

Pulse/Pattern Generators

Selector Guide

Series 3400

4200-PG2

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Selector Guide

Pulse/Pattern Generators

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Description	Broad-purpose voltage pulse and pattern generation	Dual-channel pulse generator, for use with 4200-SCS	Complete pulse I-V solution, for use with 4200-SCS	Laser diode test system	AC/DC arbitrary waveform current source	Complete Delta Mode system with DC current source and nanovolt measurement capabilities	Combined DC/pulse SourceMeter® instruments	Combined DC/pulse System SourceMeter instruments	Ideal for measuring breakdown voltage of high power devices
Voltage Pulse	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes
Current Pulse	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Pulse Width	3 ns–1000 s	10 ns–1 s	40 ns–150 ns	500 ns–5 ms	5 μ s–DC	50 μ s–12 ms	300 μ s–DC	200 μ s–DC	150 μ s–5 ms
Rise time (min.)	2.5 ns	10 ns	10 ns	100 ns	5 μ s	50 μ s			150 μ s
Voltage Source (max.)	10 V ¹	20 V ¹	5 V ¹	10 V	105 V	105 V	40 V	200 V	100 V
Current Source (max.)	400 mA	800 mA ¹	100 mA	5 A	100 mA	100 mA	3 A	10 A	10 A
Pattern Mode	Yes	No	No	No	No	No	No	No	No
Integrated Measurements	No	No	Yes	Yes	No	Yes	Yes	Yes	Yes

¹Specification applies to a 50 Ω source into a 50 Ω load.

Series 3400

Pulse/Pattern Generators



- **Broad-purpose voltage pulse and pattern generation**
- **Programmable pulse parameters: amplitude, rise time, fall time, pulse width, and duty cycle**
- **Pulse and burst modes for material and device characterization**
- **Serial data pattern simulation for functional characterization tasks**
- **Choice of single- or dual-channel signal outputs**
- **1mHz–165MHz frequency output range**
- **Independently adjustable rise and fall times**
- **3ns–1000s pulse width range**
- **Four operating modes: pulse, burst, pattern, external width**
- **GPIB and USB interfaces**
- **2U full-rack design**

Series 3400 Pulse/Pattern Generators are the latest additions to Keithley's growing line of instrumentation with pulse generation functions. They offer users extensive control over a wide variety of pulse parameters, including pulse amplitude, rise time, fall time, width, and duty cycle via the instrument's flexible user interface or over the GPIB and USB interfaces. This operational flexibility makes Series 3400 instruments readily adaptable to the needs of a wide range of users, including nanotechnology researchers, research and education organizations, and semiconductor and RF device design and development departments. Built-in pattern generation capabilities simplify simulating serial data patterns when testing devices to characterize their performance while operating under sub-optimal conditions.

Series 3400 instruments offer users important performance advantages over some of the best-selling pulse/pattern generators on the market, including:

- Clean transient response
- Simpler user interface
- Easier integration into existing test and measurement systems

The user interface for Series 3400 generators is designed to simplify configuring complex pulses and patterns. By using intuitive parameter menu keys and context-sensitive soft menu keys, users can navigate quickly to their desired parameter controls with just a few key presses, unlike competitive generators, which often have many levels of confusing sub-menus and shift-key operations. An industry-standard SCPI command set makes Series 3400 instruments code-compatible with the command set of other popular generators. This compatibility simplifies migrating existing applications from older hardware to the Series 3400 by minimizing the need to rewrite existing program code, which reduces the start-up time and costs associated with replacing older instrumentation.

Single- and Dual-Channel Options

The Model 3401 is a single-channel pulse/pattern generator. The Model 3402's specifications are identical to the Model 3401's, with the addition of a second signal output channel, which is useful for applications that require sourcing multiple streams of pulses or patterns simultaneously. Both instruments can source pulses at frequencies ranging from 1mHz to 165MHz with pulse amplitudes of up to $\pm 10V$ (with 50Ω source impedance) or $\pm 20V$ (with $1k\Omega$ source impedance). Pulse widths ranging from 3ns to 1000s in length can be programmed, with rise times as short as 2ns.

