Precision, low current sources
for device testing and characterization

Model 6220 DC Current Source
Model 6221 AC and DC Current Source

KEITHLEY

A GREATER MEASURE OF CONFIDENCE

**Lower noise and higher sourcing accuracy** than home-built solutions

Both sources work seamlessly with Model 2182A Nanovoltmeter to automate difficult low-level measurements

Supplied software builds on Keithley's applications insights to get the right source and measurement configurations for any application
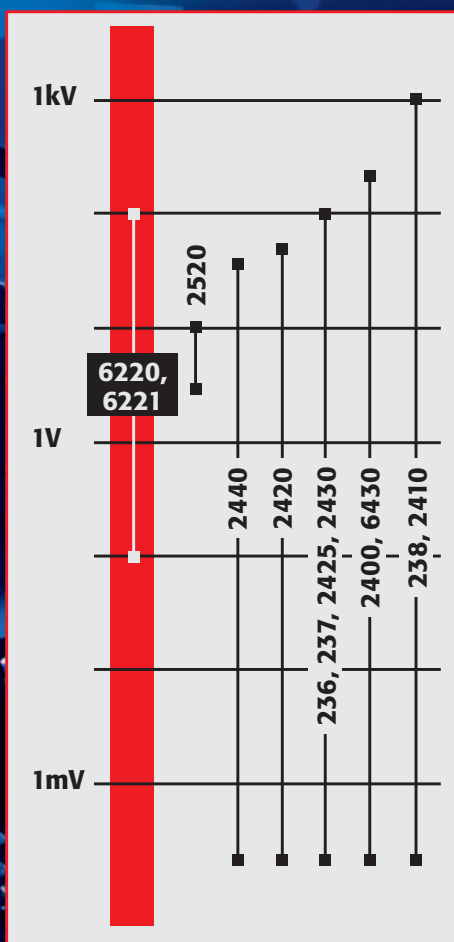
Output AC and arbitrary (ARB) waveforms at up to 100kHz

$10^{14}\Omega$ **output impedance** ensures more stable sourcing into variable loads
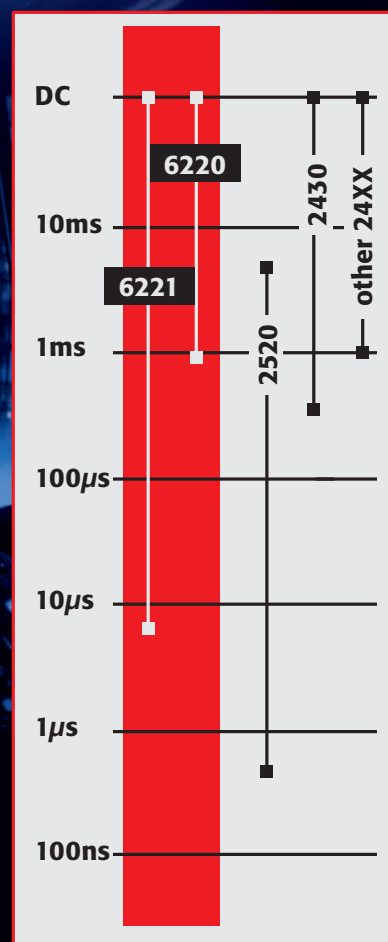
Output voltage compliance function prevents damage to fragile DUTs
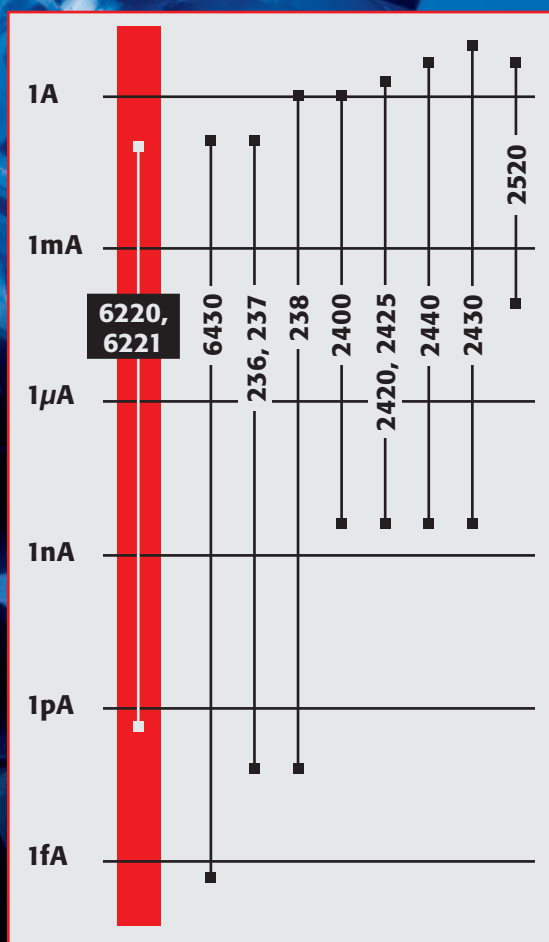
Range of output current (bipolar, except for 2520)

Range of programmable voltage compliance

Range of available current source pulse width

High accuracy, low noise sourcing combined with exceptional ease of use

Keithley's new Model 6220 DC Current Source and Model 6221 AC and DC Current Source deliver the high resolution, low noise, low current sourcing you need to test and characterize today's tiny, fragile electronics. But just as important, we've made them easy to use.

Easy to configure, easy to operate

Built-in control functions like voltage compliance, sweep and waveform generation, and current pulsing, plus a choice of communication interfaces, help you integrate them readily into test systems. Free instrument control software walks you through connecting your instruments and programming basic sourcing functions. It even supports making delta mode resistance, differential conductance, and pulse mode measurements with the Model 2182A Nanovoltmeter. The software also makes it simple to create complex waveforms with the Model 6221's arbitrary waveform (ARB) function.

