Keysight PZ2100 Series High-Channel Density Precision Source / Measure Unit Solution

PZ2100A Precision SMU Mainframe
PZ2110A High-Resolution SMU
PZ2120/21A High-Speed SMU
PZ2130/31A High-Channel Density SMU

Table of Contents

Introduction

The Keysight PZ2100 Series is the leading automated test equipment (ATE) solution that integrates enormous source/measure unit (SMU) resources into valuable rack space with flexible module options. The PZ2100 provides flexible scalability with multiple SMU module options covering a wide range of applications, from conventional static DC measurements down to 10 fA to emerging dynamic/pulsed measurements up to 15 MSa/s and down to 10 µs width. The PZ2100 provides an uncompromising high-density integration that fully uses available rack space, slots, or SMU module capabilities. The PZ2100 enables a lower cost per channel and 20x smaller rack space than conventional SMUs, significantly reducing your test costs and saving valuable rack space.

Key benefits	Key features
Save cost and valuable rack space	• 5 SMU module options flexibly configurable and upgradable in 1U, 4 slot mainframe at lower cost/ch • Scalable up to 20 ch, 20x higher density than conventional SMU • SMU integrating pulser/digitizer eliminates the need for additional instruments
Wide application coverage from DC to dynamic measurements	• Wide output range of up to 210 V / 3.5 A DC / 10.5 A pulse • Low current measurement supported by min. 10 fA high resolution • Dynamic/pulsed measurement with 15 MSa/s sampling rate and 10 µs narrow pulse • Wide dynamic range with auto ranging and seamless ranging
Simple integration and time efficiency	• Single box solution simplifies synchronization with multiple SMUs at < 50 ns accuracy • User-friendly GUI accelerates the test prototyping, debugging, and troubleshooting • SCPI programming via LAN / USB / GPIB for easy adoption to various environments • PathWave IV Curve software enables quick measurements without programming

Figure 1. PZ2100A precision source /measure unit mainframe, 4 slots, 1U

Save Cost and Valuable Rack Space

Keysight PZ2100A Precision SMU Mainframe

The Keysight PZ2100A is the precision source/measure unit (SMU) mainframe that uncompromisingly and densely integrates 20 SMU channels at maximum into valuable 1U height, full width, rack space with flexible module options at their best performance. It supports a variety of resources such as the Keysight PZ2110A High-Resolution SMU, PZ2120/21A High-Speed SMUs, and PZ2130/31A High-Channel Density SMUs with multiple functions such as pulser and digitizer, as well as precise voltage/current sourcing and measuring to adapt to a wide range of application requirements.

Type	Model	Description & key features
Mainframe	PZ2100A 	Precision SMU Mainframe, 4 slots, 1U • Scalable up to 20 channels • 5 SMU module options flexibly configurable and upgradable • Simplified synchronization at <50 ns accuracy • User-friendly GUI collectively managing up to 20 channels
High-resolution SMU	PZ2110A 	Precision SMU, 1.25 MSa/s, 10 fA, 210 V, 315 mA DC/pulse • 10 fA resolution with 30 fArms measurement noise (1 PLC) • Narrow pulse down to 20 µs pulse width • Fast digitizer mode with sampling rate up to 1.25 MSa/s • Fast transient with 1.4 V/µs slew rate at max.
High-speed SMU	PZ2120A 	Precision SMU, 1 MSa/s, 100 fA, 60 V, 3.5 A DC/10.5 A pulse • Narrow pulse down to 50 µs pulse width • Fast digitizer mode with 1 MSa/s sampling rate • Wide output range up to 60V/3.5 A DC/10.5 A pulse • Wide dynamic range with seamless measurement ranging
	PZ2121A 	Precision SMU, 15 MSa/s, 100 fA, 60 V, 3.5 A DC/10.5 A pulse • Narrow pulse down to 10 µs pulse width • Fast digitizer mode with 15 MSa/s sampling rate • Wide output range up to 60V/3.5 A DC/10.5 A pulse • Wide dynamic range with seamless measurement ranging
High-channel Density SMU	PZ2130A 	5-ch Precision SMU, 100 pA, 30 V, 500 mA DC [1] • High-density (20 Ch in 1U rack height, full width at max.) • Low cost/ch for multi-ch applications • Fast sampling measurement with a sampling rate of 250 kSa/s • Low voltage source noise down to 25 µVrms with PX0107A
	PZ2131A 	5-ch Precision SMU, 500 kSa/s, 10 pA, 30 V, 500 mA DC/pulse [1] • High-density (20 Ch in 1U rack height, full width at max.) • Narrow pulse down to 100 µs pulse width • Fast digitizer mode with sampling rate at 500 kSa/s • Low voltage source noise down to 25 µVrms with PX0107A

1. Ch1 and Ch2 expand the maximum current to +750 mA by over-range capability.

Flexibly configurable and upgradable at lower cost / ch

The Keysight PZ2100A is a precision SMU mainframe that provides 4 slots and flexibly integrates 5 SMU module options. It allows any mixed module configuration, which enables you to configure and upgrade your test system flexibly according to your application requirements.

