

CSCE 236 Embedded Systems, Spring 2015

Exam 1

Thursday, February 26, 2015

Instructions: You will have the full class period to complete this test. **Make sure to show your work to ensure you receive partial credit if your final answer is incorrect.** This is a closed book quiz, no computers, textbooks, notes, etc. are allowed.

Unless otherwise specified, assume that questions are referring to the Arduinos/Atmel processors we have been using in class.

Name:

Problem 1. *Warmups (Circle all answers that apply).*

a) (1 pt.). *What is the maximum clock speed that the ATmega328 processor can operate at?*

- (a) *8MHz*
- (b) *12MHz*
- (c) *16MHz*
- (d) *20MHz*

b) (2 pts.). *Where does malloc allocate memory?*

- (a) *In SRAM*
- (b) *On the stack*
- (c) *On the heap*
- (d) *In global memory*

c) (3 pts.). *What voltage(s) does the Arduino have available onboard?*

- (a) *1.0V*
- (b) *1.8V*
- (c) *3.3V*
- (d) *5.0V*

d) (3 pts.). *How do you read the value at memory address 0x36?*

- (a) `*((volatile uint8_t *) 0x36)`
- (b) `*((volatile uint8_t &) 0x36)`
- (c) `&((volatile uint8_t &) 0x36)`
- (d) `&((volatile uint8_t *) 0x36)`

e) (3 pts.). If an LED connected to our Arduino drops 2.0V and there is a 100 ohm resistor connected in series with it, what current(s) will be flowing through it?

(a) 10mA

(b) 20mA

(c) 30mA

(d) 40mA

Problem 2. Hex and bit operations (all references to bit locations are zero referenced). For each bit operation subproblem write a **single** line of C code to achieve the desired result.

a) (4 pts.). What is the value of $((3 \ll 3) \mid (1 \ll 6))$ in hex?

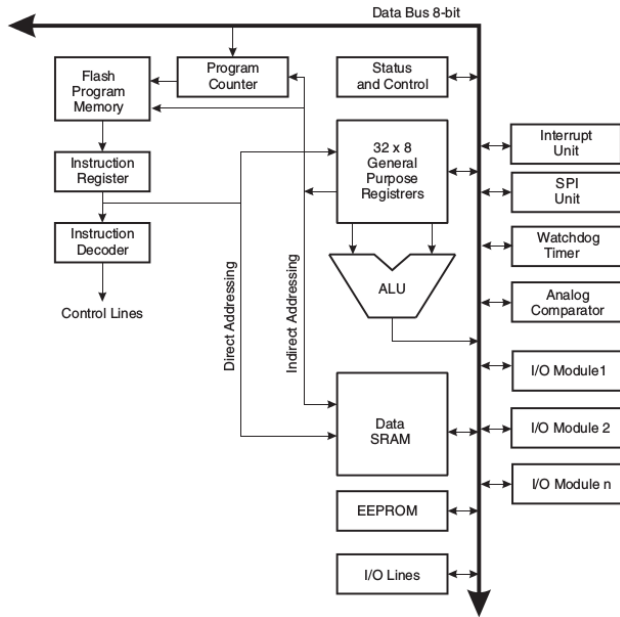
b) (4 pts.). What is the value of $((7 \ll 4) \& (1 \ll 5)) + 3$ in hex?

c) (4 pts.). Set bit 3 in the variable `var` to 1.

d) (4 pts.). Clear bit 2 in the variable `var`.

e) (4 pts.). Set bits 4-6 (inclusive) in the variable `var` to bits 8-10 in the 16-bit variable `config`. As with all of these problems, do this in a single line of code (e.g. `var=...`). The bit references are zero indexed.

Problem 3. AVR Architecture. Refer to the following block diagram from the Atmel datasheet for these questions.



a) (5 pts.). What memory architecture does our processor use? What in the block diagram shows you this?

b) (5 pts.). What does ISA stand for and what parts of the block diagram are included in the ISA?

Problem 4. Memory operations. Refer to the following code example for this question:

```

uint8_t data[] = {0x63, 0x61, 0x72, 0x72, 0x69, 0x63, 0x6b};
uint8_t *globalPtr;
uint8_t finalResult;

void function(void){
    static uint32_t counter = 0;
    counter++;
    globalPtr++;
}

int8_t main(void){
    uint16_t var = data[4] + (data[5] << 8);
    uint8_t *p1 = data + 4;

    globalPtr = data;

    function();
    p1[1] = 5;
    *globalPtr = 2;
    globalPtr = 0x10;
    *(globalPtr + 2) = 9;

    function();
    finalResult = globalPtr;

    //Draw Memory Map Here
    return 0;
}

```

a) (10 pts.). Fill in the below memory map for the above code after execution has reached the statement Draw Memory Map Here. Assumptions you should make: 1) the compiler allocates the memory in the order the statements appear; 2) global variables are allocated starting with the high address; 3) the stack starts at zero; 4) each memory location stores 8 bits; and 4) the memory is little endian (least significant byte stored at lowest address).

Address	Variable	Value
0x14		
0x13		
0x12		
0x11		
0x10		
0xF		
0xE		
0xD		
0xC		
0xB		
0xA		
0x9		
0x8		
0x7		
0x6		
0x5		
0x4		
0x3		
0x2		
0x1		
0x0		

Problem 5. Debugging

a) (10 pts.). *Below is assembly code that represents three lines in the corresponding C program. What operations do the three lines of code perform (just give the type of operation, no need for specific values)? What data types are used? Label each line of the assembly code to indicate what is going on.*

```
000000da <loop>:
  da:  80 91 10 01    lds    r24, 0x0110
  de:  8d 5f         subi   r24, 0xFD      ; 253
  e0:  80 93 10 01    sts    0x0110, r24
  e4:  60 91 11 01    lds    r22, 0x0111
  e8:  70 91 12 01    lds    r23, 0x0112
  ec:  6a 51         subi   r22, 0x1A      ; 26
  ee:  7f 4f         sbci   r23, 0xFF      ; 255
  f0:  70 93 12 01    sts    0x0112, r23
  f4:  60 93 11 01    sts    0x0111, r22
  f8:  0e 94 60 00    call   0xc0          ; 0xc0 <_Z3runhj>
```

b) (5 pts.). *In the disassembly there sections called .data, .text, and .bss. What do these represent and which are stored in flash and which are stored in SRAM?*

c) (5 pts.). *What are two other methods to debug embedded systems besides using the serial port? Explain briefly how to use these methods.*

Problem 6. *Timer/Counter.* For these questions, see the provided register description pages for *Timer1* and assume this is running on the Arduino we use in class.

a) (10 pts.). Write code to set the registers to configure *Timer 1* to measure the exact (or as near as possible) frequency of a square wave signal on pin *ICP1* (pin 8 on Arduino) that has a period of approximately 2 milliseconds. Make sure to indicate how you would convert any register values you obtain to a frequency in Hz.

Problem 7. *Digital I/O*

a) (5 pts.). What are the 3 registers that are used to configure the I/O pins on the Atmel processors? Name and describe each, including describing how they operate when configured both as an output and input.

b) (5 pts.). After executing `pinMode(7,OUTPUT)` and `digitalWrite(7,HIGH)` is pin 7 guaranteed to be set high? If not, what could be causing a difference and how can you verify?

c) (5 pts.). Draw a signal that shows what happens when a button bounces. Make sure to label the diagram to make it clear when and why bouncing is occurring.