Have an existing application that uses Keithley's Model 220 or 224 current source? The emulation mode built into the Models 6220 and 6221 eliminates the need to reprogram your application, so you can get your system back up and running again quickly.

The problem with home-built sources

Think building your own current source is a good way to save on instrumentation? Think again. Unlike the Models 6220 and 6221, home-built current sources typically don't have a practical voltage compliance capability. That makes it extraordinarily difficult to limit the amount of voltage applied when sourcing a current, so it's all too easy to damage or destroy your device under test (DUT) accidentally. The current output of home-built sources is often unpredictable, but the Models 6220 and 6221 provide $10^{14}\Omega$ output impedance that ensures stable current sourcing into variable loads. Even if a home-built source can provide reasonably high output impedance, it still can't offer capabilities like AC sourcing, fast settling, or voltage compliance.

Why lock-in amplifiers and AC resistance bridges can't compete

When combined with a Model 2182A, the Model 6220 or 6221 will easily outperform resistance measurement solutions like AC resistance bridges and lock-in amplifiers, with lower noise, lower current sourcing ranges, lower voltage measurements, and less power dissipation—all at a lower cost. Unlike a lock-in amplifier, a 622X/2182A combination doesn't require the use of a voltage-to-current converter or a voltage preamplifier and is less susceptible to phase shift errors. The Model 6221 can even expand the capabilities of lock-in amplifiers in your existing applications—its clean signals and output synchronization signal make it an ideal source for use in applications such as measuring device response at the second and third harmonic.

What is a current source?

The characteristics of a quality current source include:
- High resolution
- A wide range of compliance settings
- Fast output settling
- Low noise
- High impedance output

Any power supply can deliver current to a device, but many of them simply set the output voltage and then supply as much current as the device can draw. However, in many cases, the best way to describe a device's behavior is as a function of the current that passes through it—not of the voltage across it. That means sourcing a set current is preferable to sourcing a set voltage. Constant current sources output a specified current through the DUT (device under test) and apply whatever voltage is required to force that current. Advanced current sources like the Model 6220 and 6221 allow you to set a "compliance limit" on the level of voltage applied.

High sourcing accuracy for greater measurement confidence

The Model 6220 and Model 6221 share most of the same functions and capabilities, but the Model 6221 adds AC current sourcing, waveform generation, and pulsing functions, as well as a built-in Ethernet interface.

Execute linear staircase, logarithmic staircase, or custom current sweeps directly from the source using the 65000-point source memory.

Source and sink DC currents from 100fA to 100mA.

Measure differential conductance up to 10X faster and with lower noise with a Model 2182A than with other solutions.

Protect delicate DUTs from overvoltages with the output voltage compliance function.

Make pulsed I-V and pulsed R measurements with the Model 2182A with current pulses as short as 50µs (6221 only).

Edit output and compliance values easily with the turn of a knob. (6221 only)

Create, save, and recall up to five instrument setups.

Match your application's guarding requirements easily with the reconfigurable triax output.

Generate standard or arbitrary waveforms (6221 only) with programmable amplitudes and frequencies.

Source AC currents from 1pA to 100mA (6221 only).

Measure V or R with low noise with the Model 2182A using our faster, simpler delta mode.
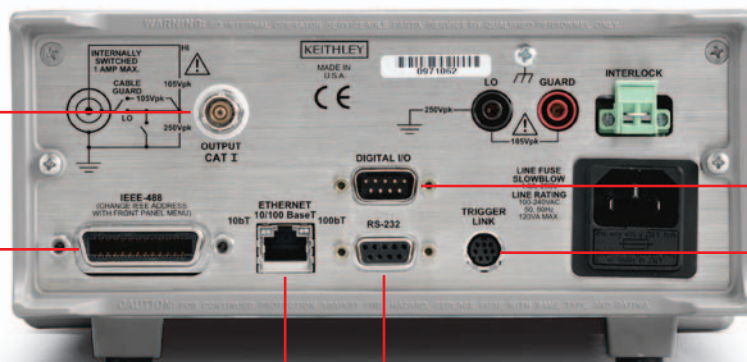
Ensure stable current sourcing into variable loads with $10^{14}\,\Omega$ output impedance.

Control your source remotely via the IEEE-488 interface.

Control external hardware via the digital I/O interface.

Synchronize source and nanovoltmeter triggering automatically and precisely through the Trigger Link interface.

Operate remotely from anywhere there's an Ethernet connection via the built-in Ethernet interface (6221 only).

Make quick, simple connections to a Model 2182A nanovoltmeter for delta, pulse delta, and differential conductance measurements.

Model 2182A
The perfect measurement companion for the Model 6220 or 6221

The Model 2182A Nanovoltmeter is the natural measurement partner for either Model 622X current source for measuring resistance and creating I-V curves. While low voltage measurements are often associated with resistance measurements of highly conductive semiconductor materials and devices, they may also be required when measuring the resistance of non-conductive materials and components. Today's electronic components are extremely small, which means they usually have limited power handling capability. As a result, when electrically characterizing these components, it's critical to keep the test signals used small to prevent component breakdown or other damage. In resistance measurements, lower test currents produce lower—and harder to measure—voltages across the devices. Linking the Model 2182A with a Model 622X Current

Source makes it possible to address both of these challenges in one easy-to-use configuration.

The Model 2182A Nanovoltmeter combines low noise, thermoelectric EMF cancellation, fast measurement rates, and 2ppm accuracy to address demanding low voltage applications such as determining the electrical characteristics of power sensitive materials, highly conductive metals, and high and low temperature superconductors.