Generate pulses and signal patterns for device characterization

PULSE/PATTERN GENERATORS

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Series 3400

Ordering Information

- 3401-F** Single-Channel Pulse/Pattern Generator
- 3401-R** Single-Channel Pulse/Pattern Generator with Rear Panel Option
- 3402-F** Dual-Channel Pulse/Pattern Generator
- 3402-R** Dual-Channel Pulse/Pattern Generator with Rear Panel Option

Accessories Supplied

CD-ROM Manual Package,
Line Cord, Rack Mount/Handle Kit

Multi-year extended warranty
and calibration contract
available for this product.

ACCESSORIES AVAILABLE

CABLES/ADAPTERS

7051-2	General Purpose BNC to BNC Cable (2 ft)
7007-1	Shielded GPIB Cable, 1m (3.3 ft)
7007-2	Shielded GPIB Cable, 2m (6.6 ft)
7051-2	General Purpose BNC to BNC Cable, 0.6m (2 ft)
7051-5	General Purpose BNC to BNC Cable, 1.5 (5 ft)
7755	50Ω Feed-Through Terminator

COMMUNICATION INTERFACES

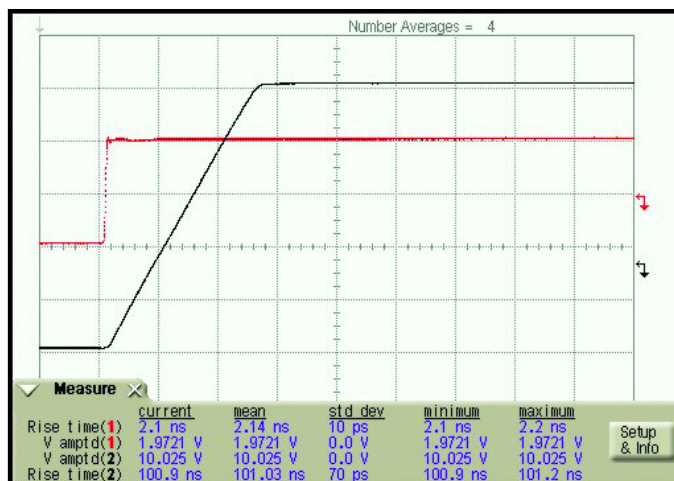
KPCI-488LP	IEEE-488 Interface/Controller for the PCI Bus
KPXI-488	IEEE-488 Interface Board for the PXI Bus
KUSB-488A	IEEE-488 USB-to-GPIB Interface Adapter

APPLICATION AREAS

- High speed serial communication characterization
- Nanotechnology
- Materials characterization
- Semiconductor
 - Charge pumping
 - AC stress testing
- Memory testing

Pulse/Pattern Generators

Figure 1: Superior pulse fidelity with precision edge control.



Application Flexibility

A number of built-in operating modes give Series 3400 pulse/pattern generators the power and flexibility today's test applications demand. These modes simplify programming and integrating Series 3400 instruments with other test hardware, such as oscilloscopes, Keithley's Series 2600 and 2400 SourceMeter® instruments, low level instruments, and the Model 4200-SCS.

- *Semiconductor Device Characterization*—Users can configure all the key parameters, including pulse width, rise time, and delay in pulse and burst mode to create the exact output desired.
- *Memory Device Stress Testing*—Channel addition can be used to add the Channel 1 and Channel 2 outputs internally to create a complete Write/Erase cycle on a single output.
- *Nanotechnology Research*—Researchers get the flexibility they need to handle varying application types.
- *Functional Tests*—By using the burst and pattern modes, clock and data signals can be simulated to test the real-world performance of many types of devices.

Instrument Features

- **Large, backlit LCD display:** Makes it easy to configure the generator's operation or confirm parameter settings with a glance.
- **Enter or adjust parameter values quickly:** Use the cursor keys and either the numeric keypad or control knob.
- **Single-function keys:** Provide instant access to the main parameter menus.
- **BNC output:** One channel (Model 3401) or two channels (Model 3402).
- **Enable the pulse output with a single key press.**
- **High speed Trigger and Strobe outputs:** Coordinate the operation of external instruments, such as oscilloscopes or other pulse generators, with the Model 3401/3402.
- **High speed Clock and External Instrument inputs:** Support tight integration with other pulse generators to produce multiple pulse trains.
- **Context-sensitive soft menu keys:** Provide fast access to the commands in the sub-menus for configuring the desired pulse or pattern parameters, without the need for confusing shift-keying and cursor control.

