

```
squash_D = val_X && (op_X == bne) && !eq_X
squash_F = squash_D || (val_D && ((op_D == jal) || (op_D == jr)))
```

```
stall_load_use_X_rs1_D =
  val_D && rs1_en_D && val_X && rf_wen_X
  && (inst_rs1_D == rf_waddr_X) && (rf_waddr_X != 0)
  && (op_X == lw)
```

```
stall_load_use_X_rs2_D =
  val_D && rs2_en_D && val_X && rf_wen_X
  && (inst_rs2_D == rf_waddr_X) && (rf_waddr_X != 0)
  && (op_X == lw)
```

```
stall_D =
  val_D && (stall_load_use_X_rs1_D || stall_load_use_X_rs2_D)
```

```
bypass_waddr_X_rs1_D =
  val_D && rs1_en_D && val_X && rf_wen_X
  && (inst_rs1_D == rf_waddr_X) && (rf_waddr_X != 0)
  && (op_X != lw)
```

```
bypass_waddr_X_rs2_D =
  val_D && rs2_en_D && val_X && rf_wen_X
  && (inst_rs2_D == rf_waddr_X) && (rf_waddr_X != 0)
  && (op_X != lw)
```

jr x1 F D X M W
opA F
op x1 F

bne x4, x2, L1 F D X M W
opA F D
opB F

add x1, x0 F D X M W
add x1, x0 F D X M W
add x1, x0 F D X M W

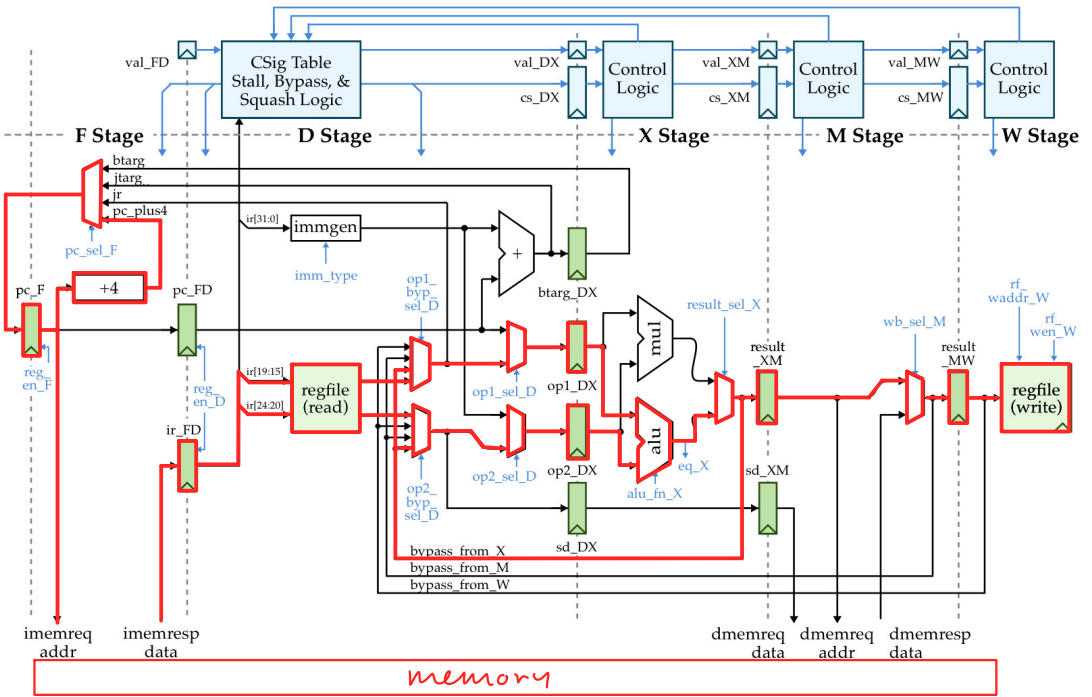
lw x1, 0(x0) F D X M W
add x1, x1, x0 F D D X M W