Whenever the Model 2182A and one of the current sources are operated together (as in the delta, differential conductance, or pulse modes), the current source configures the nanovoltmeter over the RS-232 interface, controls it through the Trigger Link interface, then retrieves the data for calculations over the RS-232 interface.

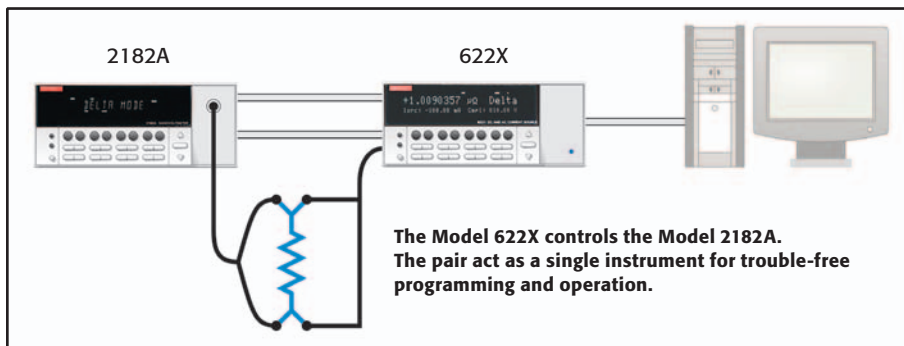**Synchronization to line provides 110dB NMRR and minimizes the effect of AC common-mode currents.**

Built-in thermocouple linearization and cold junction compensation.

Dual channels support measuring voltage, temperature, or the ratio of an unknown resistance to a reference resistor.

Choose the best speed/filter combination for your application's response time and noise level requirements.

Make low noise measurements at high speeds, typically just 15nVp-p noise at 1s response time.

Delta mode function coordinates measurements with the 622X.

The Model 622X controls the Model 2182A. The pair act as a single instrument for trouble-free programming and operation.

All the cabling required to connect either current source to the nanovoltmeter for interoperation is provided with the current source.

The optional Model 2187-4 test lead set is designed specifically to enhance the accuracy of ultra-high impedance measurements made with the Model 622X/2182A combination.

Support for complex measurement applications

Ultra-Low Power Resistance Measurements: Delta Mode

Characterizing the resistance of modern materials and components demands the ability to source very low current and measure very low voltages. Keithley's delta mode (current reversal) resistance measurement capability combines the low current DC sourcing capabilities of the Model 6220 or 6221 with the Model 2182A's low voltage measurement accuracy. This combination is ideal for making low resistance measurements (down to $10n\Omega$) for characterizing on-resistance, interconnects, superconductors, etc.

Even when the DUT is non-conductive, fragile devices can be damaged if too much power is applied, so sourcing very small currents and measuring the resulting low voltages is still critical. The delta mode function uses a current reversal and a three-point measurement algorithm to cancel the effects of thermoelectric EMFs and reduce measurement noise. Once the instruments are connected properly, starting the test is simply pressing the source's Delta button and then the Trigger button.

The delta mode automatically triggers the current source to alternate the signal polarity, and then triggers a nanovoltmeter reading at each polarity. These high speed current reversals
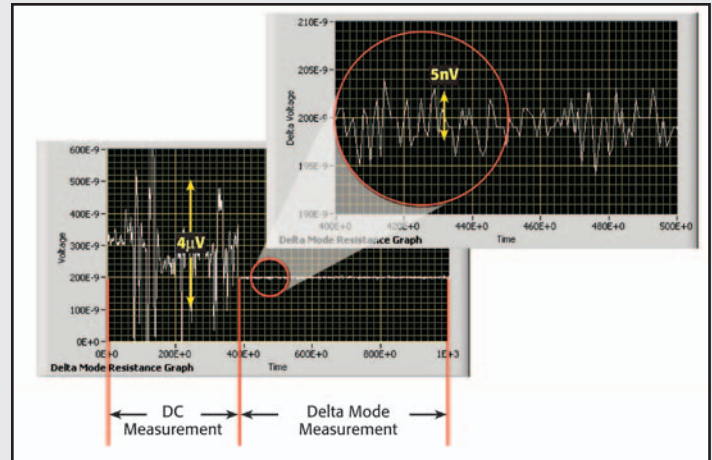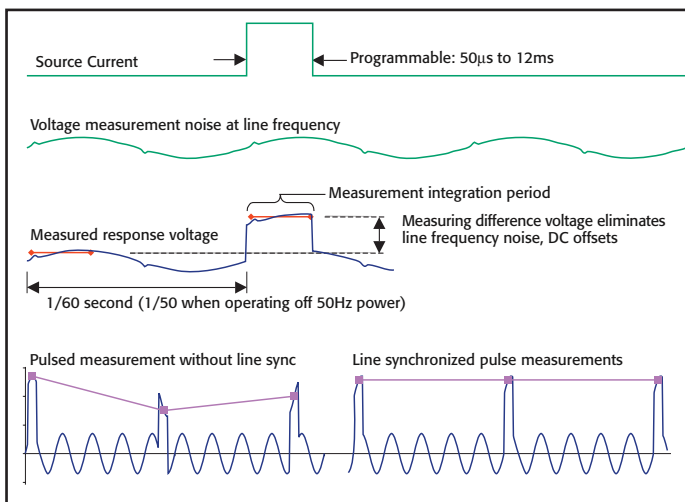

Delta mode offers 1000-to-1 noise reduction.

cancel out both constant and drifting thermoelectric offsets, reducing measurement noise and increasing voltage and resistance measurement accuracy.

For more information on delta mode measurements, see the section titled "Lock-in amplifier replacement."

