

Laboratory 3 – Sequential circuits: memory and feedback

Procedure:

This assignment has two related exercises. Demonstrate the operation of the circuits using LED's and submit a circuit design for part B on the reverse of this sheet.

Introduction:

Fig 3.1 shows the difference between combinational and sequential circuits:

(a) Combinational circuits implement one-way logic – the outputs assume the logic function implemented by the network after the transients in the current input have settled. For example, think of $C=A(\text{AND})B$ or $C=A(\text{OR})B$.

(b) Sequential circuits on the other hand, 'remember' the current state of the system in memory. The next output is computed based on the current input and the combinational logic implemented in the system.

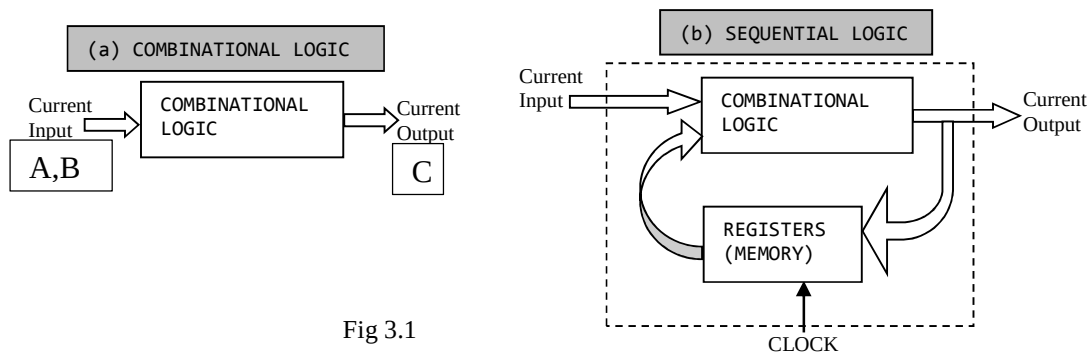
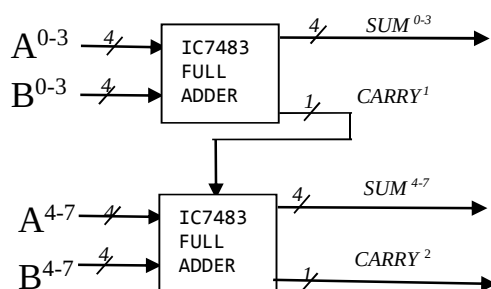


Fig 3.1

In case of synchronous sequential systems, an external clock signal orchestrates the operation of the circuit. *Good design principles dictate that the clock signal must always enter the system at the memory*: this will become clearer as you design and build more circuits. Today's lab deals with building a sequential circuit.

Part A

Build the circuit shown in Fig 3.2 for adding 2 sets of 8-bit binary numbers using two IC7483 full adder chips. Use any random combinations of inputs (eg 11011001,00000001 etc) by applying +5V and grounding the appropriate inputs of the IC to verify that your circuit works. Add any two different sets of numbers. Connect up LED's to the inputs and outputs for demonstration.



$A^{0-3} + B^{0-3} = \text{SUM}^{0-3} + \text{CARRY}^1$
 $A^{4-7} + B^{4-7} + \text{CARRY}^1 = \text{SUM}^{4-7} + \text{CARRY}^2$
 (here '+' means binary addition
 and the superscript A^{0-3} means the four bits $A^3 A^2 A^1 A^0$ etc)

$\xrightarrow{4}$ Note: This symbol means 4-bits in parallel. This is a "4-bit bus"

Fig 3.2

Part B

Using the principle of sequential logic discussed above in Fig 3.1, design and build a circuit to add a number with an *arbitrary (large N) number* of bits using just one IC7483 and a few D registers (money is limited and these IC's are expensive! Besides, the amount of wiring needed for large number of additions would be very large.)

A) You can use the logic pulse generator to provide manual pulses on the clock input to your circuit. What is the function of the clock signal here?

B) You can use a fixed input of a combination of N bits where N is a multiple of four.

i.e. for this exercise, you can simplify:

by taking $B = A$

and calculate this function instead

$$A^N + B^N = SUM^N + CARRY$$

$$A^N + A^N = SUM^N + CARRY$$

For example use:

$A = 0001\ 0001\ 0001$ (decimal 273) or $A = 1000\ 1000\ 1000$ (decimal 2184)

In the real world, you would build another sequential system to feed your adder with 4-bit numbers on a 4-bit data bus.

C) In your logic, what is the constraint on the numbers you can add?

Note: Keep in mind that a TTL gate with input left unconnected is assumed high, take this into account when designing and building your circuit.

Draw your circuit design below to implement the addition of two N -bit numbers as above: *Point out in particular how your circuit handles the carry bit.*

1)Answer: Function of CLK signal:

2)Answer: Constraint on the number that can be added with this design:

3) Circuit Design:

