

Series 3400

Signal Generators

Generate pulses and signal patterns for device characterization

FUNCT/PULSE/ARB/PAT 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 Signal 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 signal 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 signal 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.

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Ordering Information

- 3401-F** Single-Channel Signal Generator
- 3401-R** Single-Channel Signal Generator with Rear Panel Option
- 3402-F** Dual-Channel Signal Generator
- 3402-R** Dual-Channel Signal Generator with Rear Panel Option

Accessories Supplied

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

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-488LPA	IEEE-488 Interface/Controller for the PCI Bus
KUSB-488B	IEEE-488 USB-to-GPIB Interface Adapter

SERVICES AVAILABLE

3401-3Y-EW	1-year factory warranty extended to 3 years from date of shipment
3402-3Y-EW	1-year factory warranty extended to 3 years from date of shipment
C/3401-3Y-DATA	3 (Z540-1 compliant) calibrations within 3 years of purchase*
C/3402-3Y-DATA	3 (Z540-1 compliant) calibrations within 3 years of purchase*

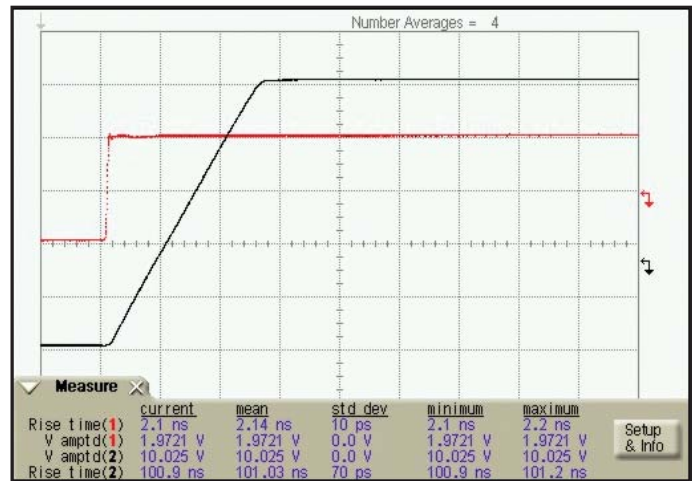
*Not available in all countries

APPLICATION AREAS

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

Signal Generators

Figure 1: Superior pulse fidelity with precision edge control.



Application Flexibility

A number of built-in operating modes give Series 3400 Signal 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 2600A 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 Signal 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 (2ⁿ-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 Signal 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, 50 into 50.
200mV to +20V, 1k into 50.

LEVEL WINDOW²: –10V to +10V, 50 into 50.
–20V to +20V, 1k into 50.

AMPLITUDE ACCURACY³: ±(0.5% amplitude + 30mV).

OFFSET ACCURACY⁴: ±100mV

OUTPUT RESOLUTION: 10mV, 50 into 50
20mV, 1k into 50

OVERSHOOT/PRE-SHOOT/RINGING⁵: ±5% ±20mV.

SOURCE IMPEDANCE⁶: 50 or 1k, selectable.

SHORT CIRCUIT CURRENT⁷: ±400mA.

NOTES

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

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: 2ⁿ-1 with n = 5–14.

DATA FORMATS: NRZ, RZ.

TIMING AND TRIGGER PARAMETERS

FREQUENCY RANGE¹: 1mHz to 165MHz.

PERIOD: 6.06ns to 1000s.

Period Accuracy: PLL: ±0.01%. VCO: ±0.5% typical with self-cal, ±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: ±0.5% ± 250ps typical with self-cal.
±3% ± 250ps without self-cal.

DELAY³: 0 to (period – 3.02 ns).

DELAY ACCURACY: ±0.5% ± 0.5ns typical with self-cal.
±3% ± 0.5ns without self-cal.

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

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

FIXED DELAY⁴: 22ns.

NOTES

1. Range reduced for 1k source impedance.
2. At 50% level. Specified at fastest rise/fall and for amplitudes <5V 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: <2.5ns 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: ±10% ±200ps.

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

NOTES

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

CLK IN AND EXT IN PARAMETERS

INPUT IMPEDANCE: 50 or 10k.

THRESHOLD: –3V to +3V.

MAXIMUM INPUT VOLTAGE: ±6V.

COUPLING: DC.

TRIG OUT AND STROBE OUT PARAMETERS

OUTPUT IMPEDANCE: 50.

LEVELS: TTL (0V/2.4V).

MAXIMUM EXTERNAL VOLTAGE: –2V to 5V.

COUPLING: DC.

REF OSC IN AND REF OSC OUT PARAMETERS

IMPEDANCE: 50, AC coupled.

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

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

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GENERAL

INTERFACES: The 340x Signal 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° 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.

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).

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.



Figure 2. Model 3402-R, Dual-Channel with Rear Outputs

Generate pulses and signal patterns for device characterization

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Model 3401/3402

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Pulse Pattern Generator Specifications

1. 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.