## Low Power I-V Characterization: Pulsed Measurements

Measurements are line synchronized to minimize 50/60Hz interference.

Although the delta mode technique reduces the power dissipated in the DUT by sourcing a lower level of current, some applications won't allow the use of reduced current in order to reduce power. For applications like these, such as I-V characterization of small, power-sensitive components, the Model 6221's high speed current pulsing capability reduces the average power dissipated in the DUT by reducing the time the current is applied, which minimizes device self-heating and prevents device damage. Both the Model 6221 and the Model 2182A have microsecond rise times on all ranges to allow taking a voltage measurement as soon as 16 microseconds after the current pulse is applied. The Model 2182A's sub-microsecond latency trigger allows the complete pulse-and-measure cycle to be as short as 50 microseconds. The 6221/2182A combination can make pulsed resistance and I-V measurements on devices ranging from $10n\Omega$ to $100M\Omega$, so it's well suited for applications like superconductor, fuel cell, optoelectronics and nanotechnology research. Unlike other pulsed measurement solutions, it provides line synchronization to minimize 60Hz interference. It also incorporates the delta technique to eliminate voltage offsets and drift that can affect measurement accuracy.

High speed differential conductance measurements

Measuring differential conductance (also known as electron energy spectroscopy, tunneling spectroscopy, or simply dI/dV) is an important method for characterizing materials and components to reveal nonlinear material properties, such as density of states. It's widely used in nanotechnology, low temperature physics, and semiconductor research. The 622X/2182A combination measures differential conductance up to ten times faster than ever before. The Model 2182A's exceptional voltage sensitivity makes it possible to obtain data in a single pass, rather than by averaging the results of several measurement sweeps. The current source and the nanovoltmeter can be operated as a single instrument that can be controlled over the GPIB connection (or via Ethernet if the Model 6221 is used). This simple combo system offers significantly better performance than other approaches to differential conductance measurements, which typically require integrating from six to eight instruments and are often plagued by errors due to ground loops and common mode currents that flow between the various instruments.
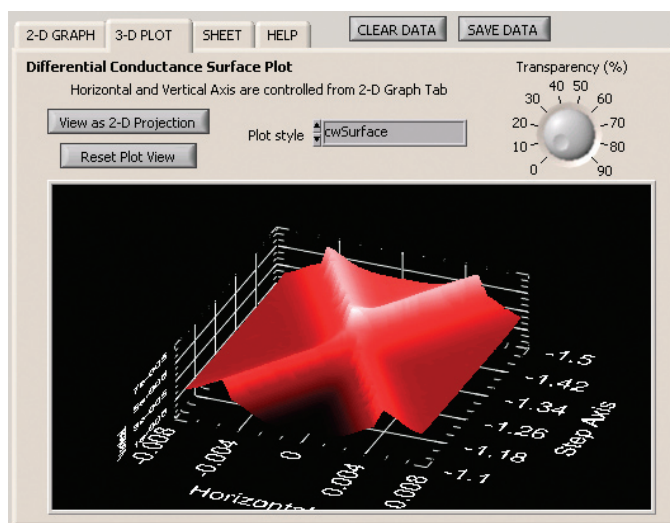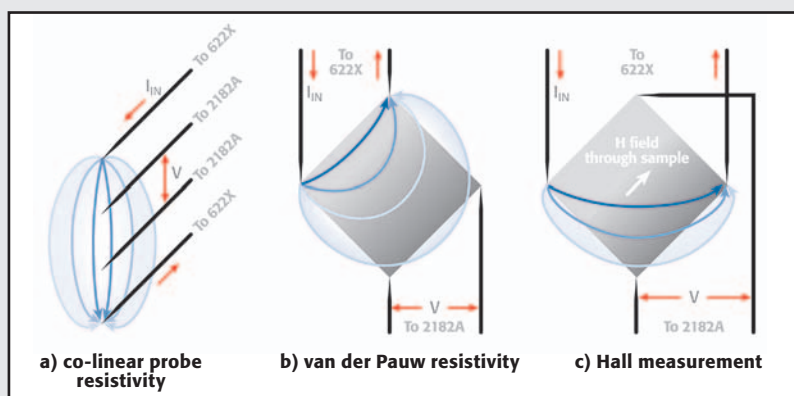

Perform, analyze, and display differential conductance measurements.

Four-point resistivity, Hall measurement, conductivity type testing

In materials research and semiconductor manufacturing, resistivity measurements are critical. These measurements must be made using the four-wire "source current/measure voltage" method with the four probes in either the co-linear configuration or the van der Pauw configuration. When the resistivity or contact resistance is high (>100kΩ, which is typical of most semiconductor materials), the amount of applied current must be kept very small. Power limitations in the material often restrict the applied current still further, so the voltages to be measured will be smaller as well.

a) co-linear probe resistivity   **b) van der Pauw resistivity**   **c) Hall measurement**

The 622X/2182A combination brings together the low noise, low current sourcing and low noise voltage measurements necessary to meet these demanding requirements.

Adding a magnetic field to this same configuration allows measuring the material's Hall coefficient using the same four contacts. Using the delta mode for each of the measurements required makes special switch systems optimized for low offset voltage unnecessary, further simplifying the measurement.

The Model 6221's AC sourcing capability makes it easy to check the conductivity type of semiconductors, using the co-linear configuration.

