PG-2 fast rise time pulse generator

- 30 ps rise time (27 ps typical), 10-90%
- 1000 mV amplitude, 50% duty cycle
- 10 MHz repetition
- Separate trigger output
- USB powered

VOLTATIVE

DESCRIPTION

The PG-2 pulse generator creates a 50% duty cycle square wave pulse train where the positive-going edges have a 10-90% rise time of 30 ps (picoseconds) or less, with a typical rise time of 27 ps.

These fast edges are useful for a variety of purposes, including bandwidth characterization of oscilloscopes, time-domain reflectometry (TDR), and ultra-wideband (UWB) sources.

The high amplitude (1000 mVpp, typical) helps to keep the signal above the noise in even the most demanding applications. The 10 MHz repetition rate and low jitter enable rapid and reliable measurements even with sampling oscilloscopes.

SPECIFICATIONS

DC characteristics

Parameter	Notes	Minimum	Typical	Maximum
Supply voltage	Via USB	4.8 V	5 V	5.5 V
Current drain	Via USB			300 mA
Operating temperature		0 °C	25 °C	40 °C
Storage temperature		-20 °C		60 °C

Trigger

Conditions: The trigger and signal output are both connected to individual 50 Ω loads, 25 °C ambient, 5 V supply voltage, 30 minute warmup

Parameter	Notes	Minimum	Typical	Maximum
Amplitude	Into 50 Ω		1 Vpp	
Rise/fall time	10%-90% voltage		400 ps	
Output impedance			50 Ω	
Output port			SMA	
Coupling			AC	

Fast-rise-time output signal

Conditions: The trigger and signal output are both connected to individual 50 Ω loads, 25 °C ambient, 5 V supply voltage, 30 minute warmup

Parameter	Notes	Minimum	Typical	Maximum
Rise time	10%-90% voltage[a]		27 ps	30 ps
Duty cycle			50%	
Pulse frequency			10 MHz	
Pulse frequency tolerance		-1 ppm	+/- 500 ppb	+1 ppm
Jitter (relative)	Relative to trigger output zero-crossing point		0.6 ps RMS[b]	2.5 ps RMS
Jitter (absolute)	Referencing the signal output alone, without regard to the trigger		<3.9 ps RMS[b]	
High level	After settling	-100 mV	0 mV	+100 mV
Low level	After settling	-1100 mV	-1000 mV	-900 mV
Amplitude	Peak-to-peak	900 mV	1000 mV	1100 mV
Overshoot			10%	25%
Settling time	To within ≤1% of long-term average amplitude (25-35 ns post-edge)		5 ns	
Output impedance			50 Ω	
Coupling			DC	
Output port	Tight-tolerance (26.5 GHz bandwidth) type		SMA female	
Edge shape			Gaussian	

[a] Referenced to the short-term average top and bottom of the pulse (2 ns before and after the rising edge)

[b] Calculated

PORTS

There are three ports on the pulser: USB-C Power In, Trigger Out, and Signal Out.

USB-C Power In

The USB-C Power In port (labeled "USB-C") is located on the same end of the pulse generator as the Trigger Out port. Connect a USB-C cable (not included) to this port and to any USB power source, such as a stand-alone wall adapter, a port on another lab instrument, or a computer. The use of a USB-C to USB-A cable is acceptable.

Trigger Out

The Trigger Out port signal is a square wave synchronized to the Signal Out port output and has a similar amplitude, but its rising and falling edges are slower than those of the Signal Out signal. Unlike the Signal Out port, it is AC coupled. The Trigger Out port is primarily intended for use with sampling oscilloscopes, which require a separate trigger signal (unlike "real time" oscilloscopes, which can trigger on and observe the same signal).

The delay between the rising edge of the Trigger Out signal and the rising edges of the Signal Out signal is very stable, but those rising edges are not concurrent. Stated differently, the phase of the Trigger Out signal relative to the Signal Out signal is fixed but non-zero.

