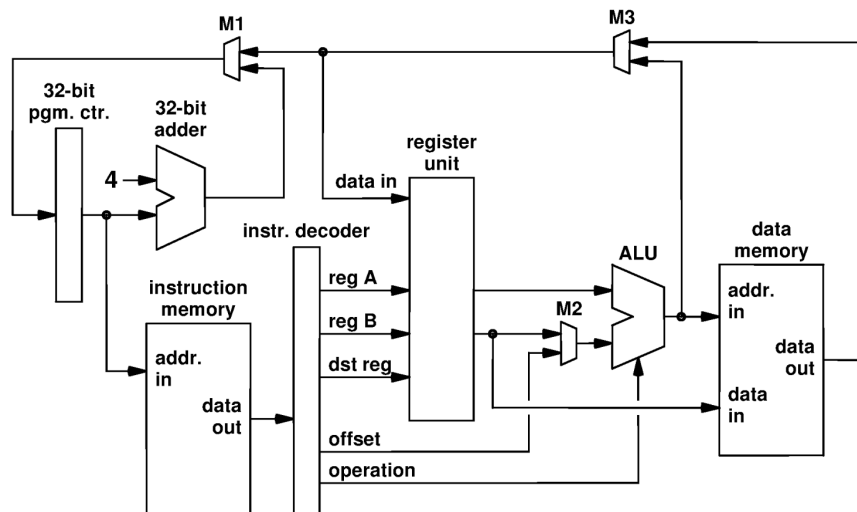


```
1  #include <stdio.h>
2
3  int main() {
4      printf("Program that prints max and min of two numbers a,b\n");
5      int a, b, max, min;
6
7      while (1) {
8          printf("Type a and <enter>: ");
9          scanf("%d", &a);
10         getchar(); // Discard new line
11
12         printf("Type b and <enter>: ");
13         scanf("%d", &b);
14         getchar(); // Discard new line
15
16         if (a > b) {
17             max = a;
18             min = b;
19         }
20         else {
21             max = b;
22             min = a;
23         }
24         printf("max=%d min=%d\n", max, min);
25
26         printf("Do you want to continue? Type y/n and <enter>");
27         char answer;
28         answer = getchar();
29
30         if (answer=='n') {
31             break;
32         }
33     } // endwhile
34
35     printf("Bye\n");
36 }
```

1. List the items in the program that are not constants and use data memory.
Answer: a, b, min, max, answer.
2. List the program lines that decide. Answer: Lines 16, 30. Arguably, Line 7 does not contain a decision because the loop is infinite: no choice but to make another iteration upon reaching the last statement of the loop. Line 20 is inextricably part of Line 16 and a single decision determines whether lines 17 and 18 are skipped or lines 21 and 22 are skipped, instead, so Line 16 is
3. What lines of C code are essential to the operation of the program, but are not visible in the source code listing because they are abstracted out for convenience and clarity?
Answer: The many lines of stdio.h



- 1 List the components in the schematic that remember.

Answer: 32-bit pgm. ctr., instruction memory, register unit, data memory.

- 2 List the components that store ALU operands.

Answer: instruction memory, register unit.

- 3 List the components in the circuit that perform a computation.

Answer: 32-bit adder, ALU.

- 4 List the components in the diagram that enable decision making.

Answer: M1, M2, M3.

Which of these components makes possible the decision making that appears explicitly at the level of abstraction of the C program on the other side of this worksheet?

Answer: The decision making in the C program is by the "if" and "if-else" program structures. These structures control skipping over certain lines of C source code. Thus, M1, which controls the fetch of the next instruction, makes the "if" and "if-else" code lines possible.

- 5 Draw a line on the schematic starting from the output of "32-bit pgm. ctr." that shows a longest propagation delay path through the circuit.

Answer: Line shows a path that connects these items in this order: 32-bit pgm. ctr. output, instruction memory, instr. decoder, register unit (via reg B), M2 (hence the choice of reg B to enter the register unit), ALU, data memory, M3, *then, because these two paths likely have near identical delay, either* [M1, input of 32-bit pgm. ctr.] *or* [dst_reg within register unit].

- 6 What circuit elements that are essential to circuit operation are not shown in the schematic because they have been abstracted out for reasons of convenience and clarity?

Answer: power and ground connections; control signal wires for M1, M2, M3, register unit, ALU, and data memory; sign extend unit for offset.

- 7 List every component in which, into which, or through which one or more bits from a single machine language instruction may be found, may enter, or may pass.

Answer: Instruction memory [in]; instr. decoder [into and through]; reg A, reg B, dst reg, offset, operation [through]; M2 [offset bits of the sign-extended offset go into and pass through]; ALU [offset bits into].