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- **Rear output option:** Moves the BNC, Trigger, and Strobe outputs and Clock and External inputs from the instrument's front panel to the rear for greater convenience in rack-mounted environments.
- **Reference Oscillator input and output:** Simplify coordinating multiple Series 3400 pulse/pattern generators with an external 10MHz signal for PLL reference.
- **Ports for GPIB and USB interfaces:** Allow controlling the instrument via an external computer, rather than the front panel controls.
- **Trigger Modes**
 - Continuous: Trigger circuitry is always armed.
 - Triggered: Trigger arming is edge sensitive, requires a selected edge prior to allowing trigger event.
 - Gated: Trigger arming circuitry is level sensitive, always armed when selected level is present.
- **Pulse Period Source and Burst/Pattern Period Source**
 - PLL oscillator
 - VCO (triggerable oscillator)
 - CLK IN
- **Amplitude Settings:** High/Low level or Amplitude/Offset are adjustable. Source impedance selectable, 50Ω or 1kΩ. Amplitudes double for 1kΩ. Channels have independent settings. Amplitudes may be set in either voltage or current units.
- **Timing:** Delay and duration are fully adjustable. Can also be programmed as duty cycle. Period is adjustable and can also be set as frequency. In NRZ pattern mode, crossing point is available instead of duration/duty cycle. Delay and duration are independently adjustable for each channel. Period is a common parameter.
- **Transition Time:** Leading and trailing edges can be independently adjusted for each channel.
- **Pattern:** PRBS (2^n-1 with $n = 5-14$), user programmable, or preset patterns can be specified. NRZ or RZ formats. User and preset patterns are two bits to 16 kbits in length.

Specifications

BASIC MODES OF OPERATION

The 340x generator may be set in one of four available modes: Pulse, Pattern, Burst, and External Width.

Pulse Mode delivers a single pulse per trigger event to the outputs. The pulse is programmable in delay and duration.

Burst Mode results in a "burst" of n pulses per trigger event, with pulses configured similarly to single pulses in Pulse mode.

Pattern Mode delivers a programmable pattern per trigger event to the outputs. The pattern is programmable or may be selected from a library of pre-configured patterns. The pattern may be presented in either NRZ or RZ formats. In NRZ mode, the pattern crossing point is programmable. In RZ mode, the duration (duty cycle) of the pattern pulse is programmable.

External Width Mode makes the pulse level follow the edges of the Ext In input. A rising edge causes the output to go high, while a falling edge causes the output to go low.

PULSE/LEVEL PARAMETERS

PULSE AMPLITUDE¹: 100mV to +10V 50Ω into 50Ω.
200mV to +20V 1kΩ into 50Ω.

LEVEL WINDOW²: -10V to +10V 50Ω into 50Ω.
-20V to +20V 1kΩ into 50Ω.

AMPLITUDE ACCURACY³: $\pm(0.5\% \text{ amplitude} + 30\text{mV})$.

OFFSET ACCURACY⁴: $\pm 100\text{mV}$.

OUTPUT RESOLUTION: 10mV 50Ω into 50Ω.
20mV 1kΩ into 50Ω.

OVERSHOOT/PRE-SHOOT/RINGING⁵: $\pm 5\% \pm 20\text{mV}$

SOURCE IMPEDANCE⁶: 50Ω or 1kΩ, selectable.

SHORT CIRCUIT CURRENT⁷: $\pm 400\text{mA}$.

1. Amplitude may be set in either voltage or current units.
2. Level may be set in either voltage or current units.
3. 50Ω into 50Ω.
4. 50Ω into 50Ω.
5. $\pm 1\%$ at 10V p-p typical. $\pm 2\%$ at 5V p-p typical.
6. $\pm 1\%$ typical.
7. $\pm 800\text{mA}$ in Channel Add Mode.