Figure 2. PZ2100A rear view having 4 slots in 1 U height, full width, rack size

Figure 3. Mixed module configuration example with PZ2110A, PZ2121A, and PZ2131A

Scalable up to 20 channels, 20x higher density than conventional SMU

The PZ2100A integrates up to 20 SMU channels into valuable 1U-height, full-width rack space, and unlike conventional SMUs, it does not require any cooling spacers when stacked. It achieves a 20x smaller footprint than conventional SMUs and enables you to save cost and valuable rack space.

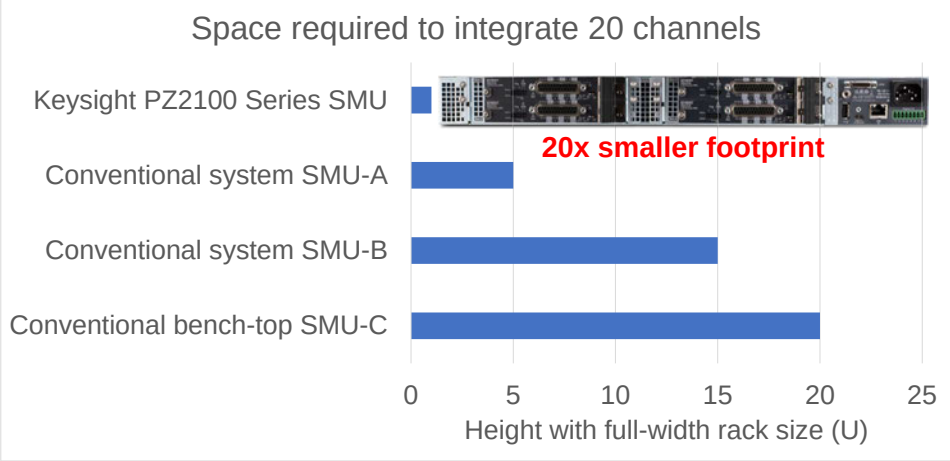


Figure 4. The PZ2100A provides 20x higher channel density integrating 20 channels in 1U rack space

All-in-one SMU integrating pulser/digitizer

Resource integration reduces measurement error

An SMU is an instrument that combines the capabilities of a current source, a voltage source, a current meter, and a voltage meter, along with the ability to switch easily between these various functions. The source and measurement circuitry are closely integrated, allowing users to achieve far better measurement performance with less measurement error than using various independent instruments to make the same measurement.

Feedback mechanism stabilizes voltage and current sourcing

Since SMUs can very accurately measure their own current and voltage output, they have many advantages over conventional power supplies. All SMUs have internal feedback loops that provide instantaneous feedback to the sourcing circuitry, which in turn allows the SMU output to remain accurate and stable even if the load conditions change unexpectedly.

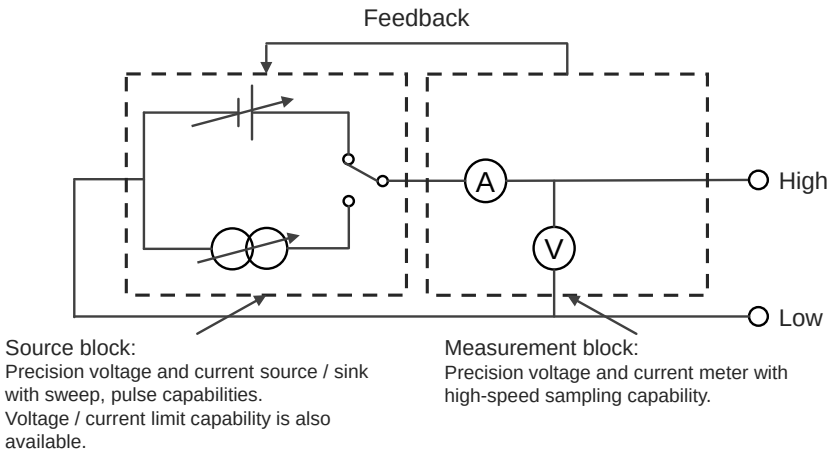


Figure 5. SMU simplified block diagram

Pulser / digitizer integration

The Keysight PZ2100 Series provides an all-in-one SMU module that integrates pulser / digitizer functions with conventional SMU functions, such as precise DC voltage / current sourcing and measuring. The integration enables the PZ2100 Series to meet emerging dynamic/pulsed measurement requirements without additional instruments.

