

# Series 3400

## Signal 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  $50\Omega$  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

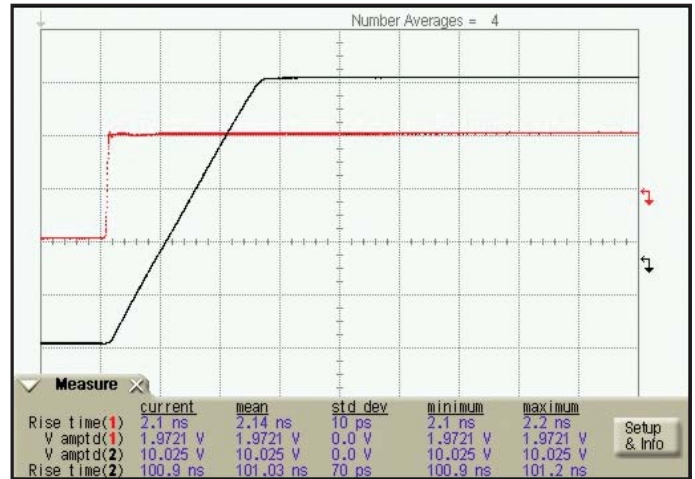
3401-3Y-EW	1-year factory warranty extended to 3 years from date of shipment
3402-3Y-EW	1-year factory warranty extended to 3 years from date of shipment
C/3401-3Y-DATA	3 (Z540-1 compliant) calibrations within 3 years of purchase*
C/3402-3Y-DATA	3 (Z540-1 compliant) calibrations within 3 years of purchase*

\*Not available in all countries

## APPLICATION AREAS

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

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.

Generate pulses and signal patterns for device characterization

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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 ( $2^n-1$  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 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 AMPLITUDE<sup>1</sup>:** 100mV to +10V, 50 into 50.  
200mV to +20V, 1k into 50.

**LEVEL WINDOW<sup>2</sup>:** -10V to +10V, 50 into 50.  
-20V to +20V, 1k into 50.

**AMPLITUDE ACCURACY<sup>3</sup>:**  $\pm(0.5\% \text{ amplitude} + 30\text{mV})$ .

**OFFSET ACCURACY<sup>4</sup>:**  $\pm 100\text{mV}$

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

**OVERSHOOT/PRE-SHOOT/RINGING<sup>5</sup>:**  $\pm 5\% \pm 20\text{mV}$ .

**SOURCE IMPEDANCE<sup>6</sup>:** 50 or 1k, selectable.

**SHORT CIRCUIT CURRENT<sup>7</sup>:**  $\pm 400\text{mA}$ .

### 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.  $\pm 1\%$  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.

### 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.

### TIMING AND TRIGGER PARAMETERS

**FREQUENCY RANGE<sup>1</sup>:** 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 WIDTH<sup>2</sup>:** 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.

**DELAY<sup>3</sup>:** 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 DELAY<sup>4</sup>:** 22ns.

### NOTES

1. Range reduced for 1k 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 TIME<sup>1</sup>:** 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.

### 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:**  $\pm 6\text{V}$ .

**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.

### 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).



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