XILINX®

Complex Digital Waveform Generator

XAPP 008.002

Application Note By BERNIE NEW

Summary

Complex digital waveforms are generated without the need for complex decoding. Instead, fast loadable counters are used to time individual High and Low periods.

Specifications

Minimum High/Low Time	44 ns
Maximum High/Low Time	>250 µs
Resolution	4 ns
Number of Highs and Lows	32
Number of CLBs	40

Xilinx Family

XC3000/XC3100
XC4000

Demonstrates

Fast Loadable Counters
CLB ROMs

Complex digital waveforms with unequally spaced transitions are often generated by decoding a counter that cycles with the same period as the waveform. If precise placement of edges is required, the counter must be clocked at high frequency. This increases the burden on the decoders; not only must they settle faster, but if the period of the waveform remains constant, they must become wider. These two requirements are incompatible. Decoders typically become slower as they get wider.

In LCA devices, this problem can be overcome by using high-speed counters in conjunction with data stored in ROM. The data stored in the ROM is not the waveform itself, but a run-length encoded version of it. A block diagram of the waveform generator is shown in Figure 1.

The values stored in the ROM are used to load a presettable counter that times the duration of individual High and Low segments of the complex waveform. A second counter is enabled whenever the timer is reloaded, and tracks the segment number in the waveform. This is used to address the ROM and access the length of the next segment.

The least significant bit of the second counter toggles after each cycle of the timer and thus creates the output waveform. This output is guaranteed to be glitch free, since it is generated by toggling a flip-flop.

In an LCA device, the ROM may be implemented in the CLBs. Each function generator may be used as a

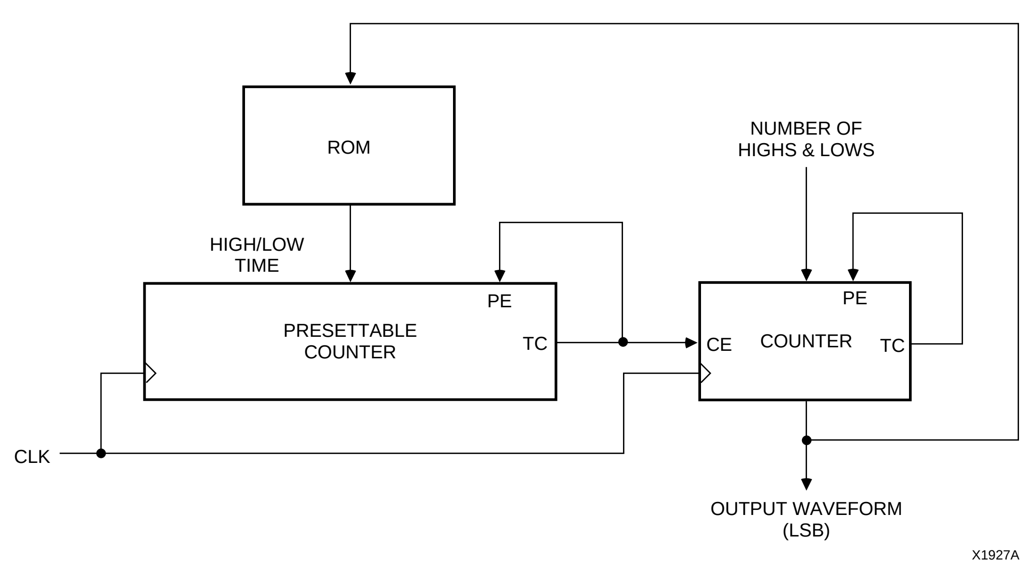

Figure 1. Precision Waveform Generator

16 x 2-bit ROM or as a 32 x 1-bit ROM. In the XC3000 series, ROM data may be entered at the schematic level using 16:1 or 32:1 multiplexers to represent ROM bits. The ROM values are applied to the data inputs of these multiplexers as hard-wired ones and zeros. CLBMAPs are used to lock the multiplexers into CLBs. APR incorporates the ones and zeros into the logic function, and creates the desired ROM as 4- or 5-input function generator look-up tables.

Using a state-skipping technique, the maximum clock rate for a presettable counter in an XC3100-series LCA device is 270 MHz. This provides for defining the duration of Highs and Lows in 4-ns increments. In such a counter, the shortest delay is 11 clocks, giving a minimum High or Low time of 44 ns. While some periods longer than this are also unavailable, the availability of all periods of 30 clocks or greater (≥120 ns) is guaranteed. The 16-bit timer allows maximum High and Low times of 262 µs. Up to 32 Highs and Lows can be accommodated using 32-word ROMs, for total waveform periods of up to 8 ms.

The 16-bit timer requires 18 CLBs, and a further six are used in the segment counter. The 32 x 16-bit ROM adds 16 CLBs, for a total of 40.

ROM values may be used more than once in a waveform. To do this, the output of the second counter must be encoded to the appropriate ROM address. With this technique, any waveform length may be accommodated, provided it comprises a limited number of distinct time intervals.

Multiple waveforms may also be generated using this scheme. A single timing counter is used to create a super-set of transition times for all the waveforms. Individual state machines are then used to create the different waveforms from this timing information.