Limit (compliance) feature prevents device damage

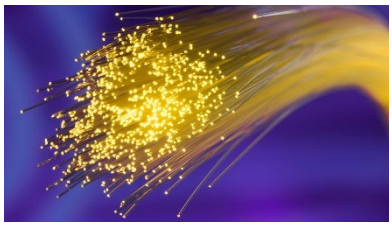
SMUs also possess a voltage and current limit (compliance) feature that allows the user to set limits and protect devices from damage caused by excessive voltage or current.

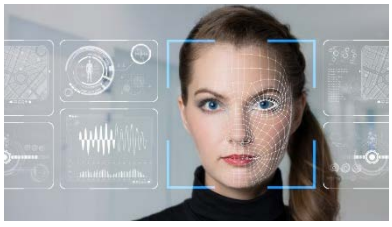
Wide Application Coverage from DC To Dynamic Measurements

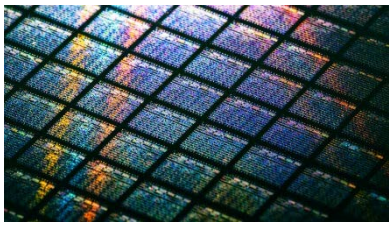
The Keysight PZ2100 Series provides an all-in-one SMU that integrates pulser / digitizer functions into a conventional SMU capability. Its pulser enables narrow pulsed measurements down to 10 µs width, and its digitizer mode enables fast dynamic measurements with a sampling rate of up to 15 MSa/s. An auto measurement range capability enables a wide dynamic range in DC measurements, and the seamless current measurement ranging function offers a wide dynamic range, even in dynamic measurements. These capabilities help the PZ2100 Series cover a wide range of applications, from conventional static DC measurements with high resolution down to 10 fA to emerging dynamic/pulsed measurements without additional instruments.

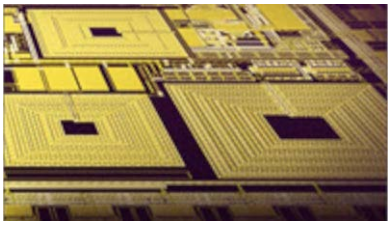
Typical applications

- Optical devices (laser diodes, photodiodes, LEDs, etc.)
- Optoelectronic components (ITLA, CDM, ICR, IC-TROSA, etc.)
- Vertical cavity surface emitting laser (VCSEL) sensors/modules
- Silicon photonics
- Integrated circuit (IC) design verification tests/function tests (RF PA/FEM, analog ICs, RFICs, MMICs, etc.)
- Quantum computing (superconducting, trapped ions, silicon-based, etc.)
- Semiconductor devices (FETs, diodes, transistors, etc.)
- Passive component devices (resistors, varistors, capacitors, etc.)









Integrated sweep and arbitrary waveform measurement functionality

The PZ2100 series' SMU has capabilities that allow it to perform more than just simple DC and pulsed measurements. They have a built-in sweep capability that supports all of the standard sweep parameters, such as linear and logarithmic modes, single and double sweep functions, and constant and pulsed sweep operations. The user can make sweep measurements just as efficiently on the PZ2100 series' SMU under remote control using SCPI commands. The PZ2100 series' GUI helps the user review the sweep settings for debugging and make sweep measurements even from the instrument front panel. This integrated sweep measurement capability improves efficiency and reduces measurement setup time.

The PZ2100 series' SMU has list sweep capability. The list sweep functions enable you to create waveforms with up to 1,000,000 steps with PZ2110A for maximum flexibility, while the others have up to 2,000 steps. You can specify a waveform of arbitrary shape using familiar spreadsheet-compatible data-entry formats. The list sweep feature is especially useful when characterizing devices where the response varies depending on the applied voltage or current. You now have the flexibility to focus on areas of interest.

