Negative delay

TODAY'S MAIL contained a federal notice about my tax-relief check. The check itself is "in the mail," but I can already feel my consumer sentiment surging with anticipation. I hope you feel the same way.

As Congress worked its way through this latest tax-relief legislation, each member of Congress surely understood the great benefits of quick action to our economy. Unfortunately, a lot of little glitches, each inserting its own delay into the process, tend to get in the way of such legislation. As a result, I tend to visualize our government as a sort of huge, lumbering, dopey example of Brownian motion.

If Congress invented negative-delay legislation, it might improve its reputation for alacrity. How about a law mandating that we all act as if the government sent the checks in February? Sounds ridiculous, and it is, because it violates the principle of causality. The rules of physical causality assert that you cannot react until something *happens*.

Similarly in digital logic, the rule of causality prohibits the existence of a negative-delay circuit. An information theorist puts the issue this way: "How could a negative-delay circuit *know* what to do before its inputs have changed?" His information-theoretic argument makes sense in the context of a general digital signal that actually incorporates useful information, but it does not apply to an *information-free* signal. An information-free signal is one for which no ongoing information, other than a fixed set of initial parameters, is required to reconstruct the signal. The rules of causality do not apply to information-free signals, because you can always use the initial parameters to predict what the signal will do next.

Before you dismiss this article as nonsense, let me point out that the class of information-free signals includes all repetitive signals. A prime example of a repetitive, information-free signal is your clock signal. The observation that causality does not apply to information-free signals means, in simple terms, that you can actually make a negative-delay circuit for your clock.

YOU CAN ACTUALLY MAKE A NEGATIVE-DELAY CIRCUIT FOR YOUR CLOCK.

Figure 1 reveals how to make a negative-delay clock repeater, which is really just a positive-delay circuit with a delay u set to a little less than one clock period. If your clock period is t, then delaying the clock by a positive amount, u, appears, for all practical purposes, the same as advancing the clock by amount $t-u$.

You can easily implement a negative clock delay by using a coaxial cable of a suitable length. For a clock period of 10 nsec (100 MHz), a small negative delay would comprise one coaxial cable measuring approximately 6 ft, depending on the exact propagation velocity of the cable and the amount of negative delay you want. A 6-ft cable, although impractical for a shippable product, might be eminently serviceable in your test laboratory as a way to advance a clock signal.

A good test plan for any digital product should include a provision for inserting a variable delay in series with each clock load in the clock-distribution tree. The delay might comprise two sections: a (negative) fixed delay equivalent to a 10% advancement of the clock period plus a variable positive delay of 0 to 20% of the clock period. With these two elements in series, you can fine-tune each clock by ±10% around its nominal value.

The variable-delay insertion point can be as simple as a 0Ω resistor located somewhere along the path for each clock load. For testing, you remove the resistor and use its pads to hand-solder ultraminiature coaxial cables coming out from and returning to the circuit under test. Remember to associate a pair of ground vias near the resistor pads for soldering the coaxial shield.

Negative delays can be useful in real life, too. Suppose you change your mind about someone you helped elect to Congress. Wouldn't you like to recast your old vote retroactively through a negative-delay voting service? That would be wonderful. According to the laws of information theory, a retroactive voting service should be possible if your Congress member represents no useful information.□

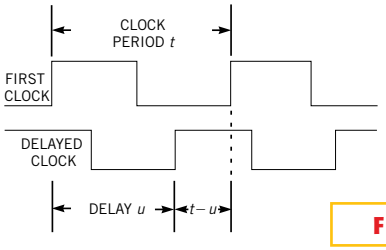

Figure 1

For any signal with period *t*, a positive delay of size *u* is indistinguishable from an advancement of size *t* – *u*.

Howard Johnson, PhD, is the author of High-Speed Digital Design: A Handbook of Black Magic *(Prentice-Hall, 1993). He frequently conducts technical workshops for digital engineers at Oxford University and other sites worldwide. Comments invited! www.sigcon.com, howiej@sigcon.com.*