Generate arbitrary current waveforms

Need to create a complex programmable load or sensor signal or to emulate signals or noise? It's easy to generate an unlimited variety of complex waveforms by adding, multiplying, joining, or filtering the standard wave shapes supplied with the Model 6221. You can program waveform repetition frequencies from 0.001Hz to 100kHz with an output update rate of 10 megasamples/second. Current waveforms can be used in many applications, such as dynamic loads used for power supply design or nerve impulse simulation.
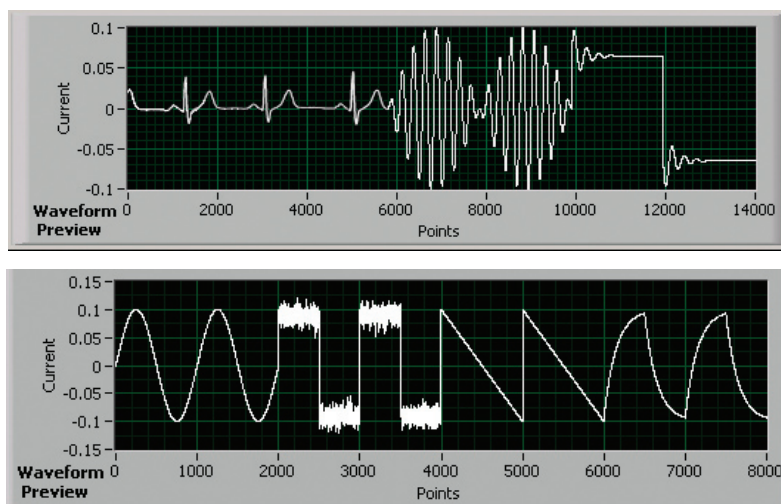
Lock-in amplifier replacement

Lock-in amplifiers have long been used for some of the applications discussed in this brochure. When operated in delta mode, the 622X/2182A combination offers a variety of advantages over lock-in amplifiers. For example, the Models 6220 and 6221 are true current sources, so there's no need to make a measurement of the current through the device, which is required for confirmation when using a lock-in amplifier. The 622X/2182A combination can also make measurements with just half as much noise as a lock-in amplifier introduces. At or below the typical response frequency of the device/cabling combination, the 622X/2182A combination even provides better noise performance than lock-ins with external preamplifiers.
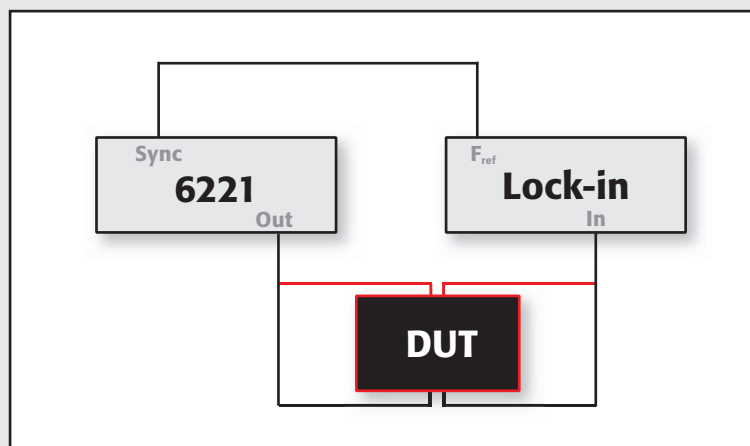
Already using a lock-in amplifier in an existing application?

The Model 6221 can extend its capabilities by providing clean sine output currents that have much lower noise that those produced with the output of a lock-in amplifier and a series resistor. This is especially true when the signal current must be very small due to power limitations in the device, such as when measuring resistive temperature sensors.

For application notes and white papers on these and other uses for the Model 6220, 6221, or 2182A, call us at 1-888-KEITHLEY or visit our website at www.keithley.com.

Built-in software support for advanced measurement functions

Measuring low level signals accurately often requires four-point probing, guarding, or shielding techniques. However, these techniques can complicate the process of connecting instrumentation to the device under test (DUT). In most cases, though, there's no instrumentation specialist standing by to help you set up your test system. Fortunately, the free instrument control software provided with the Models 6220 and 6221 has a wealth of measurement knowledge built right into it. The Setup Wizard simplifies choosing the most appropriate measurement configuration for a specific application, while the Connection Guide provides detailed set-up instructions for the chosen configuration, including the cabling and test fixture. The software walks you through controlling basic sourcing functions, as well as delta mode resistance, differential conductance, and pulse mode measurements made with the Model 2182A. It collects data and displays results in intuitive formats. IVI-style (VISA based) instrument drivers are also provided for use with application development environments like LabVIEW®, LabWindows™/CVI, Visual Basic®, C/C++, and TestPoint™.

Setup Wizard guides you step-by-step through the configuration process
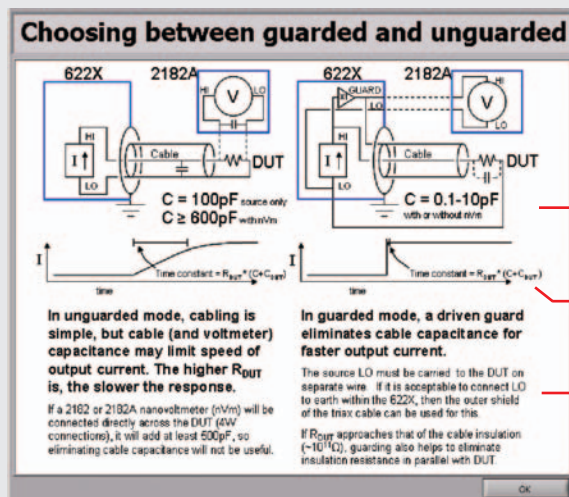
The Setup Wizard draws on the instrumentation expertise in Keithley's *Low Level Measurements Handbook* to explain measurement techniques like guarding, shielding, and four-wire measurements to help you choose the best approach for a particular application.

