ECL Pulse Generator Produces Balanced Outputs At 1 MHz

Hubert Houtman
4298 Masterson Rd., Blaine, WA 98230

CIRCLE 520

Sub-nanosecond risetime pulse generators with high repetition rates are necessary for gauging an oscilloscope's step response, time-domain reflectometry (TDR), and differential TDR. They're also effective for measuring the reverse recovery of diodes as well as the response and propagation delay of cables, transistors, amplifiers, and comparators. Time-domain studies like these generally require bipolar pulses, with a separate low-jitter pulse capable of triggering an oscilloscope or other test equipment.

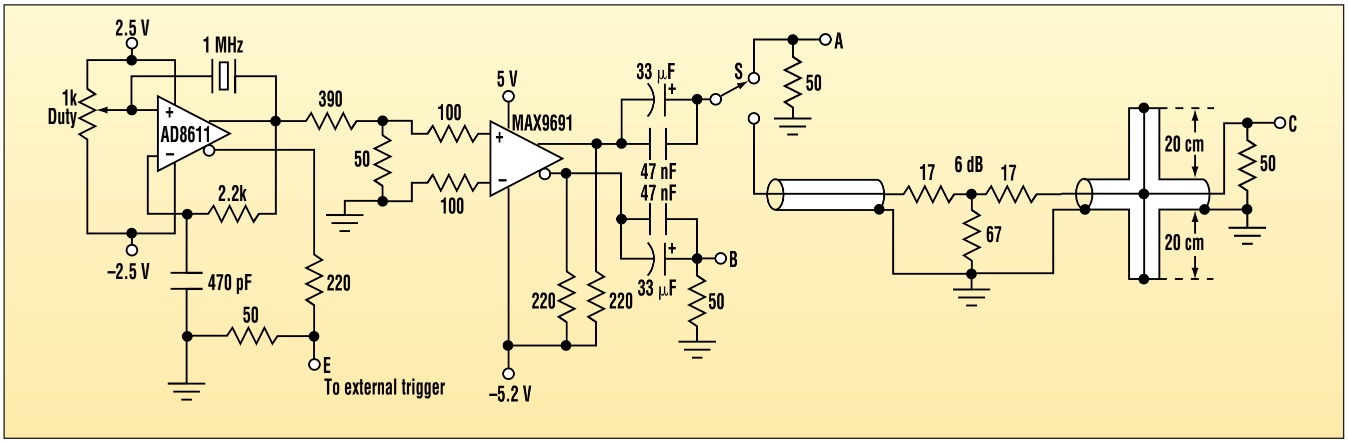
This circuit produces such a trigger, along with balanced ECL outputs, at a pulse-repetition frequency of 1 MHz *(Fig. 1)*. The AD8611 high-speed comparator is wired as a square-wave oscillator. Using the 1-kΩ potentiometer, positive feedback via a 1-MHz crystal is adjusted to yield a 50% duty cycle. While the complementary output provides a fast step-pulse to trigger an oscilloscope, the other output triggers a MAX9691 high-speed comparator. This comparator delivers balanced, ECL-level transitions that are specified at a 500-ps risetime. All components, including three BNC-connectors at A, B, and E, were mounted on a small PC board (Radio Shack #276-150) employing surfboards for the SO-8 comparators.

If the RG-58A/U cable network is connected using the switch S, the double shorting stub produces a short pulse at C. A single, inverted, delayed step-pulse is created, which follows the incident step-pulse toward C. The 6-dB attenuated step is divided at the cross-joint. It first splits into three equal transmitted pulses and one equal-and-opposite pulse that's reflected back toward the attenuator. Each pulse carries one quarter of the power, or half the voltage of the step.

At each shorted end, the pulse reflects with a sign reversal and returns to the cross-joint. Here, it splits again into three transmitted pulses and one equal-and-opposite reflected pulse. This reflected pulse, however, is canceled exactly by the equal-and-opposite pulse transmitted across the cross-joint from the other stub. So the result at C is that the primary step-pulse, which is one-quarter of the comparator's voltage, is followed by an equal-and-opposite step. The relative delay caused by the stub's round-trip time defines the length of the short pulse observed at C.

