Rc] ← tmp
    PC ← PC + 4
```

Which of the following pieces of code is a valid rewrite of the code above?

○
```
LD(R1, 0, R2)
SWAP(R1, 0, R2)
ST(R2, 0, R0)
```

○
```
LD(R0, 0, R2)
SWAP(R1, 0, R2)
ST(R2, 0, R0)
```

○
```
LD(R0, 0, R2)
SWAP(R1, 0, R2)
ST(R2, 0, R1)
```

○
```
SWAP(R0, 0, R1)
```

2. Can we implement the SWAP instruction using the unpipelined Beta datapath, by simply changing the control ROM? Recall that, in the unpipelined datapath, the data memory has combinational reads, and writes are clocked, happening at the end of the cycle. Also assume that the memory still returns valid data

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Beta ISA: 6

4 points possible (ungraded)

A “stuck-at” fault happens when a signal is shorted to VDD or GND and is permanently a logic 1 or logic 0. For each of the following stuck-at faults there is a list of instruction opcodes – please select the opcodes whose execution might be affected by the indicated fault.

1. RA2SEL stuck-at logic “0”

- [ ] ADD
- [ ] ADDC
- [ ] LD
- [ ] ST
- [ ] JMP
- [ ] BEQ
- [ ] BNE
- [ ] LDR
- [ ] Illop

2. BSEL stuck-at logic “1”

- [ ] ADD
- [ ] ADDC
- [ ] LD
- [ ] ST
- [ ] JMP
- [ ] BEQ
- [ ] BNE
- [ ] LDR
- [ ] Illop

3. WDSEL [1] (high-order bit of WDSEL mux select) stuck-at logic “0”

- [ ] LD
- [ ] ST
- [ ] JMP
- [ ] BEQ
- [ ] BNE
- [ ] LDR
- [ ] Illop

4. WERF stuck-at logic “1”

- [ ] ADD
- [ ] ADDC
- [ ] LD
- [ ] ST
- [ ] JMP
- [ ] BEQ
- [ ] BNE
- [ ] LDR
- [ ] Illop

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Beta ISA: 7

6 points possible (ungraded)

Your summer internship involves adding new instructions to the Beta processor. You’re given a list of proposed new Beta instructions, each of which is to perform a given operation during the **single clock cycle** in which the instruction executes. You decide to sort the proposals into four classes:

- **Macro**: those instructions that can be implemented on a stock Beta, simply by defining an appropriate macro;
- **CTL**: those that can be implemented on a stock Beta, by defining an appropriate macro and making appropriate changes to the control ROM;
- **HW**: those instructions that require hardware changes beyond reprogramming the control ROM.
- **None**: The instruction as described can’t be implemented, even with hardware changes

- CTL
- Hardware
- None

2. **ZERO2(rx,ry)** which sets the contents of both registers rx and ry to zero.
   - Macro
   - CTL
   - Hardware
   - None

3. **GETPC(rx)** which sets the contents of register rx to the address of the following instruction.
   - Macro
   - CTL
   - Hardware
   - None

4. **GETADR(loc, rx)** which sets the contents of register rx to the address of a nearby location tagged loc.
   - Macro
   - CTL
   - Hardware
   - None

5. **ISMEMZERO(rx,ry)** which sets the contents of register ry to the 1 if the main memory location whose address is in register rx contains zero, else ry is set to 0.
   - Macro
   - CTL
   - Hardware
   - None

6. **BITCLEAR(rx,ry)** which clears (sets to zero) the bits of register ry for which the corresponding bits of rx have the value 1; other bits of ry are left unchanged.
   - Macro

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Beta ISA: 8

10 points possible (ungraded)

Marketing has asked for the following instruction to be added to an Extended Beta instruction set, for implementation on an unpipelined Beta.

```
BGT(Rx, Ry, C )
  EA ← PC+4+4*SEXT(C)
  If Reg[Rx] > Reg[Ry] then PC ← EA
  else PC ← PC + 4
```

The Marketing people don't care about details of instruction coding (e.g., which fields are used to encode Rx and Ry in the above descriptions), but want to know if **BGT** can be implemented as a **single instruction** in the **existing Beta simply by changing the control ROM**. If so, fill in the appropriate values for the control signals in the table below. Otherwise, select NONE for each control signal. Use "-" to indicate a "don't care" value for a control signal.

Instr	ALUFN	WERF	BSEL	WDSEL	MOE	MWR
BGT	Select an option	Select an option	Select an option	Select an option	Select an option	Select ar

Submit

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- Beta ISA 6 part C — "WDSEL[1] (high-order bit of WDSEL mux select) stuck-at logic "0": makes it impossible to set WDSEL = 2 which is required for any ... — 5
- NOR in Beta ISA : 2 — I am not able to understand the explanation provided for NOR function to be implemented with ALU. I am just clueless as to what is ... — 5
- Tip for entering NONEs en masse — (This probably doesn't work on every OS/browser, but it works in Chrome on Windows) Click the first field, then hit the END key, an... — 2
- TP 7.D - Beta ISA - GETADR(lox, Rx) - Why not 'macro'? — I might be misunderstanding something, but I believe this instruction: GETADR(loc, rx) can be replaced by a single macro: CMOVE(l... — 3

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