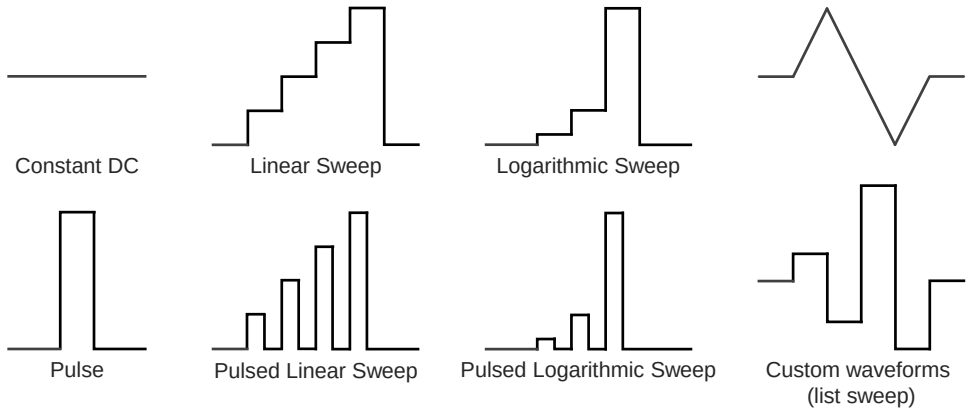
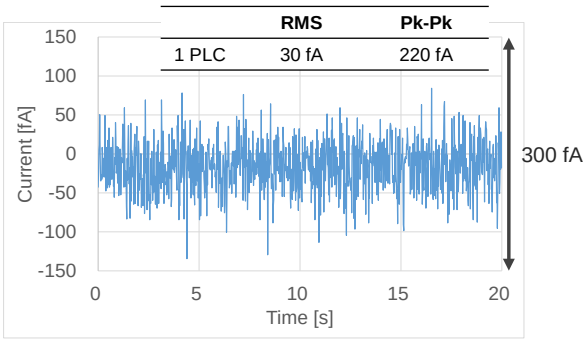


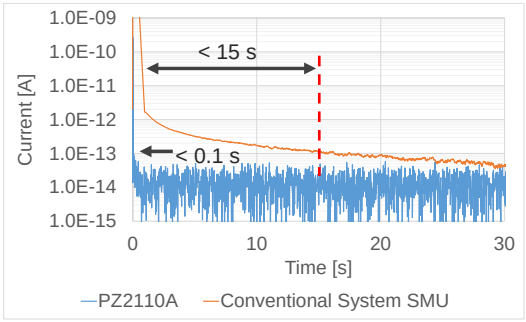
Figure 6. Built-in functions provide flexible waveform generation capabilities

Keysight PZ2110A High-Resolution SMU

The Keysight PZ2110A is a precision SMU that expands precise measurements from conventional static measurements to fast dynamic measurements. It has a resolution of 10 fA and a noise level of 30 fArms with a 1-power line cycle (PLC) aperture time for static measurement. Its fast current measurement settling time within 0.1 s to within the settling band (±100 fA) enables you to perform precise low current measurements more quickly than ever before. It has a pulse measurement as narrow as 20 µs, while for the fast dynamic measurement, it supports up to 1.25 MSa/s sampling rate with a digitizer mode. Its narrow pulse capability enables you to suppress the self-heat effect to reveal the true characteristics of the devices. It covers currents up to 315 mA and voltages up to 210 V for both source and measurement functions, making it ideal for a wide variety of current versus voltage (IV) measurement tasks that require both high resolution and accuracy. The PZ2110A can accurately perform characterization, parametric tests, and reliability tests of semiconductors, active/passive components, and general electronic devices.



Measurement noise, 10 nA range, no load, 0 V, triax cable (3 m)



Settling Time to within ±100 fA settling band, ≤10 nA range, no load, 0 V to 200 V, no cable

Figure 7. The PZ2110A enables performing precise low current measurements more quickly than ever before

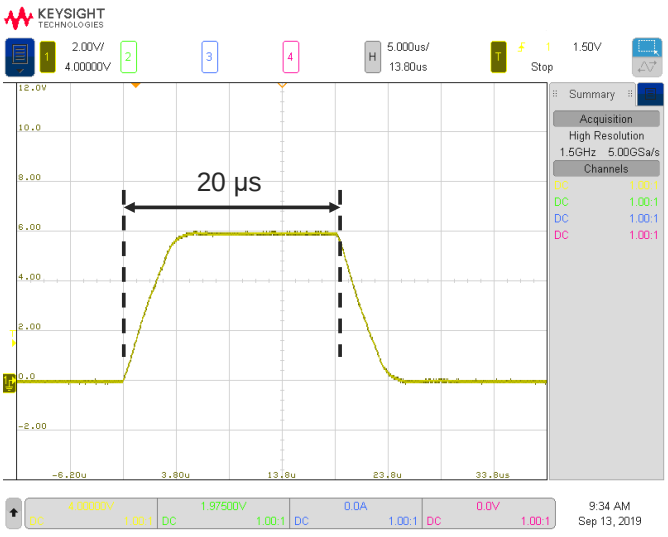


Figure 8. Narrow pulse down to 20 µs enables you to suppress the self-heat effect to reveal the true characteristics of the devices