Two BNC T-adapters (i.e., Radio Shack #278-112) make up the coaxial cross-joint. Using a bandsaw, a 90° "V" is cut into the back of one of the T-adapters at a 45° orientation. Doing so makes it possible to fit a fourth BNC port, cut similarly from the other adapter. This fourth port is soldered to the adapter's V-cut using a low-heat iron. Finally, the brass center-conductor is threaded into the cross-joint center-conductor. A short length of 1-72 UNF threaded rod, cut from a small machine screw, is used for the threading process. The completed cross-joint is then plugged into the four RG-58A/U cables *(Fig. 1, again)*.

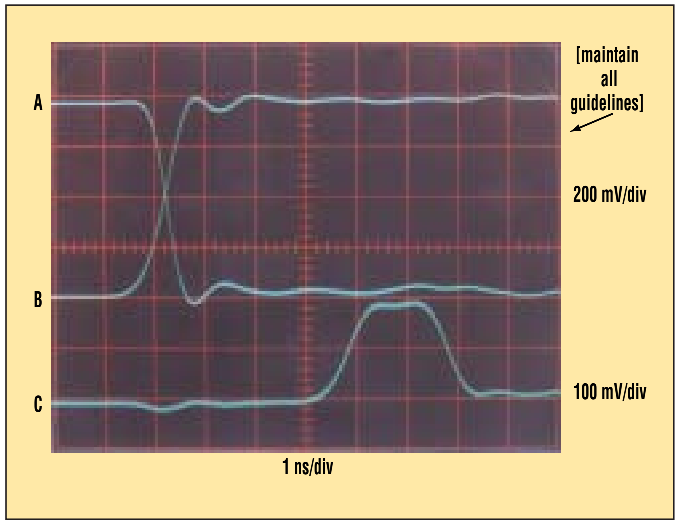
These outputs were measured on a 1-GHz-bandwidth, homebrew sampling oscilloscope with a Tek 503 X-Y oscilloscope for the display *(Fig. 2)*. The high pulse-repetition frequency of 1 MHz allows a high scan rate of 50 Hz. As a result, a live, flicker-free display is produced. Each nanosecond of equivalent time displays 200 samples,



1. The square-wave oscillator triggers the oscilloscope and the MAX9691 comparator to produce the ECL-level output step-pulses, or nanosecond pulses via the shorting-stub network. A pulse-repetition frequency of 1 MHz yields a flicker-free display at a 50-Hz scan rate.

corresponding to an interval of 5 ps/sample. The sampler was triggered by a terminated RG-58A/U cable using the attenuated AD8611 complementary output at E.

While Trace A depicts the MAX-9691's ECL-level output driven by coupling capacitors, Trace B shows the complementary output. Transition durations are about 500 ps, in agreement with the component specification sheet. Trace C illustrates the pulse after the shorting-stub network, connected by switch S.



2. Shown is the sampling-oscilloscope display of the MAX9691's output (Trace A) and its complementary output (Trace B). Trace C shows the output of the shorting-stub network.

For this 2-ns pulse, 20-cm long stubs were employed. But different stub lengths will yield other pulse durations, including sub-nanosecond pulses. Transition trace widths on this photograph are less than 0.10 of the 200-ps smallest divisions. This indicates that the system jitter is less than ±10 ps.

Due to frequency-dependent attenuation of the line, the 40-ns delay line commonly used in a sampling oscilloscope input limits the device's bandwidth. As an alternative, a 40-ns delay line may be installed between the two comparators, becoming part of the 390-Ω:50-Ω attenuator. The AD8611 will then provide a low-jitter trigger at E, which precedes the MAX9691's pulses by 40 ns. In turn, the delay line may be eliminated from the sequential-sampling oscilloscope, thereby improving its bandwidth.

For a general-purpose pulse generator, it may be beneficial to have pulses shorter than those shown. With TDR tests, however, it's better to have steps whose transition durations are commensurate with the risetime of the pulses implemented in the final system. Super-fine structure details are then automatically filtered out by the transition duration. Therefore, they will not obscure the TDR traces. A faster component, such as the Motorola MC100EL32D flip-flop, can be substituted for the MAX9691 in order to produce shorter pulses.