2. Interfaces

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

3. General Mechanical Characteristics

Size: 439 mm (17.3 in) wide x 87 mm (3.4 in) high x 393mm (15.5 in) deep

Weight: 6.80 kg (15.0 lbs)

4. Specifications

Pulse / Level Parameters	Specification
Pulse Amplitude ¹	100mV to +10V 50Ω into 50Ω 200mV to +20V 1kΩ into 50Ω
Level Window ²	-10V to +10V 50Ω into 50Ω -20V to +20V 1kΩ into 50Ω
Amplitude Accuracy ³	±(0.5% Amplitude + 30 mV)
Offset Accuracy ⁴	± 100 mV
Output Resolution	10mV, 50Ω into 50Ω 20mV, 1kΩ into 50Ω
Overshoot / pre-shoot / ringing ⁵	±5% ± 20 mV
Source Impedance ⁶	50Ω or 1 kΩ, selectable
Short Circuit Current ⁷	±400mA

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 ±1% at 10V p-p typical / ±2% at 5V p-p typical

⁶ ±1% typical

⁷ ±800 mA in Channel Add Mode



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Model 3401/3402

Pulse Pattern Generator Specifications

Timing and Trigger Parameters	Specification
Frequency Range ⁸	1mHz to 165MHz
Period	6.06 ns to 1000 s
Period Accuracy	PLL: ±0.01% VCO: ±0.5% typical with self-cal ±3% without self-calibration
Period Resolution	PLL: 4 digits, 1 ps best case VCO: 3.5 digits, 10 ps best case
Period Jitter, RMS	VCO: 0.015% + 20ps PLL: 0.001% + 15ps
Pulse Width ⁹	3.02 ns to (period – 3.02 ns)
Width Accuracy	±0.5% ± 250ps typical with self-cal ±3% ± 250ps without self-cal
Delay ¹⁰	0 to (period – 3.02 ns)
Delay Accuracy	±0.5% ± 0.5ns typical with self-cal ±3% ± 0.5ns without self-cal
Delay & Width Resolution	3.5 digits, 20 ps best case
Delay & Width Jitter, RMS	0.01% + 15ps
Fixed Delay ¹¹	22 ns

Rise/Fall Parameters	Specification
Rise / Fall Time	<2.5ns to 200ms, adjustable
Minimum Rise / Fall Time ¹²	2.5ns maximum at 10V p-p 2.3ns typical at 5V p-p 2.1ns typical at 2 V p-p
Rise / Fall Time Accuracy	±10% ± 200ps
Rise / Fall Ranges	2ns - 20ns, 10ns - 200ns, 100ns – 2us, 1us – 20us, 10us – 200us, 100us – 2ms, 1ms – 20ms, 10ms – 200ms

Burst Mode Parameters	Specification
Number of pulses	2 – 65,536

⁸ Range reduced for 1 kΩ source impedance.

⁹ At 50% level. Specified at fastest rise/fall, and for amplitudes < 5 Vpp.

¹⁰ Delay is measured from Trigger Out to Pulse Out, and is the sum of the user defined Delay plus the Fixed Delay.

¹¹ Nominal.

¹² 10% to 90%, 50 Ω source and load, at 25°C. Higher for 1kΩ source impedance, rising and falling edges independent within selected ranges.



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Pulse Pattern Generator Specifications

Pattern Mode Parameters	Specification
Pattern	
Data Pattern length ¹³	2 – 16384 bits
PRBS	2 ⁿ -1 with n = 5-14
Data Formats	NRZ, RZ

CLK IN and EXT IN Parameters	Specification
Input Impedance	50 Ω or 10 kΩ
Threshold	-3 V to +3 V
Maximum Input Voltage	± 6 V
Coupling	DC

TRIG OUT and STROBE OUT Parameters	Specification
Output Impedance	50 Ω
Levels	TTL (0V / 2.4V)
Maximum External Voltage	-2V to 5 V
Coupling	DC

REF OSC IN and REF OSC OUT Parameters	Specification
Impedance	50 Ω, AC coupled
Ref Osc In Signal	10 MHz, 0 dBm typical, 20 dBm max
Output Amplitude	10 MHz, 1 V _{pp} typical

General Specifications	
Power	100V to 240V; Single phase; 50 / 60 Hz; universal voltage input; 165 VA max.
Compliance	EMC: Conforms to European Union Directive 89/336/EEC, EN 61326-1. 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.

¹³ Pattern for each channel is independent, must be same length.



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Pulse Pattern Generator Specifications

5. Additional Information

Inputs/Outputs

- OUTPUT1- channel 1 signal output, front panel
- OUTPUT2 - channel 2 signal output (optional), front 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 10 MHz signal for PLL reference, back panel
- REF OSC OUT - generates 10 MHz signal phase locked to PLL, back panel

Trigger Modes

- Continuous - trigger circuitry is always armed
- Started - 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 (this is period of pulses in continuous mode, or period of pulses within a burst or pattern in burst or pattern modes)

- PLL oscillator
- startable oscillator
- CLK IN

Arming Source (this 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)