Design Ideas

A Simple One-Chip Comb Generator

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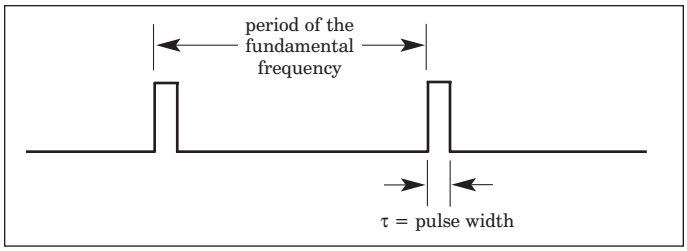
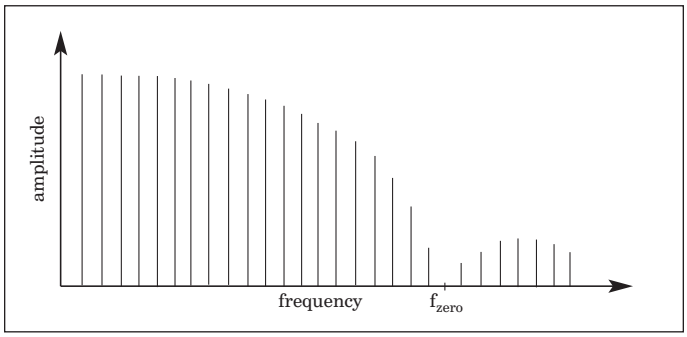
Here is a very simple way to generate harmonics of a reference signal with consistent amplitude over a wide bandwidth. All that's needed is an advanced CMOS quad NAND gate (74AC00), a crystal and a few supporting components. The output includes both odd and even harmonics that are nearly flat in amplitude up to 100 MHz.

The simplest way to create such a comb is to use a narrow pulse (Figure 1). The fundamental frequency is the repetition rate, with the spectral characteristics of the output signal determined by the pulse width. Figure 2 shows the spectrum of the comb output. The amplitude of the harmonics follows the $\sin(x)/x$ function, which has its first zero at $1/\tau$ (Hz), where τ is the pulse width in seconds. At one-half the frequency of the first zero, the amplitude will be approximately 4 dB below the fundamental. The useful frequency range will depend on your need for uniform amplitude output.

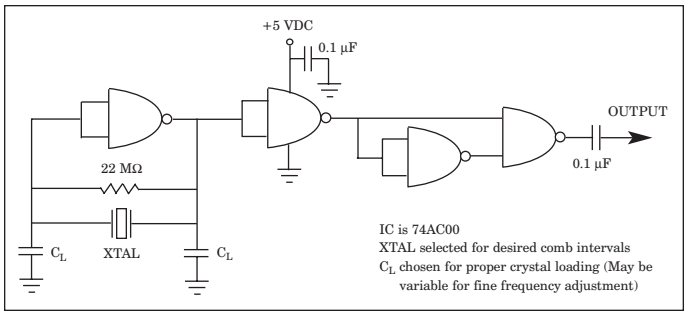
The only problem is that a waveform with a very small value of τ has a very low energy content. Signal levels become correspondingly lower as τ is reduced. Think of it as spreading out the energy over a larger number of harmonics.



■ **Figure 1. Waveform which will create a uniform "comb" over a wide frequency span.**



■ **Figure 2. The amplitude of the output spectrum has a sin(*x*)/*x* response with the first zero at $f_{zero} = 1/\tau$.**



■ **Figure 3. Schematic of the simple comb generator.**

Circuit description

The circuit is extremely simple, as shown in Figure 3. One gate of the 74AC00 is connected as an inverter and used with a 1 MHz crystal in a conventional CMOS clock oscillator circuit. A second gate used as a buffer. The buffer is needed because the one-gate oscillator does not have a "clean" square wave output.

The 1 MHz square wave is fed to one input of the "output" gate. The same signal passes through another gate (an inverter) and is routed to the other input. Thus, the output gate is turned off by the rising edge of the square wave, then quickly turned on again after the arrival of the signal through the inverter. Thus, the output is a negative-going pulse with a width equal to the propagation delay through one 74AC00 gate. The direction of the pulse has no importance in the frequency domain, and the output spectrum is the same for either an "upright" or "inverted" pulse.

The delay through an ACMOS gate is typically 5 or 6 ns. Circuit layout may increase this delay, so keep connections as short as possible and minimize stray capacitance. A bit more speed can be obtained by raising the supply to 5.5 or even 6.0 volts. For $\tau = 5$ ns, $f_{zero} = 200$ MHz, providing a useful range well over 100 MHz.

What is a comb generator good for? Here are just a few uses that come to mind:

- Calibration source for older test equipment
- Built-in-test signal source
- Replace a swept source for simple measurements
- Frequency multiplier (filter out selected harmonic)
- Connect it to a battery and short antenna, put it in your pocket and walk over to your co-worker's test bench when he's making delicate measurements! ■