Signal Out

The Signal Out port emits a fast-rise-time square wave. It is back-terminated to 50 Ω to limit reflections, but for best results the load should also be at 50 Ω.

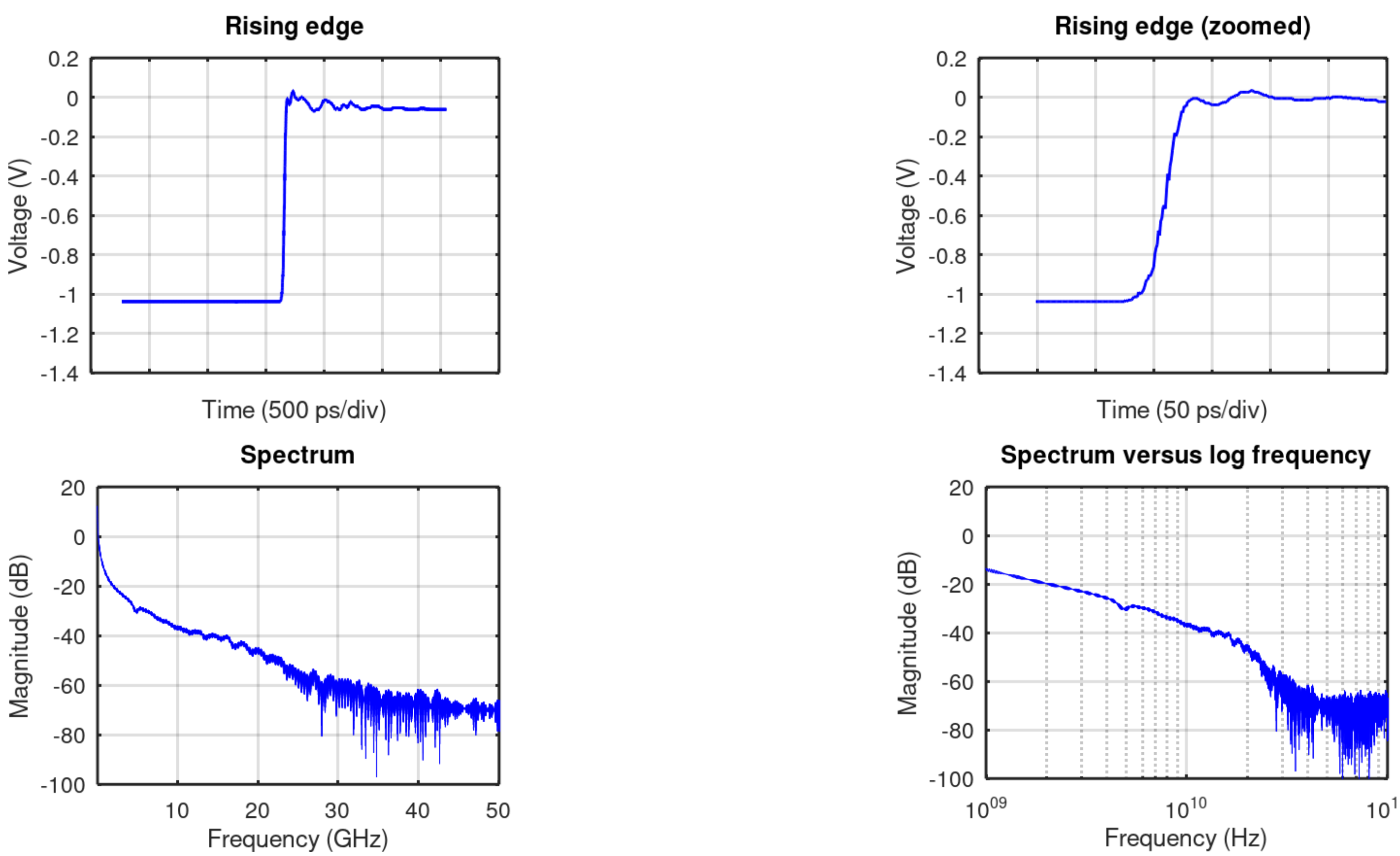
The length and type of coax and number of adapters between the Signal Out port and the measurement instrument may negatively affect the signal rise time. If possible, directly connect the Signal Out port to the input port of the instrument without any coax between them.

