

Final exam  
ECE 203  
11 June 2004  
Prepared by Robert Dick

You may not use books, notes, or calculators when completing this exam. Please show your work. Please look over all the problems now and ask questions if any of them are not clear. Manage your time. It's better to have good answers for all questions than a wonderful answer to only one question. Read the questions carefully.

Good luck!

1. (10 pts.) Use a Karnaugh map to find the a minimal SOP expression for the following function:

$$f(a,b,c,d) = \sum(0,3,5,8,9,11) + DC(2,4,7,15)$$

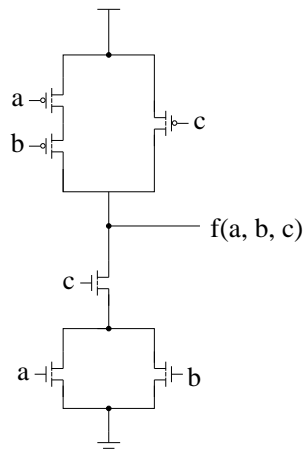
$$\text{Answer: } f = \bar{a}\bar{b}\bar{d} + cd + \bar{a}b\bar{c} + a\bar{b}\bar{c}$$

2. (10 pts.) Use the Quine-McCluskey algorithm to find a minimal SOP expression for the following function:

$$f(a,b,c) = \prod(0,5,6) + DC(2,7)$$

$$\text{Answer: } f = \bar{a}c + a\bar{b}\bar{c}$$

3. (10 pts.) Write a minimal POS expression for the function implemented by the following circuit:

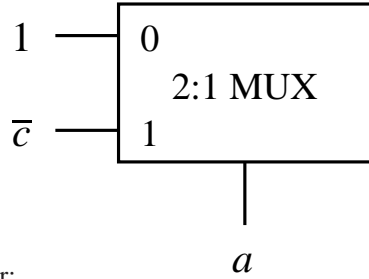


$$\text{Answer: } f = (\bar{a} + \bar{c})(\bar{b} + \bar{c})$$

4. (10 pts.) Consider the following function:

$$f(a,b,c) = a\bar{c} + \bar{a}b + \bar{a}\bar{c} + \bar{a}\bar{b}c$$

Draw a diagram showing a one-multiplexer implementation of  $f(a, b, c)$ . Use a multiplexer with as few inputs as possible.



Answer:

5. (10 pts.) Derive the state variable and output functions for a one-input, two-output synchronous Moore machine that always outputs the two-bit sum of the two most recent input values. When reset, the machine assumes that the two most recent input were both 0.

Answer: Did this one together on blackboard in class.

6. (10 pts.) Using three or fewer sentences, describe what the following PIC  $\mu$ -controller subroutine does.

```
do_something_a:
    movf 0x20, W
    movwf FSR

    movlw 1
    movwf 0x22

LABEL_A
    movf FSR, W
    subwf 0x21, W
    btfsc STATUS, Z
    return

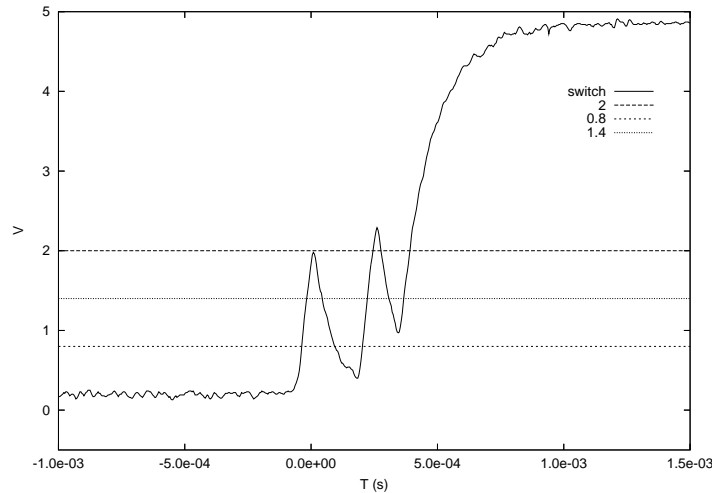
    movf 0x22, W
    movwf INDF

    bcf STATUS, C
    rlf 0x22, F
    btfsc STATUS, C
    rlf 0x22, F
    incf FSR, F

    goto LABEL_A
```

Answer: We did something almost identical in class. Please simulate it in MPLAB if it doesn't make sense.

7. The following plot shows the voltage of an input to a PIC16C74A  $\mu$ -controller when a mechanical switch attached to the input is closed.



You will need to write an assembly language subroutine that will be called whenever a change of the switch's value is first observed. Your subroutine should delay the processor long enough to be reasonably certain that closing the switch once will not be recognized as multiple close/open/close events.

You'll need some additional information to solve this problem.

- Assume instruction cycle time of the PIC16C74A  $\mu$ -controller is 400 ns.
  - You may assume that voltages above 1.4 V are recognized as high and voltages below 1.4 V are recognized as low.
  - You may assume that the switch behavior is fairly consistent on each press.
- (a) **(3 pts.)** How long do you need to wait? Use up to three sentences to justify this answer, which should not be overly pessimistic.  
 Answer: Approx. 1 ms should be sufficient. The bouncing stops after approx. 0.5 ms.
- (b) **(2 pts.)** Either name a type of gate that might be used to solve this problem in hardware, or name (one word) the important property the gate has.  
 Answer: Schmitt trigger. Hysteresis.
- (c) **(10 pts.)** Write an assembly language routine to fix this problem.  
 Answer: See the delay loop code on the website. You'll need nested loops for this to work.
8. **(0 pts.)** Have a good Summer! Email me if you want to know where to learn more about the topics this course has introduced.