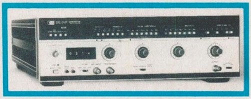


ALL ABOUT PULSE GENERATORS

PULSE GENERATORS ARE VERY SIMILAR to function generators in that they are fairly simple instruments that can be made more powerful and versatile by adding special features. We'll look at some of those special features, but first, let's continue our discussion of pulse-generator characteristics.

Output amplifier characteristics

The output-amplifier characteristics are primarily associated with the output-signal amplitude. The maximum output amplitude is usually specified under two conditions: with no load and with the amplifier terminated into a load that is equal to its characteristic impedance. Typical maximum outputs range from 5 to 10 volts.

Output-attenuator specifications indicate the minimum voltage from the pulse generator. A few low-priced pulse generators include a step attenuator that permits a 10:1 adjustment of output amplitude by using a variable control, plus additional switch-selected decade reductions in output amplitude. Frequently, other pulse-characteristic specifications are limited to situations dealing with either the maximum output from the variable attenuator, or with the variable attenuator at some major percentage of full output. Almost always the specifications do not hold at the extreme low-level limits of the continuously variable attenuator.

With the exception of very high voltage units, which are not low cost, pulse generators have a 50-ohm output impedance. Most pulse generators provide both positive and negative outputs. Those outputs are usually taken from a single output connector; the polarity of the output is switch-selected. Some units offer separate variable attenuators and output connectors for the positive and negative outputs. A positive-only output is found only on very low-cost generators.

The pulse baseline offset is a variable control that lets you offset the pulse baseline by some DC voltage. Typically, the offset is limited to a maximum of ±20% of the maximum pulse amplitude. Few low-cost pulse generators offer pulse baseline offset.

Most pulse generators protect the output from damage caused by any possible generator settings or short circuits. However, few pulse-generator outputs are protected from an external signal that is greater than the maximum output amplitude.

Trigger or synchronization output

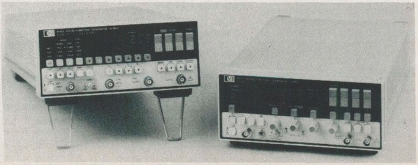
As noted earlier, pulse generators that include a delay generator have a special mode in which an additional pulse is output. That additional pulse is derived from either the trigger circuitry or the basic pulse-rate generator. The purpose of that output is to signal devices outside the pulse generator that a pulse is about to be generated. Frequently, that pulse precedes the generation of the main pulse by 20 to 40 nanoseconds, thus permitting an oscilloscope or other device to start operating on the incoming pulse. The specifications for that additional pulse, called a trigger or synchronization output, include amplitude (usually in the range of 2.5 to 5 volts); source impedance (usually 50 ohms, although 500- or 1000-ohm impedances are not uncommon); pulse width, and waveshape. On some pulse generators, the trigger output consists of a narrow pulse. Other pulse generators provide a square wave. In either case, a particular edge is used as the trigger edge; the other edge of the waveform has no significance.

Externally triggered mode

The specifications for many pulse generators change slightly when the unit is operated in the externally triggered mode. The repetition rate of most pulse generators extends down to DC when they are in the externally triggered mode. However, some pulse generators are AC-coupled in the externally triggered mode and, although the repetition rate may be quite slow, a minimum rise-time signal must be applied to the external input for triggering to take place. Other specifications pertaining to the external-trigger input include the minimum pulse width that can be used for external triggering. Most pulse generators require a minimum-pulse width of 15 nanoseconds. The minimum-pulse amplitude required to trigger the external input of a pulse generator may vary widely from generator to generator. In more sophisticated generators, a pulse amplitude of a few tenths of a volt can be used to trigger the external input successfully; low-cost generators may require pulses in the 3- to 5-volt range for successful triggering. Another specification gives the maximum amplitude that may be used for external-triggering input. The input impedance of an external trigger may run from 50- to 100,000-ohms or more. Another specification indicates whether triggering occurs at the leading or trailing edge.

Double pulse control

We've already discussed one of the



THESE COMPACT UNITS, the *model 8116A* (left) and *model 8111A* (right) from Hewlett Packard, offer the features of a function generator, as well as a pulse generator, in a single device.

One of the big reasons why pulse generators have become so popular is that they are very useful in troubleshooting digital circuits. How they are used for that is just one of the topics we'll cover this month.

