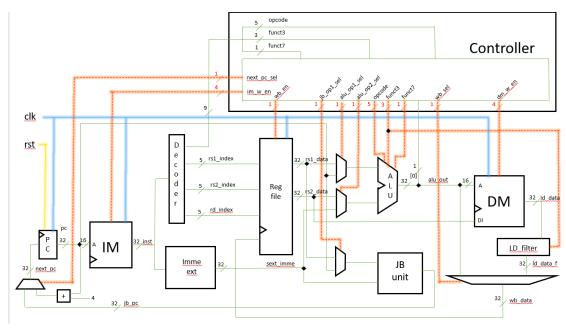
2022 計算機組織 Computer Organization

Lab 7 Report

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1. Architecture Diagram



2. Introduce each module (function / corner case / and so on...)

■ Adder

算出 Next_pc 的地方,只會負責在每個 cycle 將 pc+4。

ALU

負責每個 type 最主要的計算功能,在某些 type 還要根據不同的 input(主要為 funct3,funct7)做出不同的運算。

R_type/ I_type

這兩個 type 雖然不一樣,不過功能上很類似,都是根據 funct3 的值,產生 8 種不同的運算要求,所以我這邊就一 起說明,在程式中我有使用 define 去設定(比較好看懂),

而 Sr 有分成 Sra/Srl,要去看 funct7 判斷為哪個,有一樣判斷的還有 R_type 的 Add。值得注意的是在 I_type 的 srai 那邊, op1 也要設成\$signed(),原本只將 op2 轉成有號數,結果測資就一直不太對,改了很久才發現這個問題,所以特別挑出來講。

■ I_type_load/ S_type/ U_type_auipc

將 op1 跟 op2 作相加後接到 alu_out

■ B_type

根據 funct3 的值,將 op1 跟 op2 作不同的比較,如果比較判斷成立,就將 alu out 設成 0,不然就設成 1。

- U_type_lui 將 op2 接到 alu out
- J_type_jal/ I_type_jalr

 將 op1+4 後接到 alu out

■ Controller

這邊主要的功能是要依照 type 給出正確的控制訊號,主要就查表對照就可以了,有些不管 type 的 Output 就可以先給好。

Decoder

將原本 32-bit 的 instruction,分成

- opcode(5-bit)
- funct3(3-bit)
- funct7(1-bit)
- **■** rs1(5-bit)
- **■** rs2(5-bit)
- **■** rd(5-bit)

對表選擇要從 instruction 的哪些 bit 擷取,然後 opcode 只取 5-bit 是因為這次的 CPU 所支援到的 instruction 在最後兩個 bit 都是 1,因為沒有判別力,所以可以先不取。

■ Imme_Ext

根據不同的 type 將立即數的 bit 伸長到 32-bit,要注意 signed 跟 unsigned。

■ JB_Unit

計算要跳轉到哪個地址,如果是 jalr 的話,由於是 byte-address,所以要跟 32'd1 作 And。

■ LD_Filter

處理不同 load-bit(lb/lh/lw/lbu/lhu)的 w_en。

■ MUX

選擇要出去的訊號是哪一個,CPU 裡面總共有 5 個,分別為
NEXT PC/alu op1 mux/alu op2 mux/jb out mux/wb data mux

■ Reg_PC

將 PC 更新成 Next_pc,這邊是 moore_machine,所以用 sequentail 電路。

■ RegFile

處理 Register 讀寫的地方,分成兩個功能,第一個要在 clk 來的時候判斷是否可以複寫(wb_en == 1)並且是在 rd 不是 x0 的時候,若以上條件都成立,便將資料存到該記憶體位子;第二件事是要將 rs1 跟 rs2 的資料提取出來,注意這個功能不用等待 clk 的到來,所以要用 combination 電路。

