



Getting More Out of Today's Pulse/Pattern Generators

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Modern pulse/pattern generators give users a lot of control over the signals they create. Going beyond basic settings will allow designers and test engineers to better match outputs to application needs and improve test results.

Basic configuration settings of pulse/pattern generators include amplitude, pulse width, rise and fall times, frequency, and delays for the voltage and current outputs used in testing a variety of devices. However, the channel-add and pattern-mode functions in dual-channel instruments allow users to create composite signals that go beyond simple square waves. These multifaceted signals are often required to test complex devices, such as semiconductors, memory cells, and serial data devices.

Impedance Effects On Pulse Output

The foundation for using pulse generators to create complex outputs is an understanding how pulse signals are produced. A fundamental issue is the source and device under test (DUT) impedances and their effects on pulse output. For example, understanding impedance effects allows a pulse generator

to be used in applications where the “device acknowledge” function must be tested.

The voltage output of a pulse generator (PG) is dependent not only on the output voltage setting, but also on the PG’s internal source impedance, AND the impedance of the DUT. Usually, a PG’s default source impedance is 50Ω, but this is selectable by the user (50Ω or 1kΩ). The user can also adjust the PG’s “LoadZ” setting, i.e., a best estimate of the DUT’s impedance. For the actual output voltage to be the same as the

set voltage, the LoadZ setting must be the same as the actual DUT impedance. If these two are different, the actual output voltage will not be the same as the set voltage.

As illustrated in *Figure 1*, the PG can be modeled as a current source, ISRC, in parallel with a source impedance (50Ω in the figure). If a user sets the output to 10V and LoadZ to 50Ω, then the PG calculates a load line according to Ohm’s Law. For 10V across two 50Ω resistances in parallel, $I = 400\text{mA}$. With the source current set based on the source impedance, LoadZ, and output amplitude settings, the only thing that will affect the actual voltage across the DUT will be its actual impedance. If the actual DUT impedance is different, or changes, the actual voltage output will move along the load line (blue line in *Figure 1*). For a 50Ω source impedance and 50Ω LoadZ setting, *Figure 1* shows different load lines and output voltages (red dots) for different voltage settings (5V and 10V) and different DUT impedances (10Ω, 50Ω, and 100Ω).

Device Acknowledge Applications – Besides achieving the pulse amplitude one wants across the DUT, impedance effects can be used to check the performance of a device that is designed to receive and respond to a serial data stream. For example, the serial stream might include an address byte, instruction byte, and a data byte. The DUT is designed to acknowledge receipt of each of those byte segments. This acknowledgement is achieved by the device “pulling down” the line. In actuality, the way a device pulls down a line is to change its impedance state.

To test this performance, a complex external circuit or switching routine is often

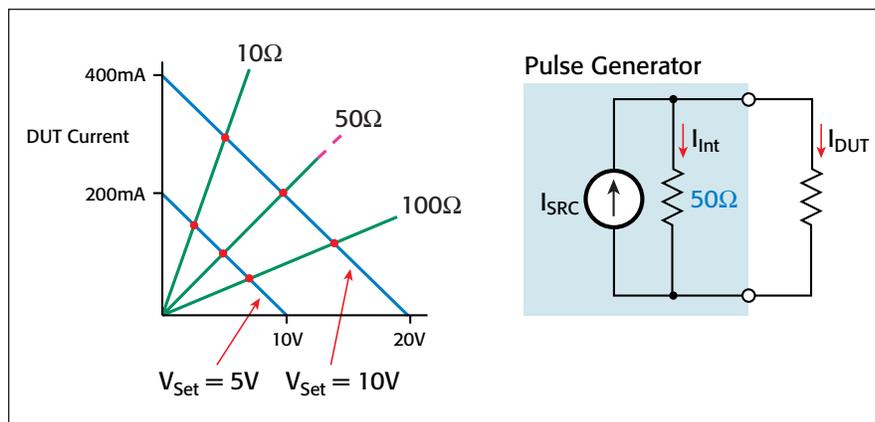


Figure 1. Effect on pulse generator voltage output with matching and mismatched DUT impedance and LoadZ settings.