Circuit configuration diagrams clarify complex measurement issues.

The accompanying equations simplify selecting the most appropriate configuration.

The effects each configuration will have on circuit performance, measurement accuracy, and setup complexity are explained simply and concisely.

Connection Guide illustrates how to connect your chosen configuration

Your chosen configuration is translated into easy-to-follow graphical setup instructions that explain how to connect the instruments to each other and to the DUT.

The Connection Guide specifies the appropriate cabling.

The cabling, connections, shielding, and grounding needed are spelled out on a case-by-case basis, including explanations of the effects of each choice on system performance.
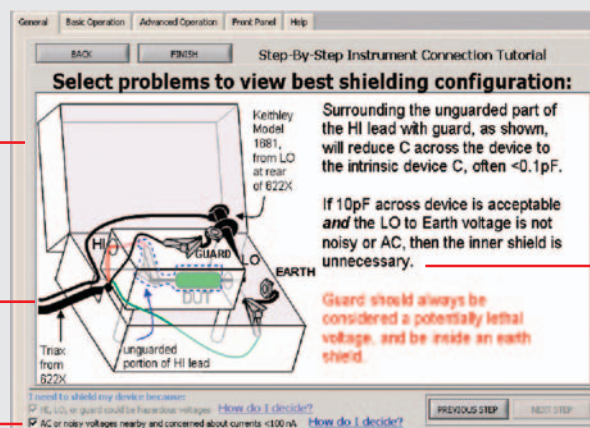
When slightly lower accuracy or speed is acceptable, the Configuration Guide identifies alternatives that may require less effort to implement.

Visit www.keithley.com/6220 to download a FREE copy of the software to try it for yourself.

Condensed Specs: Models 6220/6221

Range (+5% over range)	Accuracy (1 Year) 23°C ±5°C ±(% rdg. + amps)	Programming Resolution	Temperature Coefficient/°C 0°–18°C & 28°–50°C	Typical Noise (peak-peak)/rms[3] 0.1Hz–10Hz	6221 Only — Typical Noise (peak-peak)/rms[3] 10Hz–(BW)	Output Response Bandwidth (BW) into Short	Settling Time[1,2] (1% of final value) — Output Response Fast (Typical[3]) (6221 Only)	6220, 6221 with Output Response Slow (Max.)
2 nA	0.4 % + 2 pA	100 fA	0.02 % + 200 fA	400 / 80 fA	250/50 pA	10 kHz	90 μs	100 μs
20 nA	0.3 % + 10 pA	1 pA	0.02 % + 200 fA	4 / 0.8 pA	250 / 50 pA	10 kHz	90 μs	100 μs
200 nA	0.3 % + 100 pA	10 pA	0.02 % + 2 pA	20 / 4 pA	2.5 / 0.5 nA	100 kHz	30 μs	100 μs
2 μA	0.1 % + 1 nA	100 pA	0.01 % + 20 pA	200 / 40 pA	25 / 5.0 nA	1 MHz	4 μs	100 μs
20 μA	0.05% + 10 nA	1 nA	0.005% + 200 pA	2 / 0.4 nA	500 / 100 nA	1 MHz	2 μs	100 μs
200 μA	0.05% + 100 nA	10 nA	0.005% + 2 nA	20 / 4 nA	1.0 / 0.2 μA	1 MHz	2 μs	100 μs
2mA	0.05% + 1 μA	100 nA	0.005% + 20 nA	200 / 40 nA	5.0 / 1 μA	1 MHz	2 μs	100 μs
20mA	0.05% + 10 μA	1 μA	0.005% + 200 nA	2 / 0.4 μA	20 / 4.0 μA	1 MHz	2 μs	100 μs
100mA	0.1 % + 50 μA	10 μA	0.01 % + 2 μA	10 / 2 μA	100 / 20 μA	1 MHz	3 μs	100 μs

ADDITIONAL SOURCE SPECIFICATIONS

OUTPUT RESISTANCE: >10$^{14}\Omega$ (2nA/20nA range).

OUTPUT CAPACITANCE: <10pF, <100pF Filter ON (2nA/20nA range).

LOAD IMPEDANCE: Stable into 10μH typical, 100μH for 6220, or for 6221 with Output Response SLOW.

VOLTAGE LIMIT (Compliance): Bipolar voltage limit set with single value. 0.1V to 105V in 0.01V programmable steps.

MAX. OUTPUT POWER: 11W, four quadrant source or sink operation.

GUARD OUTPUT Accuracy: ±1mV for output currents <2mA (excluding output lead voltage drop).

PROGRAM MEMORY: Number of Locations: 64K. Offers point-by-point control and triggering, e.g. sweeps.

Max. Trigger Rate: 1000/s.

RMS Noise 10Hz–20MHz (2nA–20mA Range): Less than 1mVrms, 5mVp-p (into 50Ω load).

SOURCE NOTES

1. Settling times are specified into a resistive load, with a maximum resistance equal to 2V/Ifull scale of range. See manual for other load conditions.

2. Settling times to 0.1% of final value are typically <2× of 1% settling times.

3. Typical values are non warranted, apply at 23°C, represent the 50th percentile, and are provided solely as useful information.

2182 MEASUREMENT FUNCTIONS

DUT RESISTANCE: Up to 1GΩ (1nS) (100MΩ limit for pulse mode).

DELTA MODE RESISTANCE MEASUREMENTS and DIFFERENTIAL CONDUCTANCE: Controls Keithley Model 2182A Nanovoltmeter at up to 24Hz reversal rate (2182 at up to 12Hz).

PULSE MEASUREMENTS (6221 only):

Pulse Widths: 50μs to 12ms, 1pA to 100mA.

Repetition Interval: 83.3ms to 5s.

