# Problem Set #9

RealDigital

**1.** (12 points) Sketch a block diagram for a magnitude comparator **bit-slice circuit**. Create K-maps to define the bit-slice circuit, and use them to find optimal logic equations. **Sketch the bit-slice circuit**.

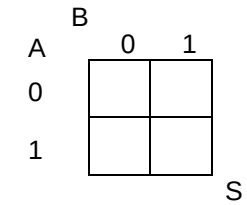
**2.** (12 points) Modify the bit-slice block of problem 1 by removing the logic gates and signals that form the EQ output. Sketch a **"block" circuit diagram** for a **4-bit comparator** that uses the modified bit slice blocks, and add a single gate to form the EQ output from the LT and GT outputs from the MSB (most significant bit).

(4 points) Could you make the bit-slice modules even more efficient by leaving in the EQ logic and removing some other logic? Explain.

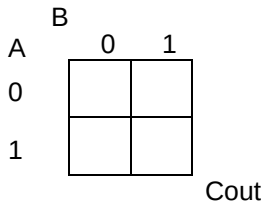
**3.** (10 points) Complete truth tables and K-maps for HA and FA circuits, using XOR patterns where appropriate. Loop minimum SOP equations, and sketch the circuits (assume all inputs and outputs are active high).

Half Adder

| A | B | S | Cout |
|---|---|---|---|
| 0 | 0 | | |
| 0 | 1 | | |
| 1 | 0 | | |
| 1 | 1 | | |



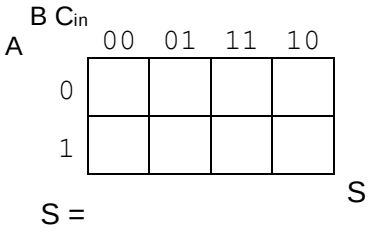

S =



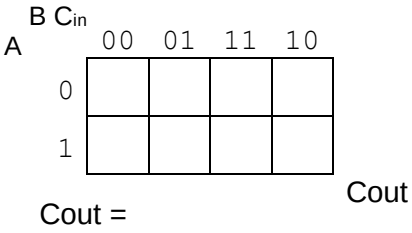

Cout =

Full Adder

| A | B | Cin | S | Cout |
|---|---|---|---|---|
| 0 | 0 | 0 | | |
| 0 | 0 | 1 | | |
| 0 | 1 | 0 | | |
| 0 | 1 | 1 | | |
| 1 | 0 | 0 | | |
| 1 | 0 | 1 | | |
| 1 | 1 | 0 | | |
| 1 | 1 | 1 | | |




S =

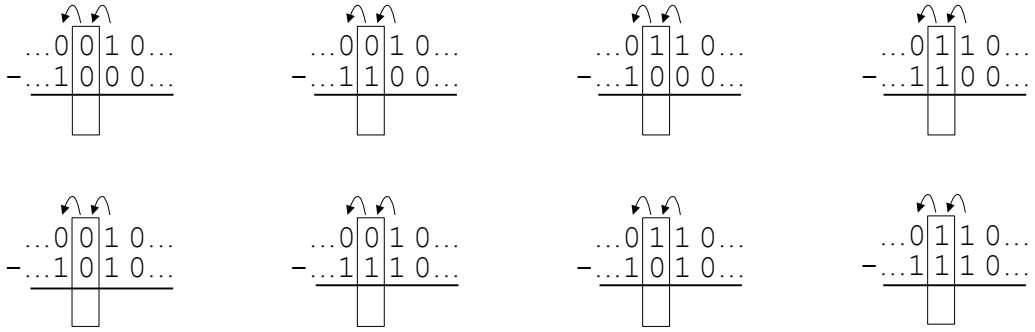



Cout =

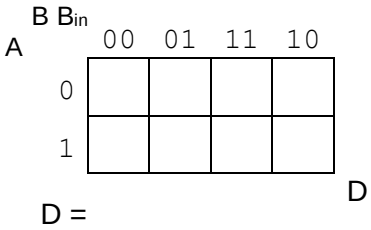
**4.** (10 points) Sketch a block diagram for a full adder using two **half-adder blocks** and an OR gate.

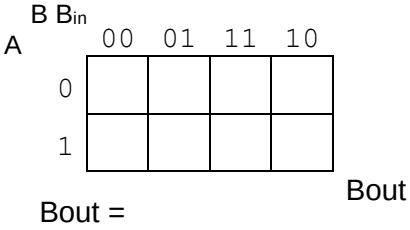
**5.** (8 points) Sketch an entire **Carry-Propagate-Generate circuit** that can form the **carry-ins** for all four bits of 5-bit CLA.

**6.** (20 points) Design a full-subtractor bit-slice circuit (Borrow-Ripple Subtractor). Label the inputs A, B, and Bin, and label the outputs D and Bout. Start by completing the subtraction examples, then complete the truth table and K-maps, and then sketch the circuit.




| A | B | Bin | D | Bout |
|---|---|---|---|---|
| 0 | 0 | 0 | | |
| 0 | 0 | 1 | | |
| 0 | 1 | 0 | | |
| 0 | 1 | 1 | | |
| 1 | 0 | 0 | | |
| 1 | 0 | 1 | | |
| 1 | 1 | 0 | | |
| 1 | 1 | 1 | | |



**7.** (8 points) Complete the number conversions indicated. Note that all binary numbers are two's complement representations.

$-19_D$ = _____$_B$ $10011010_B$ = _____$_D$

$10000000$ = _____$_D$ $-101_D$ = _____$_B$

**8.** (22 points) Complete the four 2's compliment arithmetic problems below assuming that all operations use an adder. Showing both the decimal and binary numbers in each case.

17 0 0 0 0 1 0 0 0 1
- 11 + 1 1 1 1 1 0 1 0 1

-22
+ 6 +

35
- 42 +

19
- (-7) +

1 0 1 0 0 1 1 0
+ 1 1 1 1 0 1 0 1

Is the answer to the equation on the left correct in 8 bits? Explain.

**9.** (10 points) Sketch a circuit to convert a 4-bit binary number to its 2's complement representation using only 3 XOR/XNOR gates and 2 AND or OR gates.

**10.** (8 points) Examine several examples of addition overflow and subtraction underflow, and sketch a circuit below that can output a '1' whenever an addition or subtraction result is incorrect due to underflow or overflow. Assume that both operands and result of the addition and subtraction are N-bits. (Hint: compare the carry in and carry out signals of the most-significant bit).

**11.** (16 points) Fill in the squares below to show all signal values when "1101" and "1010" are multiplied.