similar for M, W

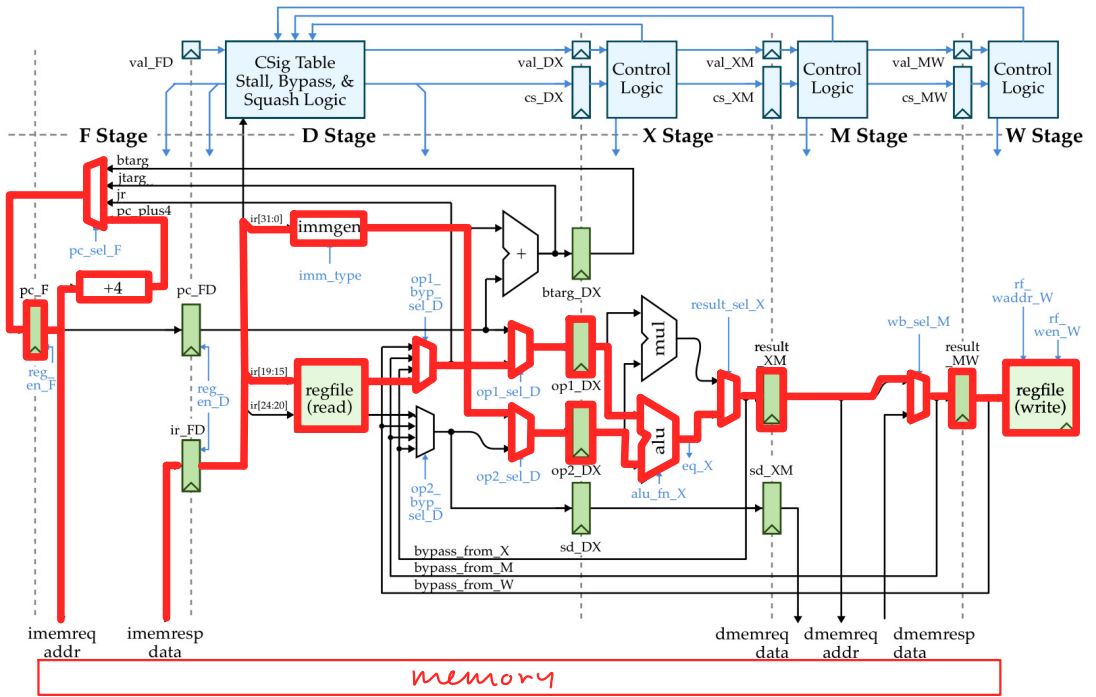
X M W (invalid?)

prioritize closer bypass path!

