A Feel for the Pulse

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Understanding your test requirements will help you select the right pulse generator for the job.

Introduction

Rapidly changing and advancing technology continually challenges test equipment manufacturers to develop new systems for testing the latest generation of electronic devices and materials. Industries such as semiconductor and communication technology, with rapid development of new standards, often require cutting-edge device testing and new source and measurement capabilities.

In recent years, new testing techniques have been developed to meet these challenges. One such technique is pulse testing. The uses for instruments with pulse capabilities are many. For instance, testing advanced semiconductor devices as well as RF devices such as high-speed serial communications links.

Pulse Testing

Pulse testing involves delivering a single pulse to an output. This pulse is used to test a variety of things, such as for transient testing of a device to determine its transfer function and thereby characterize the material under test.

Pulse or pattern generators are used in a wide variety of applications in both the lab and on the production line. Researchers often need to stimulate a device under test (DUT) with a pulse, series of pulses, or known data patterns at specified rates in order to characterize device performance. Pulse or pattern generators are often configured into test systems that also include SMUs, digital multimeters, voltmeters, switches, and oscilloscopes.

Need for Pulse Testing

The need for pulse sources has been growing over time. Shrinking device geometries, new materials, and more complex designs are having a tremendous impact on device lifetimes due to increased fragility, higher power density, and new failure mechanisms. This need is driven in part by the higher operating speeds of today's electronic circuits. The higher operating speed requires test equipment that can produce simulated clock and data signals at the rate that the circuit will actually perform.

Also, analog components used in these circuits behave differently at higher speeds, so they can't be characterized at DC using traditional DC methods. Because pulse sizes can be made extremely small, on the order of a few nanoseconds, pulse testing overcomes the problems inherent in DC testing techniques. Therefore, pulsed test signals are needed to characterize these components.

In addition, as components have become smaller, the need for pulsed testing techniques becomes more critical. Smaller DUTs are more susceptible to self-heating, which can destroy or damage the part or change its response to test signals, masking the response the user is seeking. Pulse testing is commonly used when characterizing nanoelectronic devices.

Advanced IC technologies incorporate new materials and failure mechanism that traditional DC testing techniques may not be powerful enough to uncover. The limits of DC methods are apparent in charge-trapping behavior in gate dielectrics in semiconductor devices. The issue is the relatively long periods of time required for these DC techniques.

During device development, structures like single electron transistors (SETs), sensors, and other experimental devices often

Figure 1. Keithley's Series 3400 Pulse/Pattern Generators feature a frequency range from 1mHz to 165MHz with programmable rise and fall times down to two nanoseconds.

display unique properties. Characterizing these properties without damaging one-of-a-kind structures requires systems that provide tight control over sourcing to prevent device self-heating.

Voltage pulsing can produce much narrower pulse widths than current pulsing, so it's often used in experiments such as thermal transport, in which the timeframe of interest is shorter than a few hundred nanoseconds.

High amplitude accuracy and programmable rise and fall times are necessary to control the amount of energy delivered to a device.

What to Look For

The three key items to keep in mind while evaluating a pulse/pattern generator are flexibility, fidelity and ease of use.

Flexibility is key to a good pulse generator. It lets users control the critical signal parameters such as amplitude, offset, rise and fall times, pulse widths, and duty cycle of the output signal. Interdependency of these parameters can reduce the flexibility of the instrument. It is important to understand that if you adjust one parameter, that another parameter does not change. For example if you adjust the rise-time of the pulse, does the pulse amplitude change? This extensive control over key signal parameters makes the instrument flexible and useable in many different applications.

The second key item to look for is pulse fidelity. The amount of overshoot, or droop in a pulse can make the instrument not suitable for your application. These undesirable effects can be worsened by the setup and cabling that your application requires. Using an instrument that minimizes these effects will help reduce these setup challenges. Instruments that can deliver an extremely short duration pulse, on the order of a few nanoseconds wide, with tight control of critical signal parameters, are highly useful for testing sensitive devices. Also related to the fidelity of the pulse is to look carefully at the specifications of the unit. Often times parameter such as rise-time or fall-time are specified at either 10% to 90% or 20% to 80%. Using 20%-80% allows a slower pulse to appear to have a faster rise-time. Additionally using the looser specification, the actual fidelity of the pulse could be significantly lower.

Ease of use is another factor to consider, which often times gets overlooked. For example, an intuitive user interface makes instruments simple to use for both experienced test engineers as well as novice users instrumentation for the first time.

Conclusion

Facilities involved in testing semiconductor devices and nanotechnology devices and high speed components are faced with intense budget and time-to-market constraints. However, they cannot compromise on measurement quality, valuable rack or bench-top space, or ease of use. These designers have a need for test instruments such as pulse generators that satisfy their needs for current as well as future testing. KEITHLEY

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Printed in the U.S.A. No. 2781 0806