CHARLES GILMORE

special features found on many pulse generators—double pulses (see part 1 of this article in the March 1982 issue). Double pulses can be obtained by triggering the pulse generator first from the main repetition-rate generator, and then from the delay generator. In addition to triggering external devices, the double-pulse feature is useful for generating signals whose frequency is twice the repetition rate indicated. The delay generator controls the pulse separation. The basic repetition rate is twice that of the repetition-rate generator; however, the pulse-to-pulse spacing may not be equal unless the delay generator is set to exactly one-half the repetition rate. There is some minimum spacing that must be maintained so that two distinct pulses are produced. Spacings that are below that minimum can result in just a single pulse being output.

The double-pulse feature is also useful for testing logic IC's. Pulse resolution refers to the minimum spacing between input pulses that will permit the IC to respond correctly. That means that the double-pulse feature can be used for determining the pulse resolution of the IC.

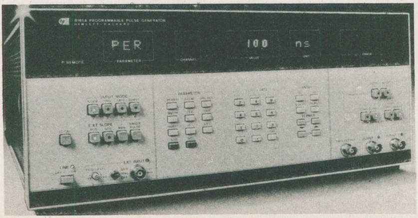
Gating

Gating, found on several low-cost pulse generators, basically permits you to generate a pulse burst. The length of the burst is controlled externally. There are two types of gate controls—synchronous and asynchronous.

In the synchronous mode, the gating signal is used to control the repetition-rate generator directly. That is, the repetition-rate generator is turned on and off by the gating signal. When the gating signal is turned on, the repetition-rate generator turns on and the pulse generator creates signals that are synchronized exactly to the gating signal.

When used in the asynchronous mode, the repetition-rate generator runs freely. The output of the repetition-rate generator is turned on and off by the gating signal, and therefore, the pulse-generator output is not synchronized to the gating signal. Asynchronous gating assures more uniformity from pulse period to pulse period, especially within the first few pulses of the gating interval; however that uniformity is achieved by sacrificing synchronization.

The gating amplifier's input requirements vary considerably from generator to generator. In some units, a positive voltage above a certain threshold is required to gate the pulse repetition-rate generator. In other generators, when an impedance that is lower than a certain value is connected from the gating input to ground, the output pulse is cut off.



INTENDED FOR USE in high-technology applications, the *model 8161A* from Hewlett Packard offers a 100-MHz repetition rate, 5-volt maximum amplitude, and dual-channel capacity (optional).

Pulse-burst mode

The pulse-burst mode found on some generators lets you preset an internal counter, by using thumbwheel switches. When the pulse-burst mode is used, each pulse is counted, and when the count equals the preset value in the counter, no more pulses are output. That is particularly useful for checking the accuracy of counters and similar instruments.

Square-wave mode

With most pulse generators, a square-wave output must be established. That is done by adjusting the repetition-rate control and the pulse-width control. If the pulse-repetition rate is adjusted, a new pulse-width control setting is required to maintain a square-wave output. Some pulse generators come with a special switch setting that allows the pulse generator to be operated in a square-wave mode. When operated in that mode, the output maintains a 50% duty cycle at all repetition-rate settings, regardless of the pulse-width control setting.

Variable risetime and falltime

The ability to vary the risetime and falltime of a pulse is often convenient during device testing. In generators having that capability, the output risetime and falltime can be adjusted until the device under test stops. The risetime and falltime that causes that can then be determined. Variable risetimes and falltimes are available only on more expensive generators.

Complementing output

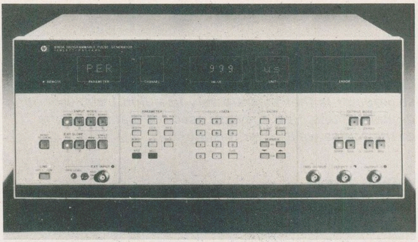
Complementing the output lets a pulse generator that normally produces a positive pulse with a 25% duty cycle produce one with a 75% duty cycle. That, of course, lets a pulse generator output a pulse with a very high duty-cycle.

Output connectors

The most common output connector for use with pulse generators is a BNC connector. A few of the older, high-voltage, vacuum-tube pulse generators have binding posts, but that type of connector is not suitable for handling high-frequency outputs. Pulse generators manufactured by General Radio, and by a few other companies, use a special connector known as the GR connector. The GR connector has a constant impedance that adds virtually no aberrations to the output pulse. Its main disadvantages are its expense and general unavailability. The quality of most available low-cost generators, however, does not warrant the use of that connector.

Applications

As we've seen, there are many special features that can be added to the basic pulse generator to make it more versatile. That is one reason why a pulse generator is such a useful device, with more possible applications than we can reasonably discuss here. However, we will look at some of the basic applications for a pulse generator, especially those that are rather general in nature and can help us understand some of the more special and complicated applications.