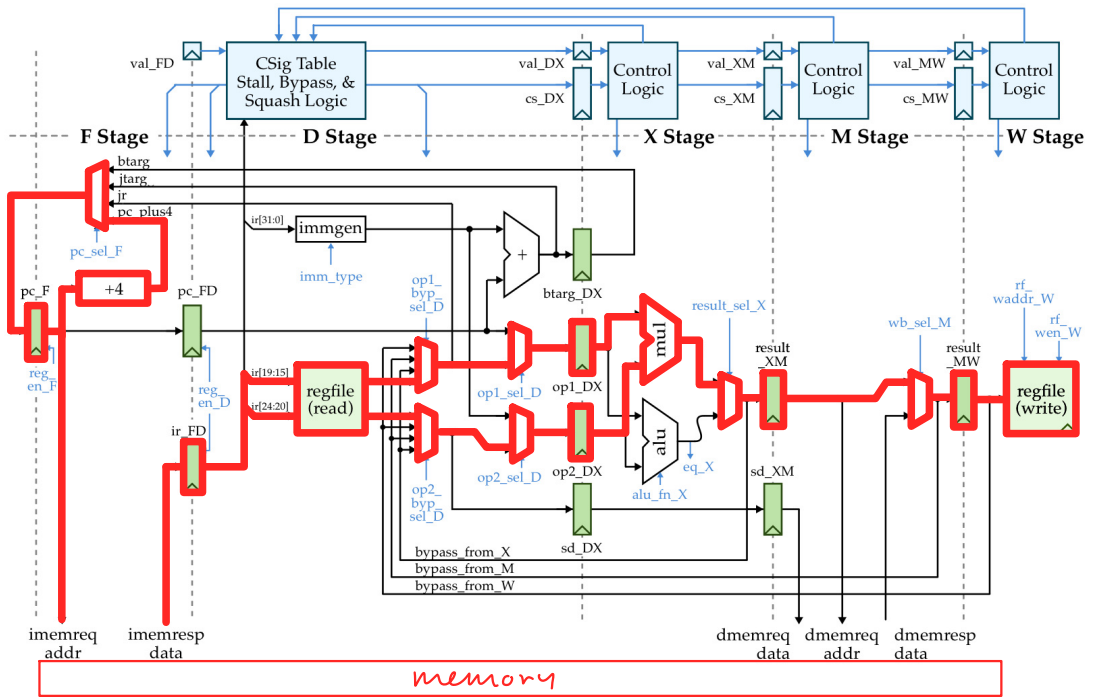
ADD



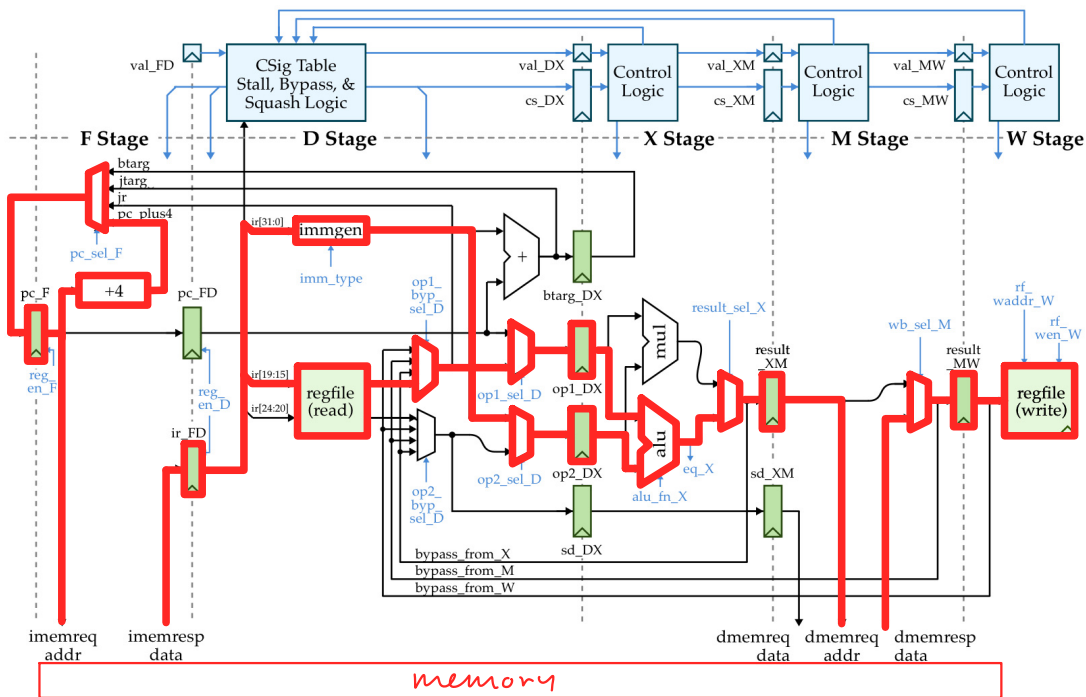
ADDI



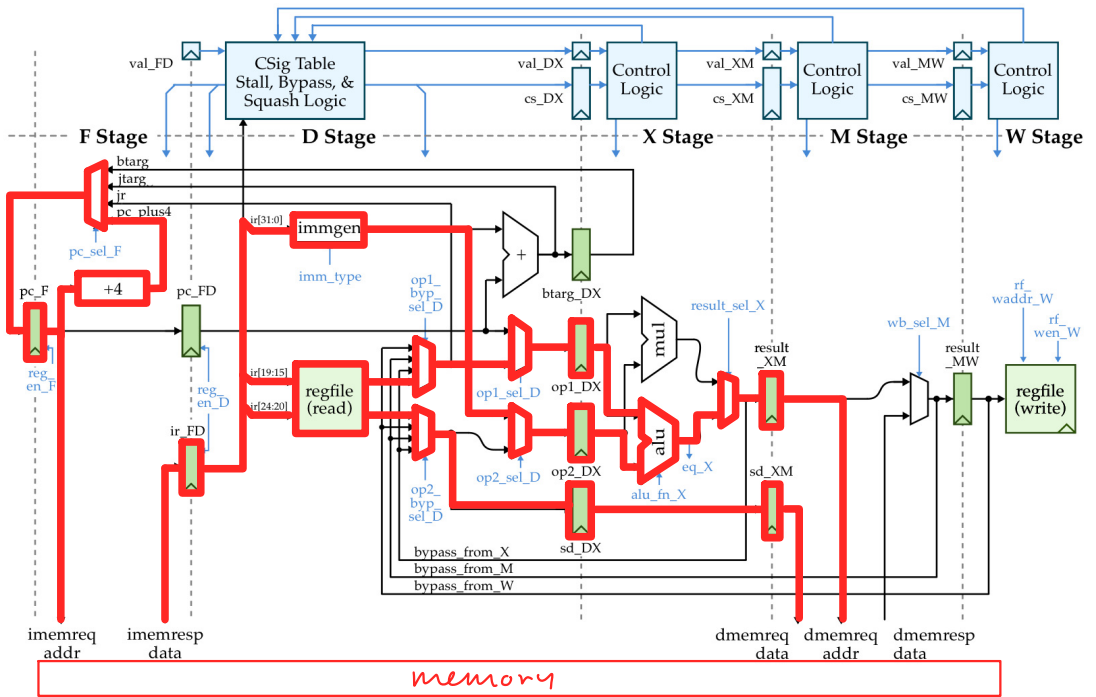
MVL



LW

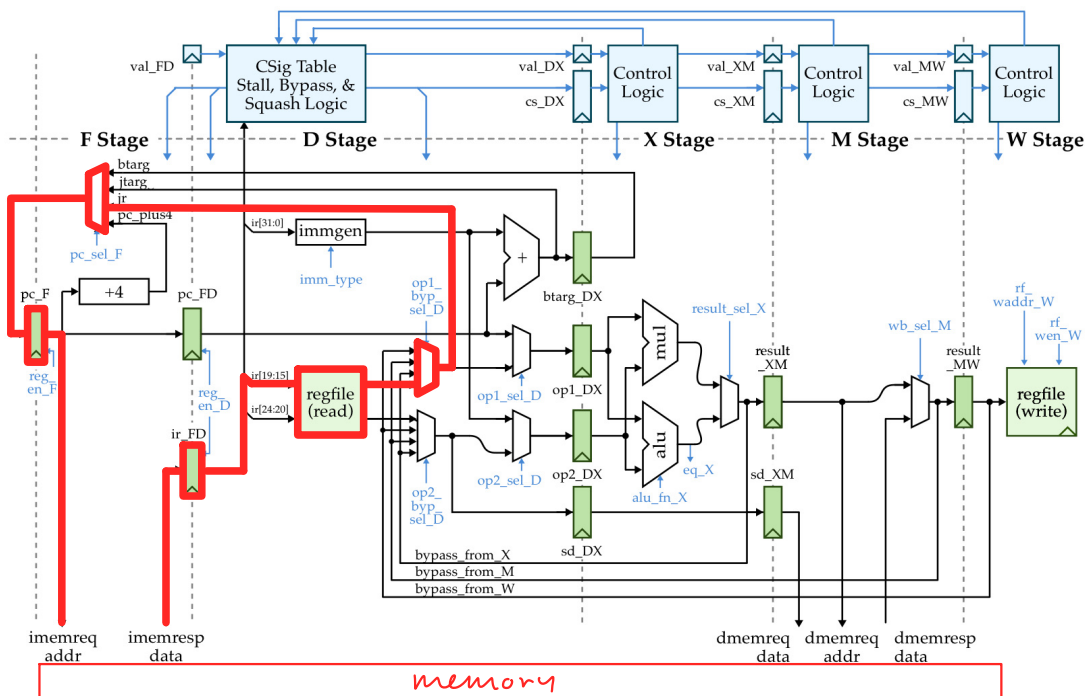


SW



