

## Final Exam Spring 2012-Part II

### Problem 1 (5 points)

Draw a block diagram of the datapath unit of a circuit capable of executing the pseudocode given below.

In this code, MEM\_D represents a single-port memory of the size of 32 x 16. The circuit takes as an input a stream of 8-bit ASCII characters representing a GMU catalog. It searches for the first 32 instances of the string "GMU". Then, it calculates an average and maximum distance between the two subsequent repetitions of this string (including the distance between the first instantiation of the string and the beginning of the catalog).

begin:

```
wait for s=1
done = 0
count = 0
first = SPACE
second = SPACE
third = SPACE
last = 0; sum=0; max=0
i=-2
```

```
while (count < 32) do
  first = second
  second = third
  third = din
  if ((first = 'G') and (second = 'M') and (third = 'U')) then
    dist = i - last
    last = i
    sum = sum + dist
    if max < dist then
      max = dist
    end if;
    MEM_D[count] = dist
    count ++;
  end if;
  i++
end while
```

```
avr = sum/32
```

```
done = 1
wait for s=0
// when s=0, an external circuit can read data from memory MEM_D, one number at a time,
// using ports mem_addr and mem_dout
go to begin
```

***Please clearly mark the widths of all buses in your circuit.***

**In the above pseudocode:**

**SPACE represents an 8-bit ASCII code of the space = 0x20.**

**The ASCII codes of ‘G’, ‘M’, and ‘U’ are 0x47, 0x4D, and 0x55, respectively.**

Assume the following interface to your circuit:

Port	Width	Meaning
clk	1	System clock.
reset	1	System reset – clears all internal registers and counters. Active high.
din	8	Input data bus.
s	1	Operating mode: 0 = waiting for data/reading results, 1 = processing.
rd	1	Read enable. 0 = high impedance on the output bus dout, 1 = valid output dout
dout	8	One of the two results calculated by the circuit.
sel_out	1	Selection between the two calculated results: 0 = avr, 1 = max.
mem_addr	5	Address in memory location MEM_D.
mem_dout	16	High impedance (if s=1) or value of memory location MEM_D[mem_addr] (if s=0).
done	1	Asserted when all results are ready, zero otherwise

### Problem 2 (5 points)

1. Draw an ASM chart corresponding to the pseudocode from Problem 1.
2. Express all operations in your ASM chart in terms of active values of control signals generated as outputs of the Control unit and used as inputs in the Datapath.

### Problem 3

#### Task 1 (5 points)

Draw a detailed block diagram of the digital system including

1. the PicoBlaze core, KCPSM3
2. the instruction ROM required for the basic operation of the PicoBlaze core
3. 128-bit external data RAM visible under addresses 0x80-0xFF
4. two input registers with the virtual addresses 0x20 and 0x10
5. two output registers with the virtual addresses 0x40 and 0x20
6. a D flip-flop with the output Q connected to the interrupt input of the PicoBlaze core, input SET connected to the external port INT, and input CLR connected to an appropriate output of the PicoBlaze core.

Assume that

- input register with the address 0x20 is the same as the output register with the address 0x20
- the input and output registers and the data RAM specified above are the only i/o devices that the PicoBlaze core is communicating with

- your system needs to be able to allow the PicoBlaze core to write to all aforementioned output registers and data RAM, and read from all aforementioned input registers and data RAM using instructions OUTPUT and INPUT, respectively
- you need to provide all details of the address decoder, and build it out of basic logic components you are familiar with
- all registers and flip-flops have a reset input connected to the external port RESET.

Please clearly mark on your schematic:

- sizes of all memories and registers
- sizes and directions of all buses.

### Task 2 (5 points)

Determine the contents of

1. PC
2. Stack
3. Flags I, preserved C, and preserved Z
4. All output registers
5. Internal registers s0, s1, s2, s3
6. Flags C, Z

at the time of the execution of the instruction

RETURNI DISABLE

before this instruction takes effect assuming that

- at the time = 0 a short pulse is generated at the input RESET
- at the time = 10 seconds, a short pulse is generated at the input INT
- the contents of the instruction memory is given by the following program:

CONSTANT BIT5, 20  
CONSTANT BIT2, 04

ADDRESS 000  
LOAD s0, C3  
LOAD s1, 20

INIT:

OUTPUT s0, (s1)  
ADD s0, 10  
SL0 s1  
JUMP NZ, INIT  
ENABLE INTERRUPT

STORE s0, 00  
FETCH s1, 00  
INPUT s0, 20

LOOP:

CALL LOOP  
JUMP INIT

JUMP LOOP

ISR:

ADDRESS 100

```
INPUT s2, 80
LOAD s3, AA
OR s3, BIT2
XOR s3, BIT5
SLA s3
ADDCY s2, s3
RETURNI DISABLE
```

```
ADDRESS 3FF
JUMP ISR
```