TIMING AND TRIGGER PARAMETERS

FREQUENCY RANGE¹: 1mHz to 165MHz.

PERIOD: 6.06ns to 1000s.

Period Accuracy: PLL: $\pm 0.01\%$. VCO: $\pm 0.5\%$ typical with self-cal, $\pm 3\%$ without self-calibration.

Period Resolution: PLL: 4 digits, 1ps best case.

VCO: 3.5 digits, 10ps best case.

Period Jitter, RMS: VCO: 0.015% + 20ps. PLL: 0.001% + 15ps.

PULSE WIDTH²: 3.02ns to (period - 3.02ns).

WIDTH ACCURACY: $\pm 0.5\% \pm 250\text{ps}$ typical with self-cal.
 $\pm 3\% \pm 250\text{ps}$ without self-cal.

DELAY³: 0 to (period - 3.02 ns).

DELAY ACCURACY: $\pm 0.5\% \pm 0.5\text{ns}$ typical with self-cal.
 $\pm 3\% \pm 0.5\text{ns}$ without self-cal.

DELAY AND WIDTH RESOLUTION: 3.5 digits, 20ps best case.

DELAY AND WIDTH JITTER, RMS: 0.01% + 15ps.

FIXED DELAY⁴: 22ns.

1. Range reduced for 1kΩ source impedance.
2. At 50% level. Specified at fastest rise/fall and for amplitudes $< 5\text{V p-p}$.
3. Delay is measured from Trigger Out to Pulse Out, and is the sum of the user defined Delay plus the Fixed Delay.
4. Nominal.

RISE/FALL PARAMETERS

RISE/FALL TIME: $< 2.5\text{ns}$ to 200ms, adjustable.

MINIMUM RISE/FALL TIME¹: 2.5ns maximum at 10V p-p.

2.3ns typical at 5V p-p. 2.1ns typical at 2V p-p.

RISE/FALL TIME ACCURACY: $\pm 10\% \pm 200\text{ps}$.

RISE/FALL RANGES: 2ns–20ns, 10ns–200ns, 100ns–2μs,
1μs–20μs, 10μs–200μs, 100μs–2ms, 1ms–20ms,
10ms–200ms.

1. 10% to 90%, 50Ω source and load, at 25°C. Higher for 1kΩ source impedance, rising and falling edges independent within selected ranges.

BURST MODE PARAMETERS

NUMBER OF PULSES: 2–65,536.

PATTERN MODE PARAMETERS

PATTERN:

Data Pattern Length: 2–16,384 bits. Pattern for each channel is independent, must be same length.

PRBS: 2^n-1 with $n = 5-14$.

DATA FORMATS: NRZ, RZ.

CLK IN AND EXT IN PARAMETERS

INPUT IMPEDANCE: 50Ω or 10kΩ.

THRESHOLD: -3V to +3V

MAXIMUM INPUT VOLTAGE: $\pm 6\text{V}$

COUPLING: DC.

TRIG OUT AND STROBE OUT PARAMETERS

OUTPUT IMPEDANCE: 50Ω.

LEVELS: TTL (0V/2.4V).

MAXIMUM EXTERNAL VOLTAGE: -2V to 5V

COUPLING: DC.

REF OSC IN AND REF OSC OUT PARAMETERS

IMPEDANCE: 50Ω, AC coupled.

REF OSC IN SIGNAL: 10MHz, 0dBm typical, 20dBm max.

OUTPUT AMPLITUDE: 10MHz, 1V p-p typical.

Series 3400

Pulse/Pattern Generators

GENERAL SPECIFICATIONS

INTERFACES: The 340x generator can be controlled via the front panel GUI interface, a GPIB interface, or a USB interface. IEEE 488.2, SCPI compliant.

POWER: 100V to 240V, single phase, 50/60Hz; universal voltage input; 165VA max.

EMC: Conforms to European Union Directive 89/336/EEC, EN 61010-1.

SAFETY: Conforms to European Directive 73/23/EEC, EN 61010-1.

