

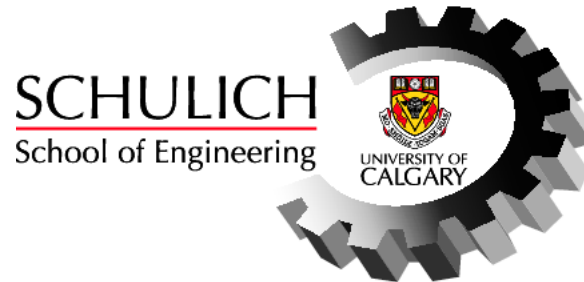
---

**Student Name or ID Number**

Lecture Section: \_\_\_\_\_

*L01 - Norm Bartley*

*L02 - Svetlana Yanushkevich*



DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

## ENEL 353 - Digital Circuits

### **Midterm Examination**

Thursday, November 3, 2005

Time: 5:00 - 6:30 PM

---

**Instructions:**

- Time allowed is 90 minutes.
  - The examination is closed-book.
  - Non-programmable calculators are permitted.
  - The maximum number of marks is 50, as indicated; the midterm examination counts 15% toward the final grade.
  - Please use a pen or heavy pencil to ensure legibility.
  - Please answer questions in the spaces provided; if space is insufficient, please use the back of the pages.
  - Please show your work; marks will be awarded for proper and well-reasoned explanations.
-

Name: \_\_\_\_\_, ID: \_\_\_\_\_

1. [10 marks total.]

- (a) [6 marks.] Represent the following numbers using 6-bit 2's-complement format and perform the addition. Indicate in each case if an overflow occurs, and why.

(i)  $(-12_{10}) + 13_{10}$

(ii)  $(-14_{10}) + (-32_{10})$

- (b) [2 marks.] Consider the number  $-37_8$ . Give the 6-bit sign-magnitude and 2's-complement binary representations of this number.

- (c) [2 marks.] Add the decimal numbers 91 and 19 using BCD arithmetic.

2. **[8 marks total (4 marks each).]** Consider the following two logic expressions:

$$f = (x + y)(x' + z)$$
$$g = xz + x'y$$

Prove or disprove that  $f$  and  $g$  are equivalent in the following two ways.

- (a) By expanding each expression to its canonical SOP form ( $f$  and  $g$  are equivalent if their canonical forms are identical).
- (b) By direct algebraic manipulation *without* using a K-map, a truth table, or your canonical forms from part (a).

3. [20 marks total.] A function  $F$  of four variables  $x_1, x_2, x_3$  and  $x_4$ , is given by the Karnaugh map:

$x_3x_4$	\				
$x_1x_2$		1	0	0	1
		0	1	0	0
		0	0	1	0
		1	0	0	1

- (a) [2 marks.] Find a minimal SOP algebraic expression using this map.

- (b) [2 marks.] Find a minimal POS expression using this map.

**Note:** *For this and all remaining parts of this problem, you may assume that the variables and their complements are available to your circuit.*

- (c) **[4 marks.]** Draw the logic diagram of an *AND-OR* circuit implementation corresponding to the simplest (i.e., lowest “cost”) of your answers to parts (a) and (b) above. Use only 2-input gates in your drawing.
- (d) **[4 marks.]** Using algebraic transformations and/or circuit manipulation, implement the circuit you drew in part (c) using 2-input NAND gates only (inverters are not available).

- (e) **[4 marks.]** Using algebraic transformations and/or circuit manipulation, implement the circuit you drew in part (c) using 2-input NOR gates only (inverters are not available).
- (f) **[4 marks.]** Implement the logic function  $F$  using 2-to-4 decoders. You may use any additional AND, OR, and NOT gates as necessary.

4. **[12 marks total.]** Design a circuit with four inputs  $x_3, x_2, x_1, x_0$  ( $x_3$  is the MSB) and four outputs  $y_3, y_2, y_1, y_0$  ( $y_3$  is the MSB) that implements a BCD-to-Gray code conversion.

(a) **[4 marks.]** Create the truth table for the circuit's four outputs.

(b) **[8 marks.]** For your answer to part (a), give minimal SOP expressions for each output suitable for the simplest-possible multiple-output circuit implementation. Carefully indicate shared product terms (if any) that can be used. (It is not necessary to draw the circuit.)