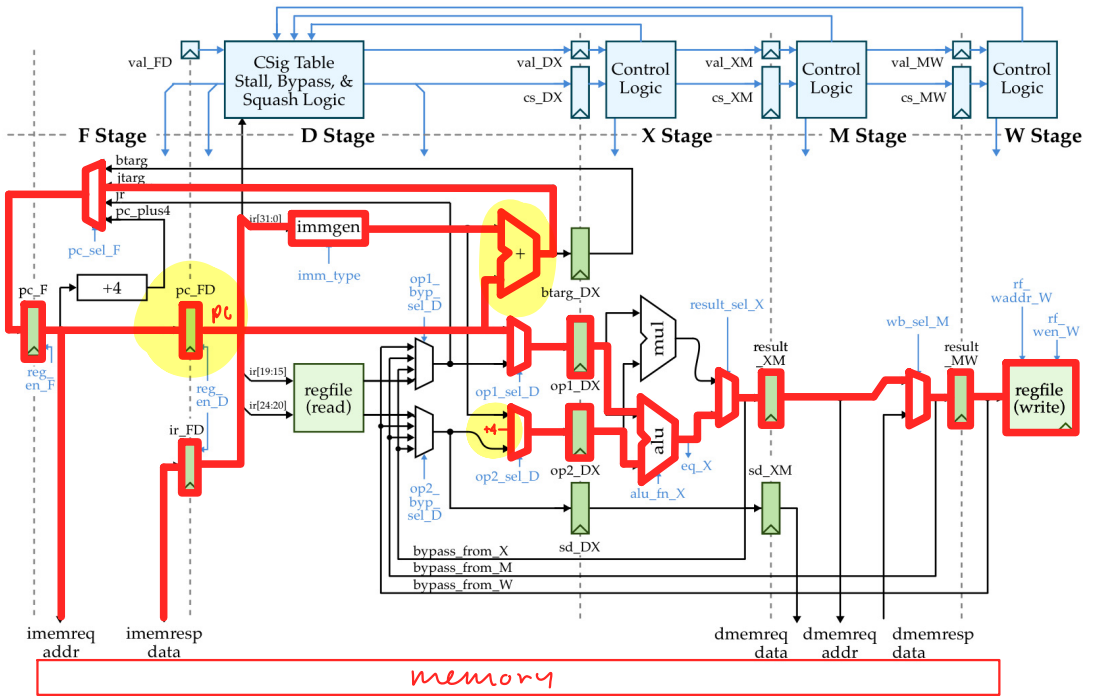
SW r52 imm(r41)

JR



jr rs1

JAL



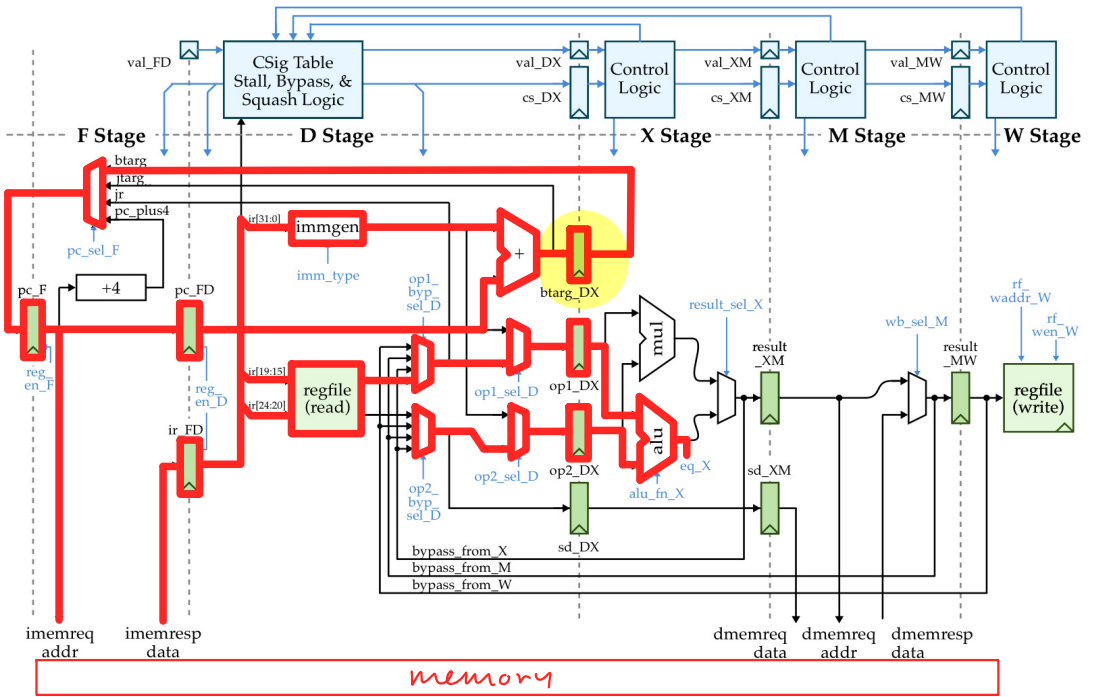
jal rd addr

$R[rd] \leftarrow PC + 4$

$PC \leftarrow \text{addr}$

$\underbrace{\hspace{1cm}}_{PC + \text{sext}(\text{imm})}$

BNE



bne rs1 rs2 addr

if $R[rs1] == R[rs2]$

$PC \leftarrow PC + 4$

if $R[rs1] != R[rs2]$

$PC \leftarrow \text{addr}$

$PC + \text{sext}(\text{imm})$

CSR/W