OPERATING TEMPERATURE: 0°C to 50°C

OPERATING HUMIDITY: 80% R.H. up to 35°C. De-rate 3% R.H./°C, 35° to 50°C.

STORAGE TEMPERATURE: -25°C to 65°C.

ALTITUDE: Maximum 2000 meters above sea level.

ENVIRONMENTAL: For indoor use only.

DIMENSIONS, WEIGHT: 439mm wide × 87mm high × 393mm deep (17.3 in. × 3.4 in. × 15.5 in.). Net weight 6.80kg (15.0 lbs.).

Additional Information

INPUTS/OUTPUTS

OUTPUT1: Channel 1 signal output, front or rear (optional) panel.

OUTPUT2: Channel 2 signal output (optional), front or rear (optional) panel.

TRIG OUT: Generates trigger pulse on each period, front panel.

STROBE OUT: Programmable NRZ in pattern mode, marks burst width in burst mode, front panel.

CLK IN: Accepts external CLK, front panel.

EXT IN: Accepts external signal for arming, front panel.

REF OSC IN: Accepts external 10MHz signal for PLL reference, back panel.

REF OSC OUT: Generates 10MHz signal phase locked to PLL, back panel.

TRIGGER MODES

CONTINUOUS: Trigger circuitry is always armed.

TRIGGERED: Trigger arming is edge sensitive, needs selected edge prior to allowing trigger event.

GATED: Trigger arming circuitry is level sensitive, always armed when selected level is present.

PULSE PERIOD SOURCE

A period of pulses in continuous mode, or period of pulses within a burst or pattern in burst or pattern modes.

- PLL oscillator.
- VCO (triggerable oscillator).
- CLK IN.

ARMING SOURCE

Sets period of entire burst/pattern in burst/pattern mode.

- EXT IN.
- PLL oscillator (in started mode, if not used as pulse period source).
- MANUAL (in started mode).



Model 3402-R, Dual-Channel with Rear Outputs

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4200-PG2

Dual-Channel Pulse Generator



- Frequency range of 1Hz–50MHz
- Pulse width programmable from 10ns to near DC
- Dual independent channels
- Pulse amplitude range: 100mV–20V into 50 Ω , 100mV–40V into 1M Ω
- Programmable parameters: Pulse width, duty cycle, rise time, fall time, amplitude, offset, delay, and pulse count

The Model 4200-PG2 dual-channel pulse generator is an option for the Model 4200-SCS semiconductor characterization system. This pulse generator produces voltage pulses as short as 10ns in high speed mode or up to $\pm 20V$ (into 50 Ω) in high voltage mode. Two pulse generators on one card provides you with the flexibility to apply pulses to two points on a DUT, such as the gate and the drain, simultaneously.

Using a supplied User Test Module, it is simple to incorporate pulse generation into KITE test sequences. The pulse generator can also be used as a stand-alone pulse generator using the pulse generator's Windows[®] GUI. This GUI can control a wide range of variables, including pulse frequency, duty cycle, rise/fall time, amplitude, offset, delay, and the ability to trigger single pulses and/or pulse chains.

The dual-channel pulse generator has a wide range of uses. Typical applications include:

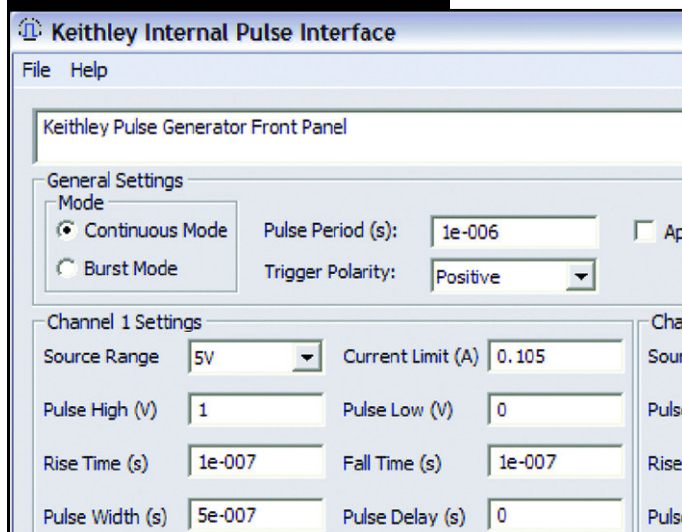
- Charge pumping to characterize interface state densities in MOSFET devices
- Using AC stress pulses of varying frequencies to simulate real-world AC signals applied to clocked devices
- Basic clock generation for test vectoring and failure analysis
- Digital triggering

The pulse generator can be purchased as an upgrade to existing 4200-SCS systems (KTEI version 6.0 or above required) or as an option for new 4200-SCS systems.