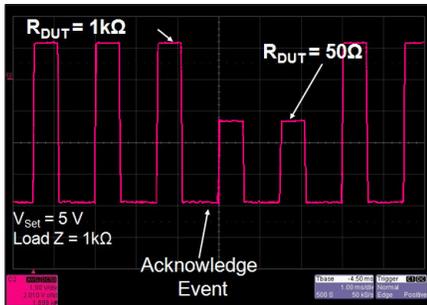


Figure 2. Example of serial data stream testing by using a change in impedance to pull down the amplitude of the pulse generator output, thereby indicating the DUT acknowledgement circuit is working properly.

used. However, a pulse generator can be used to simplify this test. The PG, configured with 50Ω output impedance, could send a set of pulses to the DUT, and the voltage across the device would be monitored with an oscilloscope. If, for instance, the DUT's normal impedance is 1kΩ, and it drops to 50Ω to acknowledge receipt of the pulse train, this will pull down the pulse voltage amplitude, as shown in *Figure 2*. The lower amplitude pulses are a clear indication that the acknowledge event has occurred.

Techniques for Generating Complex Outputs

Most dual-channel PGs have *channel-add* and *pattern-mode* features that allow the creation of complex waveforms. With the channel-add feature, the PG does a point-by-point addition of the amplitude of the pulse trains on the two channels, and the composite waveform is placed on the Channel 1 output port. Of course, the amplitudes, pulse widths, rise times, and polarities of the two channels could be different, and a delay between the start times of the two pulse streams could

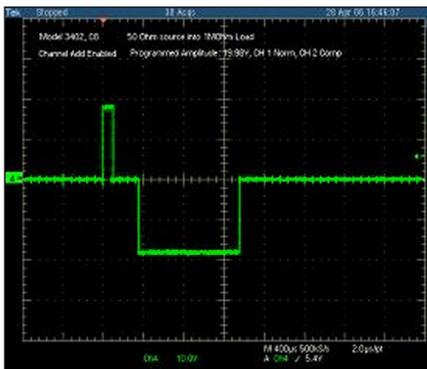


Figure 3. Write/Erase pulse train used for flash memory testing, and created with a PG's channel-add feature.

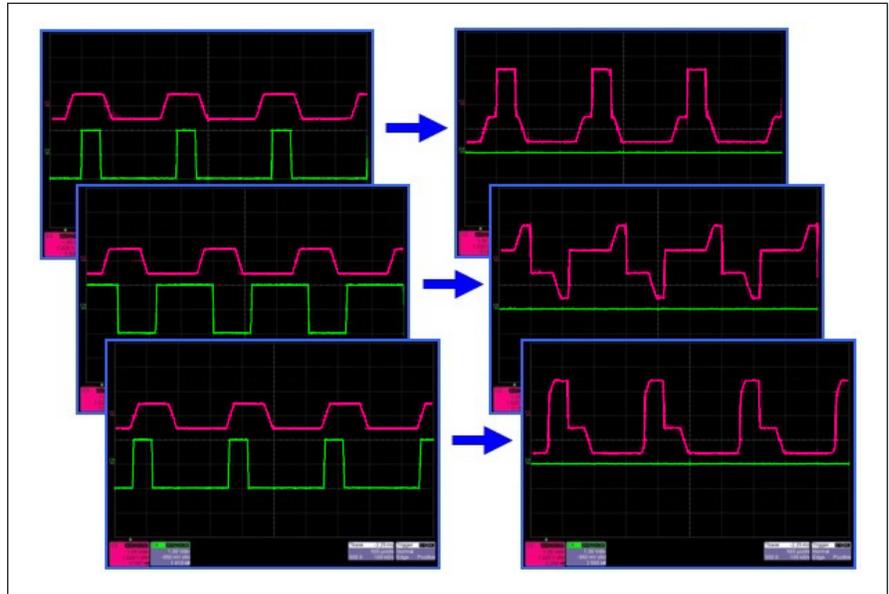


Figure 4. Three examples of using a PG's channel-add feature. The top view shows the addition of two positive pulses; the middle view is the addition of positive and negative pulses with different properties; the bottom view shows the addition of two positive pulses of different widths that are synchronized for the same start time.

be set. Using these features, complex wave shapes can be created by taking advantage of the overlapping outputs.

