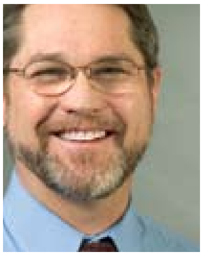

BY HOWARD JOHNSON, PhD

Initial condition

The PCB (printed-circuit-board) transmission line in **Figure 1a** lacks an end termination. If you leave switch S_1 closed for a long time, the line comes to rest in a state with precisely 0V at all points. The transmission line in **Figure 1b** behaves similarly. With S_2 closed, it also comes to rest in a state with 0V at all points. The voltages in the two situations are the same, but the currents differ. In the first case, the line at rest carries no current. In the second case, the end termination supplies a substantial current as long as you hold the line in a low state. To make the numbers easy, assume 2V logic, a perfect switch at the source, and values of 100Ω for both R_1 and R_2. Those values produce a steady-state current of 20 mA for **Figure 1b**.

At time zero, with both lines in their respective steady-state conditions, open both switches. In the case of **Figure 1a**, just before you open the switch, no current flows through it. Opening S_2 therefore changes nothing; it has no effect on the circuit. Opening S_1 in **Figure 1b** has a different effect. In the steady-state condition, 20 mA spills continuously through the switch. When you interrupt that state of events by opening S_2, the current at the left end of the line changes from 20 mA to 0A. You can emulate that effect with a superposition of two linear-current sources, I_B and I_C, which connect (**Figure 1c**).

Current source I_B replaces the 20 mA of steady-state current flowing through S_2 in **Figure 1b**. It sets the initial conditions before your switching event, and it perpetually sinks 20 mA. At time zero, a 20-mA step of current from source I_C cancels the current from source I_B, bringing the net current to 0A. The combination of two sources duplicates the conditions at the left of **Figure 1b** the moment S_2 opens. The linear-current-source model clarifies the actions that occur at time zero. Directing a positive step of 20 mA into the line must create a positive-step-voltage waveform moving to the right with an amplitude of 20 mA×50Ω=1V. In a 2V system, that scenario makes a half-sized step.

If your goal is to inject a total voltage step of 2V into the line, making a full-sized step, which initial state do you prefer? Starting with **Figure 1a**—that is, with no termination—you must do all the work with the top half of your totem-pole driver, sourcing a full 40 mA to create a full-sized signal. Most drivers can't source that much current. On the other hand, a circuit with a symmetric end termination enjoys the benefit of sinking 20 mA the entire time it holds low. When the bottom half of the totem-pole driver lets go, the line voltage at the source automatically jumps up halfway. The top half of the totem-pole driver then needs only to source the other half of the current (20 mA) to bring the line up to full voltage. A symmetric end termination biases the line at a halfway voltage, so that the driver need source or sink only enough current to swing the line halfway either direction. That's why I like it.EDN

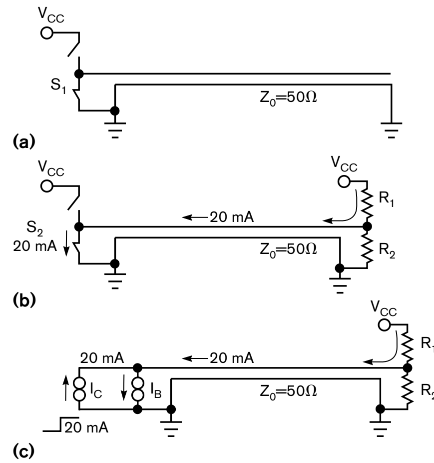

Figure 1 End termination R_1/R_2 establishes an initial current before switching high. If you leave switch S_1 closed for a long time, the line comes to rest in a state with precisely 0V at all points (a). The end termination supplies a substantial current as long as you hold the line in a low state (b). When you interrupt that state of events by opening S_2, the current at the left end of the line changes from 20 mA to 0A. You can emulate that effect with a superposition of two linear-current sources, I_B and I_C, which connect (c).

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