Signal Out is DC coupled and has a DC offset of approximately -500 mV (into 50 Ω). Ensure that the instrument connected to this port can handle a non-zero DC offset safely.

ESD CAUTIONS

Static-sensitive device. Observe standard electronics-lab precautions for handling. Keep trigger and signal outputs capped when not in use.

TYPICAL RESPONSES



All response chart data collected using pre-production PG-2 pulse generator connected directly to a Tektronix SD-32 50 GHz sampling head attached to a Tektronix 11801C sampling oscilloscope. Spectrum plots are for a single isolated rising edge.

PHOTOS

APPLICATION EXAMPLES

Measuring oscilloscope bandwidth

The ultra-fast rising edge of the pulse generator can be used to accurately estimate the bandwidth of an instrument like an oscilloscope.

For this approach to work, the response of the oscilloscope must be Gaussian.

If the response of the oscilloscope is instead better approximated by an RC curve, as is sometimes the case when the bandwidth-limiting function of an oscilloscope is enabled, the bandwidth can still be estimated, but slightly different measurement points and coefficients are needed.

When the actual rise time of the signal source is well-characterized, it is possible to use this technique to accurately estimate the rise time and thus the bandwidth of an instrument even when the rise time of the instrument is of roughly the same magnitude as that of the signal source. Stated differently, this pulse generator can be used to accurately measure the oscilloscope bandwidths exceeding 10 GHz.

To convert from rise time to the equivalent 3 dB bandwidth, use the formula:

$$BW[GHz] = \frac{0.35}{\text{rise\_time[ns]}}$$

…where *rise_time* is in nanoseconds, and the resulting bandwidth is in GHz.

For example, if the rise time of a Gaussian edge is 27 ps, as is the case for the typical PG-2 pulse generator, the equivalent 3 dB bandwidth is:

$$\frac{0.35}{0.027\ [\text{ns}]} = \ 13\ \text{GHz}$$

To find the effective rise time for a gaussian signal source going into a gaussian-response instrument, use the formula:

$$rise\_time_{measured} = \sqrt{rise\_time_{source}{}^{2} + rise\_time_{instrument}{}^{2}}$$

When the rise time of the instrument being tested is more than about an order of magnitude slower than that of the pulse generator (i.e., when the instrument rise time is slower than about 300 ps for this pulse generator), the rise time of the pulse generator can be treated as if it were zero (i.e., infinitely fast).

Conversely, when the rise time of the instrument being tested is closer than about a factor of 10 to the rise time of the pulse generator (i.e., when the instrument rise time is faster than about 300 ps, equivalent to the instrument having a 3 dB bandwidth of more than about 1 GHz), the rise time of the pulse generator should be factored out so as to avoid unacceptable error in the estimate of the instrument rise time.

Let's work an example of the second case, where the instrument rise time is faster than about 300 ps. Assume that we've measured the rising edge of a PG-2 pulser that has a known calibrated rise time of 27 ps, and that edge as measured on the instrument being tested appears to be 85 ps. First, let's solve for the instrument rise time given the measured rise time and known source rise time using the equation above:

$$rise\_time_{\mathrm{instrument}} = \sqrt{rise\_time_{\mathrm{measured}}{}^{2} - rise\_time_{\mathrm{source}}{}^{2}}$$

Plugging in the values:

$$\sqrt{85^2 - 27^2} = 80.6$$

Thus, in this example, the actual rise time of the instrument is 80.6 ps, so the bandwidth of the instrument is about 4.3 GHz.