Testing memory cells, such as Flash memory, is an example of where these features could be used. In a typical write/erase cycle, a positive pulse is used for writing and a negative pulse for erasing. The output shown in *Figure 3* illustrates a composite pulse train created from positive and negative pulses that might be used to test flash memory devices. Arranging the shapes of channel 1 and channel 2 would allow a user to change the output wave shape to test other memory cell technologies, such as PRAM. The various views in *Figure 4* show composite waveforms created from positive and negative pulses of different amplitudes, widths, rise times, and delay times. Notice the different output waveform shape that can be achieved by simply changing the time delay between the two channels.

Pattern mode is normally used for serial data simulation, but it is also useful in creating complex outputs. When pattern-mode is used, the PG creates a series of "0" and "1" bits to generate the waveform. In NRZ (non-return to zero) mode, the pulse does not return to the low level after the pulse width is complete. In this mode the pulse will remain high until the next bit. If this bit is again high, the output will continue to be high. The

output will only return to the low level once a zero bit is encountered.

By lining up a series of "1" bits, an increasing pulse width sweep can be created. *Figure 5* shows a pulse width sweep where the output pulse width is increasing over time. In this example the number of "0" bits is decreasing, thus maintaining a consistent frequency. A different test application could be created to change the number of "0"s, and thereby create a frequency sweep.

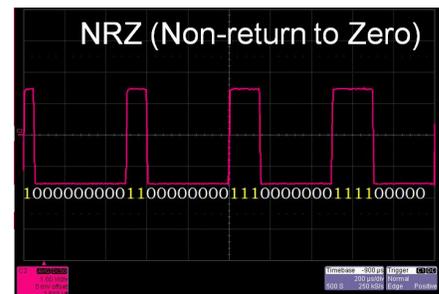


Figure 5. Pattern mode waveform created with a Keithley Model 3402 Pulse/Pattern Generator.

For even more complex output wave-shapes, both the PG's pattern-mode and channel-add functions can be used to create a wider range of output combinations. Patterns can be overlapped or delayed to achieve the desired output. An example is shown in *Figure 6* for a device that is controlled from a data communications line.

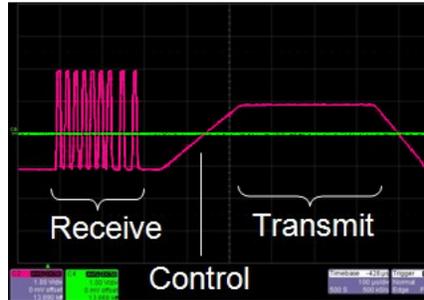
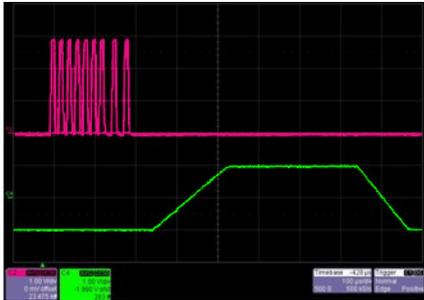


Figure 6. Signal used for testing devices that have communication and control signals embedded in a single line.

In Figure 6, the Receive signal is created on channel 1, and the Transmit signal is created on channel 2. Then the channel-add feature was used to combine the two sets of waveforms in the left view to achieve the composite output in the right view. To create the Receive signal, pattern mode was used to set up the exact serial data bit stream required for the device. For the Transmit signal, a very long risetime is required as a control signal by the device to switch to transmit mode. This is accomplished by setting the rise time on channel 2. Then the output pattern is created by putting a large number of “1” bits in

a row (more than 200 in this example). Once the two channels are configured, the channel add feature puts the entire signal on a single channel. The device can now receive data and also be put into a transmit state to test the output of the device.

Other Features to Consider

Today’s pulse/pattern generators have a wide range of capabilities for creating and using complex waveforms to test sophisticated electronic devices. In addition to the functions described earlier, there are a number of other features and specifications that

should be considered:

- Pulse frequency range
- Amplitude range and accuracy (flatness)
- Range of pulse widths and rise/fall times
- Availability of a burst mode
- Voltage overshoot, undershoot, and droop
- Data communication interfaces available
- Speed and ease of set-up
- Intuitive user interface

Such features provide the flexibility for a broad array of test functions and applications.

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About the Author

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