Four-Digit Panel Meter Costs Less Than Six Dollars

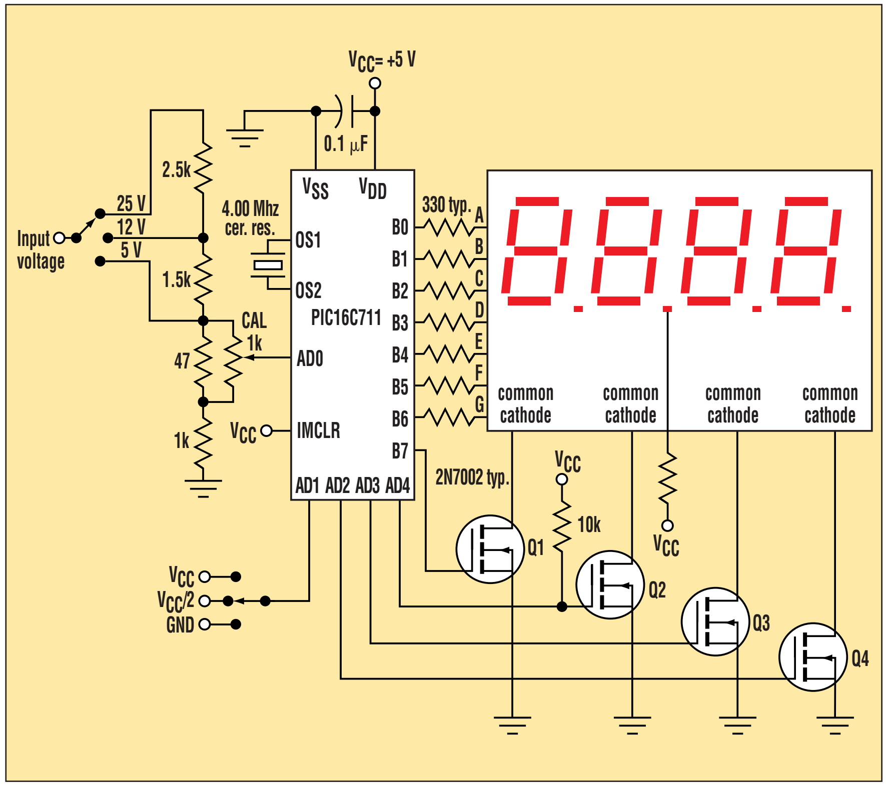
Jim Walker

812 North Rd., San Bernardino, CA 92404; (909) 987-4673

CIRCLE 521

While many products can be improved by the incorporation of a digital panel meter, the price of the device often precludes its inclusion. The circuit shown offers a low-cost solution *(see the figure)*. As an added bonus, the circuit is pin-selectable for three different display ranges. The total parts cost is less than $6.00 in quantities of 100.

The low-cost PIC16C711 forms the heart of the panel meter. It is config-



This four-digit panel meter is an inexpensive but attractive add-on for a variety of products.

ured with two of its inputs as 8-bit analog-to-digital converters (ADC). While AD0 is the voltage input, AD1 is the range-select input. If AD1 is wired to ground, the unit will display a range of 0.00 to 5.10 V with a 20-mV resolution (the left digit is blank).

With AD1 wired at mid-voltage, the display reads 00.00 to 12.75 V with a 50-mV resolution. With AD1 wired to V_{CC}, the display reads 00.0 to 25.5 V with a 100-mV resolution (the right digit is blank). A total of 256 voltage increments are displayed.

Since the voltage reference is the V_{CC} supply, the accuracy after calibration is as stable as V_{CC}. The 16C711 is rated for ±1/2-LSB over temperature. The micro has an open drain output on RB4, requiring an external pull-up resistor. Also note that external voltage attenuators are required for the upper voltage ranges.

The PIC chip functions as a seven-segment decoder/driver, driving all four seven-segment LEDs at once. Only one of the four seven-segment LEDs is illuminated at a time. It is pulled to ground on the common cathode terminal by Q1 through Q4, respectively. The decimal point is selected through an independent resistor.

The LED pack is MSQC6940C, available from Mouser for $2.06 per 100 units. The PIC16C711-04P is available from Digikey for $2.23 per 100 units. The 4-MHz resonator is ZTT-4.00MG, also available from Digikey at $0.45 per 100 units. The PIC code listing for the PIC16C711 can be viewed or downloaded at *www.PlanetEE.com* (click on the Ideas for Design icon).

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