Pulse I-V Solution Package

Keithley also offers the Model 4200-PIV package, which is a complete pulse I-V package for the Model 4200-SCS. This tightly integrated unit is a turnkey solution that provides the functionality of a dual-channel pulse generator, dual-channel digital oscilloscope, specialized interconnect, and patent pending pulse I-V software. All required connectors and cables are included.

The specialized interconnect supports pulse I-V testing with either DC or RF cables, connectors, probes, etc. The interconnect also combines pulse and DC sources to a single DUT pin to allow both DC and pulse characterization without recabling or switching.



For more information about the Model 4200-PG2, 4200-PIV, and the Model 4200-SCS, see page 268.

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4200-PG2

Dual-Channel Pulse Generator

4200-PG2 Specifications¹

CHANNELS: Two.

PULSE/LEVEL²

	HIGH SPEED	HIGH VOLTAGE
AMPLITUDE 50Ω into 50Ω	100 mV p-p to 10 V p-p	10 V p-p to 40 V p-p
50Ω into 1MΩ	200 mV p-p to 20 V p-p	20 V p-p to 80 V p-p
DC LEVEL	–5.0 V to +5.0 V	–20.0 V to +20.0 V
Accuracy	±(3% + 50 mV)	±(3% + 100 mV)
AMPLITUDE/LEVEL RESOLUTION		
50Ω into 50Ω	1 mV	10 mV
50Ω into 1MΩ	2 mV	20 mV
OUTPUT CONNECTORS	SMA	SMA
SOURCE IMPEDANCE	50Ω nominal	
Accuracy	±0.5%	
SHORT CIRCUIT CURRENT	±200 mA	±800 mA peak
BASELINE NOISE	±(0.1 % + 5 mV) RMS typical	±(0.1 % + 5 mV) RMS typical
OVERSHOOT/PRE-SHOOT/RINGING	±5% of amplitude ±20 mV ³	±5% of amplitude ±80 mV
OUTPUT LIMIT	Programmable high and low voltage output levels	

TIMING

	HIGH SPEED	HIGH VOLTAGE
FREQUENCY RANGE	1 Hz to 50 MHz	1 Hz to 2 MHz
TIMING RESOLUTION	10 ns	10 ns
RMS JITTER (period, width)	0.01% + 200 ps typical	0.01% + 200 ps typical
PERIOD RANGE	20 ns to 1 s	500 ns to 1 s
Accuracy	±1% + 200 ps	±1%
PULSE WIDTH RANGE	10 ns to (period – 10 ns)	250 ns to (period – 10 ns)
Accuracy	±3% + 200 ps	±(3% + 5 ns)
TRANSITION TIME (rise/fall time)	10 ns – 1 s variable	150 ns – 1 s variable
Resolution	10 ns	10 ns
TRANSITION SLEW RATE	10 nV/ns to 0.5 V/ns	40 nV/ns to 0.2V/ns
Accuracy	±1% for transition time ≥1 V/100 ns	±1% for transition time ≥0.4 V/100 ns
Linearity	3% for transition time ≥100 ns	3% for transition time ≥100 ns
OUTPUT TIMING FIDELITY	Pulse period and width are variable in 10ns steps without any output glitches or dropouts (outside the 10ns to 100ns window)	

NOTES

- 1 Unless specified otherwise, all specifications assume a 50Ω termination.
- 2 Level specs are valid after 50ns typical settling time (after slewing) for the high speed mode and after 500ns typical settling time (after slewing) for the high voltage mode.
- 3 For transition time >60ns.



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