■ SRAM

依照當前的 w_en,分為兩個功能,第一個是在 clk 來時,將 data 存到 memory 中;第二個是直接讀取 memory 的資料。

■ Top

將不同的 module 用線路連接好。

3. Screenshot the successful result of prog0

```
DM['h9004] = fffffff8, pass

DM['h9008] = 00000008, pass

DM['h900c] = 00000001, pass

DM['h9010] = 00000001, pass

DM['h9014] = 78787878, pass

DM['h9018] = 000091a2, pass

DM['h901c] = 00000003, pass

DM['h9020] = fefcfefd, pass

DM['h9024] = 10305070, pass

DM['h9028] = ccccccc, pass

DM['h902c] = ffffffcc, pass

DM['h9030] = ffffcccc, pass

DM['h9034] = 000000cc, pass

DM['h9038] = 0000cccc, pass

DM['h9030] = 00000004, pass

DM['h9040] = 00000004, pass

DM['h9044] = 00000003, pass

DM['h9044] = 00000003, pass

DM['h9044] = 00000003, pass

DM['h9044] = 00000003, pass

DM['h9046] = 000000066, pass
DM['h9048] = 000001a6, pass

DM['h904c] = 00000ec6, pass

DM['h9050] = 2468b7a8, pass

DM['h9054] = 5dbf9f00, pass

DM['h9058] = 00012b38, pass

DM['h905c] = fa2817b7, pass

DM['h9060] = ff000000, pass

DM['h9064] = 12345678, pass

DM['h9068] = 00000f000, pass

DM['h906c] = 000000f00, pass

DM['h9070] = 0000000f0, pass

DM['h9074] = 0000000f1, pass

DM['h9078] = 56780000, pass

DM['h907c] = 78000000, pass
 DM['h907c] = 78000000, pass

DM['h908c] = 00005678, pass

DM['h9084] = 00000078, pass

DM['h9088] = 12345678, pass

DM['h908c] = fffff6000, pass
 DM['h908c] = ce780000, pass
DM['h9090] = fffff000, pass
DM['h9094] = fffff000, pass
DM['h9098] = fffff000, pass
DM['h909c] = fffff000, pass
DM['h90a0] = fffff000, pass
DM['h90a4] = fffff000, pass
DM['h90a8] = 13579d7c, pass
DM['h90a6] = 13578000, pass
DM['h90b0] = fffff004, pass
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                                                                                                                 Waku Waku !!
```

4. Screenshot the successful result of prog1

```
DM['h9000] = 00000000, pass
DM['h9004] = 00000001, pass
DM['h9008] = 00000001, pass
DM['h900c] = 00000003, pass
DM['h9010] = 00000003, pass
DM['h9014] = 00000006, pass
DM['h9018] = 00000008, pass
DM['h901c] = 0000000a, pass
DM['h901c] = 0000000a, pass

DM['h9020] = 0000000a, pass

DM['h9024] = 0000000b, pass

DM['h9028] = 0000000c, pass

DM['h902c] = 0000000f, pass

DM['h9030] = 00000010, pass

DM['h9034] = 00000012, pass

DM['h9038] = 00000012, pass

DM['h903c] = 00000017, pass

DM['h9040] = 00000017, pass

DM['h9044] = 00000017, pass

DM['h9044] = 00000018, pass
 DM['h9048] = 00000018, pass
 DM['h904c] = 0000001b, pass
DM['h9050] = 0000001e, pass
DM['h9054] = 00000025, pass
DM['h9058] = 00000025, pass
DM['h9058] = 00000025, pass

DM['h905c] = 00000026, pass

DM['h9060] = 00000027, pass

DM['h9064] = 00000028, pass

DM['h9068] = 00000028, pass

DM['h906c] = 00000029, pass

DM['h9070] = 0000002b, pass

DM['h9074] = 0000002d, pass
DM['h9078] = 0000002d, pass
 DM['h907c] = 0000002e, pass
 DM['h9080] = 0000002f, pass
 DM['h9084] = 00000031, pass
 DM['h9088] = ffffffce, pass
 DM['h908c] = ffffffce, pass
DM['h908c] = ffffffce, pass

DM['h9090] = ffffffd1, pass

DM['h9094] = ffffffd1, pass

DM['h9098] = ffffffd2, pass

DM['h909c] = ffffffe2, pass

DM['h90a0] = ffffffe9, pass

DM['h90a4] = ffffffed, pass

DM['h90a8] = ffffffed, pass
 DM['h90ac] = ffffffed, pass
 DM['h90b0] = ffffffef, pass
 DM['h90b4] = fffffff3, pass
 DM['h90b8] = fffffff7, pass
 DM['h90bc] = fffffffa, pass
 DM['h90c0] = fffffffa, pass
 DM['h90c4] = fffffffd, pass
 DM['h90c8] = fffffffe, pass
DM['h90cc] = ffffffff, pass
```

```
DM['h90d0] = 00000000, pass
DM['h90d4] = ffffffcf, pass
DM['h90d8] = ffffffd2, pass
DM['h90dc] = ffffffd2, pass
DM['h90e0] = ffffffd4, pass

DM['h90e4] = ffffffd5, pass

DM['h90e8] = ffffffd6, pass

DM['h90ec] = ffffffdb, pass

DM['h90f0] = ffffffe3, pass

DM['h90f4] = ffffffe3, pass
DM['h90f8] = ffffffe8, pass
DM['h90fc] = ffffffe9, pass
DM['h9100] = ffffffee, pass
DM['h9104] = ffffffee, pass
DM['h9108] = ffffffee, pass
DM['h910c] = ffffffef, pass
DM['h9110] = fffffff0, pass
DM['h9114] = fffffffe, pass

DM['h9118] = 00000000, pass

DM['h911c] = 00000000, pass

DM['h9120] = 00000000, pass

DM['h9124] = 00000003, pass

DM['h9128] = 00000009, pass
DM['h912c] = 0000000f, pass
DM['h9130] = 00000013, pass
DM['h9134] = 00000016, pass
DM['h9138] = 00000017, pass
DM['h913c] = 00000017, pass
DM['h9140] = 00000023, pass
DM['h9144] = 0000002e, pass
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