ARBITRARY FUNCTION GENERATOR (6221 only)

WAVEFORMS: Sine, Square, Ramp, and 4 user defined arbitrary waveforms.

FREQUENCY RANGE: 1mHz to 100kHz.[5]

FREQUENCY ACCURACY: ±100ppm (1 year).

SAMPLE RATE: 10 MSPS.

AMPLITUDE: 2pA to 210mA peak-peak into loads up to 10$^{12}\Omega$.

AMPLITUDE RESOLUTION: 16 bits (including sign).

AMPLITUDE ACCURACY (<10kHz): [5]

Magnitude: ±(1% rdg + 0.2% range).

Offset: ±(0.2% rdg + 0.2% range).

SINE WAVE CHARACTERISTICS:

Amplitude Flatness: Less than 1dB up to 100kHz.[6]

SQUARE WAVE CHARACTERISTICS:

Overshoot: 2.5% max.[6]

Variable Duty Cycle: [4] Settable to 1μs min. pulse duration, 0.01% programming resolution.

Jitter (RMS): 100ns + 0.1% of period.[6]

RAMP WAVE CHARACTERISTICS:

Linearity: <0.1% of peak output up to 10kHz.[6]

ARBITRARY WAVE CHARACTERISTICS:

Waveform Length: 2 to 64K points.

Jitter (RMS): 100ns + 0.1% of period.[6]

WAVEFORM NOTES

4. Minimum realizable duty cycle is limited by current range response and load impedance.

5. Amplitude accuracy is applicable into a maximum resistive load of 2V/I$_{full scale}$ of range. Amplitude attenuation will occur at higher frequencies dependent upon current range and load impedance.

6. These specifications are only valid for the 20mA range and a 50Ω load.

GENERAL SPECIFICATIONS

COMMON MODE VOLTAGE: 250V rms, DC.

COMMON MODE ISOLATION: >10$^9\Omega$, <2nF.

REMOTE INTERFACE: SCPI (Standard Commands for Programmable Instruments).

Digital I/O: 1 trigger input, 4 TTL/relay drive outputs.

OUTPUT CONNECTIONS:

Teflon insulated 3-lug triax connector for output.

Banana safety jack for GUARD, OUTPUT LO.

Screw Terminal for CHASSIS.

DB-9 connector for EXTERNAL TRIGGER INPUT, OUTPUT, and DIGITAL I/O.

Two position screw terminal for INTERLOCK.

WARRANTY: 1 year.

ENVIRONMENT: Operating: 0°–50°C, 70%R.H. up to 35°C. Derate 3% R.H./°C, 35°–50°C. Storage: −25°C to 65°C, guaranteed by design.

EMC: Conforms to European Union Directive 89/336/EEC, EN 61326-1.

SAFETY: Conforms to European Union Directive 73/23/EEC, EN61010-1.

VIBRATION: MIL-PRF-28800F Class 3, Random.

WARMUP: 1 hour to rated accuracies.

Passive Cooling: No fan.

Condensed Specs: Model 2182A Nanovoltmeter

DELTA (hardware-triggered coordination with 24XX series or 622X series current sources for low noise R measurement):
Accuracy = accuracy of selected Channel 1 range plus accuracy of I source range.
DELTA measurement noise with 6220 or 6221: Typical 3nVrms/$\sqrt{}$Hz (10mV range)[14]. 1Hz achieved with 1PLC, delay = 1ms, RPT filter = 23 (20 if 50Hz).

PULSE-MODE (with 6221): Line synchronized voltage measurements within pulses from 50μs to 12ms, pulse repetition rate up to 12Hz.
Pulse measurement noise (typical rms noise, R_{DUT}<10Ω): $\pm$(0.009ppm of range*)/meas_time/$\sqrt{}$pulse_avg_count + 3nV**/$\sqrt{}$(2 · meas_time · pulse_avg_count) for 10mV range**.

* 0.0028ppm for the 100mV range, 0.0016ppm for ranges 1V and above.
** 8nV/$\sqrt{}$Hz for ranges above 10mV   meas_time (seconds) = pulsewidth – pulse_meas_delay in 33μs incr.

DC Volts Specifications (20% over range)

Conditions: 1PLC with 10 reading digital filter or 5PLC with 2 reading digital filter.

Accuracy: $\pm$(ppm of reading + ppm of range)
(ppm = parts per million) (e.g., 10ppm = 0.001%)

Range		Resolution	Input Resistance	90 Day TCAL ±5°C	1 Year TCAL ±5°C	2 Year TCAL ±5°C	Temperature Coefficient 0°–18°C & 28°–50°C
10.000000	mV [1,2]	1 nV	>10 GΩ	40 + 4	50 + 4	60 + 4	(1 + 0.5)/°C
100.00000	mV	10 nV	>10 GΩ	25 + 3	30 + 4	40 + 5	(1 + 0.2)/°C
1.0000000	V	100 nV	>10 GΩ	18 + 2	25 + 2	32 + 3	(1 + 0.1)/°C
10.000000	V	1 μV	>10 GΩ	18 + 2	25 + 2	32 + 3	(1 + 0.1)/°C
100.00000	V [2]	10 μV	10 MΩ ±1%	25 + 3	35 + 4	52 + 5	(1 + 0.5)/°C

DC Noise Performance [3] (DC noise expressed in volts peak-to-peak)

Response time = time required for reading to be settled within noise levels from a stepped input, 60Hz operation.