HEWLETT PACKARD'S *MODEL 8160A* programmable pulse generator features a delay generator, pulse-burst mode, double pulses, as well as optional dual-channel capability.

Testing IC logic

There are three different types of tests that can be performed on logic IC's: they are functional, DC, and AC tests. Functional testing is probably the most commonly used in servicing; the DC and AC tests are more likely to be performed in industrial, production, or research-and-development situations, although they certainly are not confined to those situations.

The functional test simply determines if the IC performs to its truth-table definitions. For most combinational logic IC's (gates, inverters, decoders, encoders, multiplexers, etc.), an adequate functional-test setup will consist of a socket, power supply, some way to check the state of the outputs (i.e., whether the pin or pins are logic 1 or logic 0), and some way to switch the inputs to either a signal source or ground. A pulse generator is by far the best signal source to use when doing functional tests on sequential-logic IC's. In such a setup, a series of pulses from a pulse generator can be used to step an IC through its various states. An oscilloscope or logic monitor can be hooked up to the IC's outputs so that those states can be monitored.

When a pulse generator is used to perform a functional test on saturating logic, the baseline of the generator should be at 0 volts, and the pulse amplitude should be set well above the minimum for logic 1. The object is to see if the IC functions in accordance with its truth table.

In most cases, a simple functional test is all that will be required, since logic IC's rarely fail to meet their other specifications (such as logic-voltage levels, fan-ins and fan-outs, etc.), and even if they do, most logic IC's have a built-in safety factor that will often allow them to continue to operate. However, that is not the case if one of the inputs of a gated fails to operate.

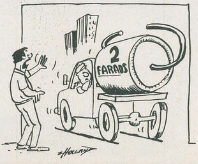
Testing the DC parameters of an IC is usually required only if functional testing indicates that the IC is following its truth-table, but the circuit is still not operating. If replacing the suspected IC with another causes the circuit to operate properly, a failure to meet either the DC- or AC-voltage parameters is likely to be the cause of the problem.

The DC-voltage parameters of a logic IC are: the maximum DC voltage accepted by an input as a logic 0; the minimum DC voltage accepted by an input as a logic 1; the maximum DC output at logic 0 into full load, and the minimum logic 1 output-voltage level under full load. Other DC parameters that are not quite as important, but can still cause circuit problems, are: maximum power-supply current; maximum output-current supplied by the IC into a short at logic 1, and the IC's ability to operate at the minimum or maximum supply voltage. All that can be tested using a generator with DC-offset.

A close examination of input and output parameters using an oscilloscope is necessary to determine the proper signal level. When testing DC parameters, it is important to set the pulse-generator repetition rate significantly lower (by at least two orders of magnitude) than the maximum operating speed of the logic circuits. Similarly, the pulse width used for testing must be significantly longer (again, by at least two orders of magnitude) than the minimum pulse width that can be handled by the IC family. A good rule-of-thumb to follow when setting the pulse-generator parameters is to use the lowest possible repetition rate that will permit flicker-free oscilloscope readings. Then, adjust the pulse width for approximately a 50% duty cycle. Information on DC-parameter measurement can usually be found in manufacturer's IC data books.

If the IC will be used in a relatively high-frequency application, especially if used at or near its maximum rated frequency, failure to operate may be due to a problem involving the AC parameters. Again, the manufacturer's data handbook contains the method and the specifications for AC parameter measurement. Depending on which logic family is used, a fairly complex pulse generator is likely to be required, along with a sophisticated dual-trace oscilloscope. Some AC parameters are: minimum and maximum input rise-times; minimum and maximum output risetimes and falltimes; propagation delays through the IC, and maximum repetition-rates. When making those tests on TTL logic, a pulse generator with good risetime specifications (on the order of 5 to 10 nanoseconds), a repetition rate of 20 to 40 MHz, and DC offset are the minimum requirements. With ECL and Schottky TTL circuits, it is impossible to measure those AC parameters using a low-cost pulse generator. With MOS and CMOS circuitry, AC parameter measurements can be made using a 10-MHz generator with DC-offset capability and risetimes as great as 10 to 20 nanoseconds. The oscilloscope must be able to measure risetimes of 10 to 40 nanoseconds.

In the next part of this series, we'll continue our look at how to use pulse generators by showing you the proper way to connect them to a circuit. **R-E**



"Hold it! I ordered two MICRO farad!"