

University of Puerto Rico Mayagüez
Department of Electrical and Computer Engineering
ICOM 4036: Structure and Properties of Programming Languages

Problem Set 2: Low-level Programming Languages I
(DUE Sept 29 in class)

1. **CMOS Computers.** Design a CMOS computer to compute the XOR logical function described in the following truth table:

<i>A</i>	<i>B</i>	<i>Output</i>
0	0	0
0	1	1
1	1	0
1	0	1

You should follow the algorithm described in class to specify pull-up and pull-down networks and interconnect them appropriately to obtain the desired functionality.

2. **Combinational Computers.** Design an n-bit ALU to compute the functions described in the following table using only NAND gates:

<i>M1</i>	<i>M0</i>	<i>Operation</i>
0	0	A AND B (bitwise)
0	1	Shift A Left (1 bit)
1	0	Shift A Right (1 bit)
1	1	A + B

The ALU should receive inputs M(2 bits), A(n bits), B(n bits) and an input carry C_{in} and should produce outputs C(n bits) and an output carry C_{out} . You may find it useful to apply the bitwise design technique discussed in class.

3. **Sequential Computers.** Augment the EASY I microprogram in order to implement a SUB instruction that subtracts the X operator from the accumulator and places the result in the accumulator. Your design cannot modify the Easy I ALU. Show modified versions of the level 2 flowchart and the
4. PLP Exercise 5.1. Generalize your answers to n-bit numbers.
5. PLP Exercise 5.7