Response Time	NPLC, Filter	10 mV	100 mV	Range 1 V	10 V	100 V	NMRR [4]	CMRR [5]
25.0 s	5, 75	6 nV	20 nV	75 nV	750 nV	75 μV	110 dB	140 dB
1.0 s	1, 18	25 nV	175 nV	600 nV	2.5 μV	100 μV	95 dB	140 dB
60 ms	1, Off	70 nV	300 nV	700 nV	6.6 μV	300 μV	60 dB	140 dB

Voltage Noise vs. Source Resistance [6]

(DC noise expressed in volts peak-to-peak)

Source Resistance		Noise	Analog Filter	Digital Filter
0	Ω	6 nV	Off	100
100	Ω	8 nV	Off	100
1	kΩ	15 nV	Off	100
10	kΩ	35 nV	Off	100
100	kΩ	100 nV	On	100
1	MΩ	350 nV	On	100

Temperature (Thermocouples)

(Displayed in °C, °F, or K.)   **Type: J, K, N, T, E, R, S, B**

Measurement Characteristics

A/D Linearity: $\pm$(0.8ppm of reading + 0.5ppm of range).
DC Input Bias Current: <60pA DC @ 23°C, –10V to 5V. <120pA @ 23°C, 5V to 10V.
Common Mode Current: <50nA p-p at 50Hz or 60Hz.
Input Protection: 150V peak to any terminal. 70V peak Channel 1 LO to Channel 2 LO.
Channel Isolation: >10GΩ.
Earth Isolation: 350V peak, >10GΩ and <150pF any terminal to earth. Add 35pF/ft with Model 2107 Low Thermal Input Cable.

Operating Characteristics [7,8]   60Hz (50Hz) Operation

Function	Digits	Readings/s		PLCs
Delta with 622X	6.5	47	(40.0)[15]	1
DCV Channel 1,	7.5	3	(2)	5
Channel 2,	7.5 [11]	6	(4)	5
Thermocouple	6.5 [12]	18	(15)	1
	6.5 [12,13]	45	(36)	1
	5.5 [11]	80	(72)	0.1
	4.5 [10,11]	115	(105)	0.01

System Speeds [7,9]

Range Change Time: [8]	<40 ms	(<50 ms).
Function Change Time: [8]	<45 ms	(<55 ms).
Autorange Time: [8]	<60 ms	(<70 ms).
Max. Internal or External Trigger Rate: [10]	120/s	(120/s).

Remote Interface

GPIB (IEEE-488.2) and RS-232C. SCPI (Standard Commands for Programmable Instruments).

Notes

1. When properly zeroed using REL function. If REL is not used, add 100nV to the range accuracy.
2. Specifications include the use of ACAL function. If ACAL is not used, add 9ppm of reading/°C from T_{CAL} to the listed specification. T_{CAL} is the internal temperature stored during ACAL.
3. Noise behavior using 2188 Low Thermal Short after 2.5 hour warm-up. ±1°C. Analog Filter off. Observation time = 10× response time or 2 minutes, whichever is less.
4. For L_{SYNC} On, line frequency ±0.1%. If L_{SYNC} Off, use 60dB.
5. For 1kΩ unbalance in LO lead. AC CMRR is 70dB.
6. After 2.5 hour warm-up, ±1°C, 5PLC, 2 minute observation time, Channel 1 10mV range only.
7. Speeds are for 60Hz (50Hz) operation using factory defaults operating conditions (*RST). Autorange Off, Display Off, Trigger Delay = 0, Analog Output off.
8. Speeds include measurements and binary data transfer out the GPIB. Analog Filter On, 4 readings/s max.
9. Auto Zero Off, NPLC = 0.01.
10. 10mV range, 80 readings/s max.
11. Sample count = 1024, Auto Zero Off.
12. For L_{SYNC} On, reduce reading rate by 15%.
13. Front Auto Zero off, Auto Zero off.
14. Applies to measurements of room temperature resistances <10Ω, Isource range ≤20μA.
15. Display off, delay 1ms.

General

POWER SUPPLY: 100V/120V/220V/240V.
WARRANTY: 3 years.
EMC: Complies with European Union Directive 89/336/EEC (CE marking requirement), FCC part 15 class B, CISPR 11, IEC 801-2, IEC-801-3, IEC 801-4.
SAFETY: Complies with European Union Directive 73/23/EEC (low voltage directive); meets EN61010-1 safety standard. Installation category I.

Additional current sourcing solutions

Keithley offers a variety of alternatives if your application requires sourcing higher currents than the 100mA the Model 6220 or 6221 can deliver or demands additional measurement functions. Refer to the charts on page 2 for guidance on the ranges and other capabilities these instruments can provide.

Series 2400 SourceMeter® instruments offer higher current sourcing ranges (up to 10A), built-in voltage measurements, and Source V/Measure I configuration.

For Hall voltage measurements on high resistance materials, the **Model 4200-SCS Semiconductor Characterization System** offers the convenience of low current sourcing, multiple channels of high impedance voltage measurement, and switching in one integrated box.

The **Model 2520 Pulsed Laser Diode Test System** offers faster pulsing than the Model 6221 (up to 500ns), faster measurements (streaming at 100ns), and higher current output (up to 5A).

For characterizing very high resistance devices ($>100M\Omega$), the **Model 6430 Sub-Femtoamp Remote SourceMeter® instrument** or the **Model 4200-SCS** may offer a better solution than the Model 622X/2182A combination—they can also operate in Source Voltage/Measure Current mode, which can provide more detailed curves on high resistance samples.

Need somebody to talk to?

There's a Keithley applications engineer ready with advice on configuring a test system for your low current sourcing application. Call us toll free at 1-888-KEITHLEY (534-8453) (US only) or call your local Keithley sales office and ask to speak with one of our low level instrumentation specialists.

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For Keithley's help with low level sourcing and measurement solutions, contact one of the experts listed below.

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