DIGITAL COUNTERS

A digital counter, or simply counter, is a semiconductor device that is used for counting the number of times that a digital event has occurred. The counter's output is indexed by one LSB every time the counter is clocked.

A simple implementation of a 4-bit counter is shown in Figure 1, which consists of 4 stages of cascaded J-K flip-flops. This is a binary counter, since the output is in binary system format, i.e., only two digits are used to represent the count, i.e., '1' and '0'. With only 4 bits, it can only count up to '1111', or decimal number 15.

As one can see from Figure 1, the J and K inputs of all the flip-flops are tied to '1', so that they will toggle between states every time they are clocked. Also, the output of each flip-flop in the counter is used to clock the next flip-flop. As a result, the succeeding flip-flop toggles between '1' and '0' at only half the frequency as the flip-flop before it.

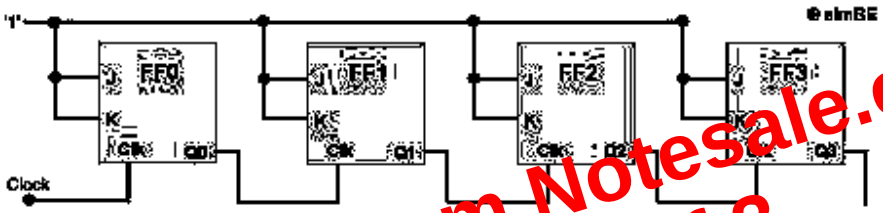

Figure 1. A Simple Ripple Counter Consisting of J-K Flip-flops

Thus, in Figure 1's 4-bit example, the last flip-flop will only toggle after the first flip-flop has already toggled 8 times. This type of binary counter is known as a 'serial', 'ripple', or 'asynchronous' counter. The name 'asynchronous' comes from the fact that this counter's flip-flops are not being clocked at the same time.

A 4-bit counter, which has 16 unique states that it can count through, is also called a modulo-16 counter, or mod-16 counter. By definition, a modulo-k or base-k counter is one that returns to its initial state after k cycles of the input waveform. A counter that has N flip-flops is a modulo 2^N counter.

An asynchronous counter has a serious drawback - its speed is limited by the cumulative propagation times of the cascaded flip-flops. A counter that has N flip-flops, each of which has a propagation time t, must therefore wait for a duration equal to N x t before it can undergo another transition clocking.