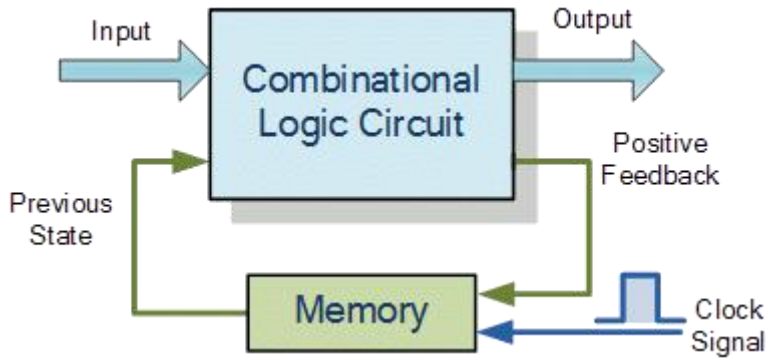
Sequential Logic Circuits

Sequential Logic Circuits use flip-flops as memory elements and in which their output is dependent on the input state

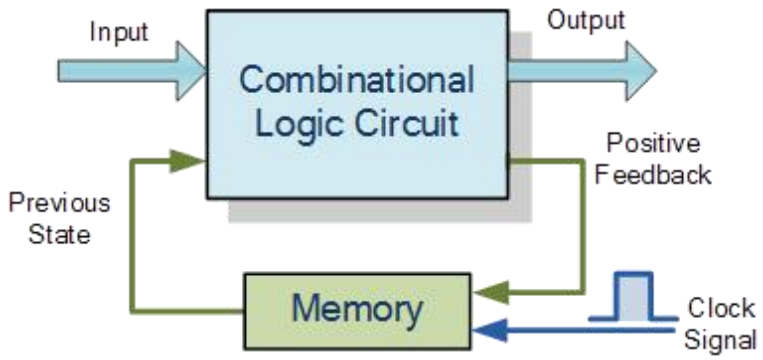


Unlike Combinational Logic circuits that change state depending upon the actual signals being applied to their inputs at that time, Sequential Logic circuits have some form of inherent “Memory” built in.This means that sequential logic circuits are able to take into account their previous input state as well as those actually present, a sort of “before” and “after” effect is involved with sequential circuits.

In other words, the output state of a “sequential logic circuit” is a function of the following three states, the “present input”, the “past input” and/or the “past output”. Sequential Logic circuits remember these conditions and stay fixed in their current state until the next clock signal changes one of the states, giving sequential logic circuits “Memory”.

Sequential logic circuits are generally termed as two state or Bistable devices which can have their output or outputs set in one of two basic states, a logic level “1” or a logic level “0” and will remain “latched” (hence the name latch) indefinitely in this current state or condition until some other input trigger pulse or signal is applied which will cause the bistable to change its state once again.

Sequential Logic Representation

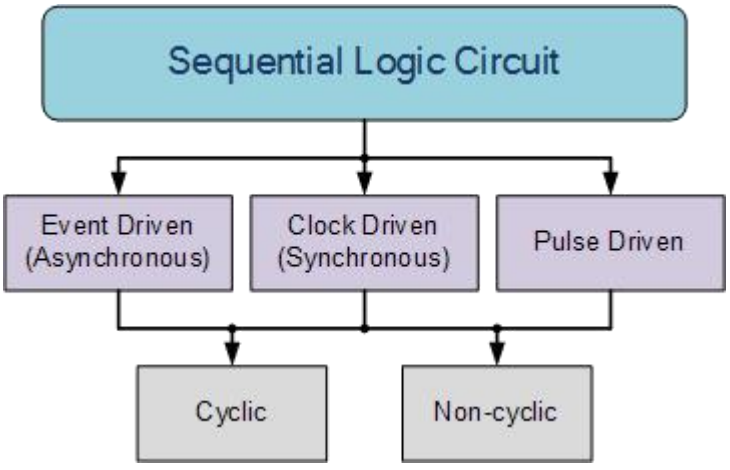


The word "Sequential" means that things happen in a "sequence", one after another and in Sequential Logic circuits, the actual clock signal determines when things will happen next. Simple sequential logic circuits can be constructed from standard Bistable circuits such as: Flip-flops, Latches and Counters and which themselves can be made by simply connecting together universal NAND Gates and/or NOR Gates in a particular combinational way to produce the required sequential circuit.

Classification of Sequential Logic

As standard logic gates are the building blocks of combinational circuits, bistable latches and flip-flops are the basic building blocks of sequential logic circuits. Sequential logic circuits can be constructed to produce either simple edge-triggered flip-flops or more complex sequential circuits such as storage registers, shift registers, memory devices or counters. Either way sequential logic circuits can be divided into the following three main categories:

1. Event Driven – asynchronous circuits that change state immediately when enabled.
2. Clock Driven – synchronous circuits that are synchronised to a specific clock signal.
3. Pulse Driven – which is a combination of the two that responds to triggering pulses.

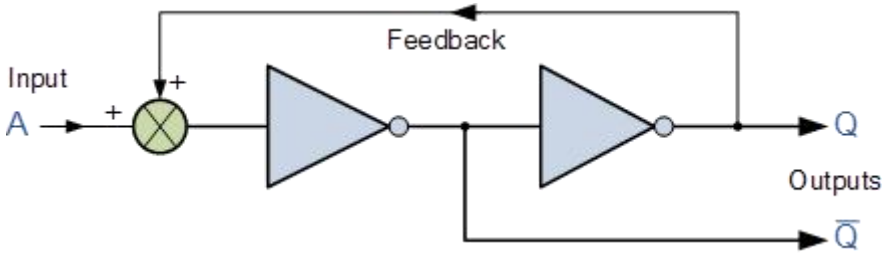


As well as the two logic states mentioned above logic level "1" and logic level "0", a third element is introduced that separates sequential logic circuits from their combinational logic counterparts, namely TIME.

Sequential logic circuits return back to their original steady state once reset and sequential circuits with loops or feedback paths are said to be “cyclic” in nature.

We now know that in sequential circuits changes occur only on the application of a clock signal making it synchronous, otherwise the circuit is asynchronous and depends upon an external input. To retain their current state, sequential circuits rely on feedback and this occurs when a fraction of the output is fed back to the input and this is demonstrated as:

Sequential Feedback Loop



The two inverters or NOT gates are connected in series with the output at Q fed back to the input. Unfortunately, this configuration never changes state because the output will always be the same, either a “1” or a “0”, it is permanently set. However, we can see how feedback works by examining the most basic sequential logic components, called the SR flip-flop.

MCQ

Q1. Which sequential circuits generate the feedback path due to the cross-coupled connection from output of one gate to the input of another gate?

a. Synchronous

b. Asynchronous

c. Both

d. None of the above

ANSWER: b. Asynchronous

Q2. What is/are the crucial function/s of memory elements used in the sequential circuits?

a. Storage of binary information

b. Specify the state of sequential

c. Both a & b

d. None of the above

ANSWER: c. Both a & b

Q3. How are the sequential circuits specified in terms of time sequence?

a. By Inputs

b. By Outputs

c. By Internal states

d. All of the above

ANSWER: d. All of the above

Q4. The behaviour of synchronous sequential circuit can be predicted by defining the signals at _____.

a. discrete instants of time

b. continuous instants of time

c. sampling instants of time

d. at any instant of time

ANSWER: a. discrete instants of time