2.3 Sequential Logic Circuits

Sequential logic circuits differ from combinational circuits by including memory elements that store past input states. Flip-flops are the fundamental building blocks of sequential circuits, capable of storing one bit of information. The RS flip-flop, named for its Set (S) and Reset (R) inputs, changes state based on input conditions. When S is 1 and R is 0, the output is set to 1, while when S is 0 and R is 1, the output resets to 0. The gated flip-flop introduces an enable input, ensuring state changes occur only when enabled. Edge-triggered flip-flops transition states on specific clock edges, either rising or falling, reducing timing errors. The master-slave flip-flop consists of two interconnected flip-flops, where the master captures the input on the clock's rising edge and transfers it to the slave on the falling edge, preventing glitches and race conditions.

Registers consist of multiple flip-flops used to store multi-bit data. Shift registers, a type of register, shift data left or right with each clock pulse, used in serial-to-parallel and parallel-to-serial conversions. Registers find applications in temporary data storage, signal processing, and communication systems.

Counters, which count events in digital systems, are categorized into asynchronous (ripple) and synchronous counters. Asynchronous counters have flip-flops triggered sequentially, introducing delays due to signal propagation. Synchronous counters trigger all flip-flops simultaneously with a common clock signal, improving speed and reliability. Binary counters count in binary sequence, while up/down counters can increment or decrement based on control signals. Counters are widely used in digital clocks, frequency dividers, and microprocessors for timing and control applications.