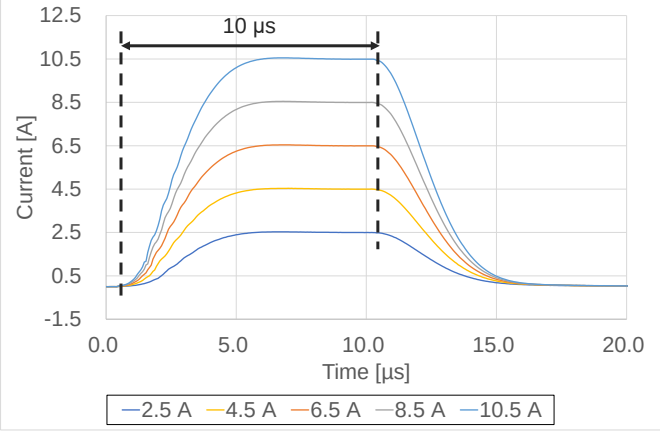
Keysight PZ2120/21A High-Speed SMU

The Keysight PZ2120A and PZ2121A are high-speed precision SMUs featuring best-in-class narrow pulse width, fast digitizer mode, fast transient response, and seamless current measurement range. They enable a wide range of emerging applications across a wide output range of up to 60 V/3.5 A DC/10.5 A pulse and a high resolution of up to 6 µV/100 fA.

The PZ2121A is capable of pulsed/dynamic measurements with best-in-class narrow pulse width down to 10 µs and a fast digitizer mode with sampling rates of up to 15 MSa/s. The Keysight PX0105A low inductance cable is well-designed for the PZ2121A and reduces the measurement error caused by the cable inductance in narrow pulsed measurements. These capabilities make the PZ2121A suitable for emerging applications such as vertical-cavity surface-emitting laser (VCSEL) optical devices.

The PZ2120A expands static DC measurements for a wide range of integrated circuit (IC) testing to emerging dynamic measurements with a sampling rate up to 1 MSa/s, seamless current measurement ranging, and narrow pulse width down to 50 µs. The PZ2120A's fast transient performance enables it to reduce the transient voltage drop due to pulsed loading and recover quickly to its program voltage. These capabilities make the PZ2120A suitable for design verification and production IC testing, such as RF PA/FEM.

In addition, their low measurement noise performance of as low as 400 fArms at 1 PLC enables measurements with shorter aperture times, and their seamless current measurement ranging function enables a wide dynamic range and eliminates range change time, which improves test throughput.



PX0105A
low inductance cable

Figure 9. 10 µs narrow pulse output with measuring at 15 MSa/s sampling rate

Keysight PZ2130/31A High-Channel Density SMU

The Keysight PZ2130A and PZ2131A are high-channel density precisionSMUs with 5 channels per module. It allows for the integration of up to 20 SMU channels into valuable 1U height, full width, rack space, and saving space at a low cost per channel for a wide range of applications requiring numerous precision power supplies. The channels can work synchronously in the module and support accurate measurement in the range of up to 30 V / 500 mA with resolution down to 6 µV / 10 pA (100 pA for the PZ2130A). Besides, Ch1 and Ch2 expand the maximum current to +750 mA by over range capability. The narrow pulse function with a width down to 100 µs and fast Digitizer Mode with a sampling rate up to 500 kSa/s allow the PZ2131A to expand the conventional static DC measurements to emerging dynamic measurements. Their seamless current measurement ranging function eliminates the time it takes to change the range and expands the dynamic range to cover multiple measurement ranges, which reduces test duration. These capabilities make the PZ2130A and PZ2131A suitable for applications that require numerous precision power supplies, such as semiconductor reliability tests, Optoelectronics, and integrated circuit (IC) tests. The Keysight PX0107A low noise filter adapter lowers its voltage source noise level down to 25 µVrms, which makes it suitable for noise-sensitive applications such as quantum computing as well.

Figure 10. PZ2100 with 20 channels configuration integrating four PZ2131A modules

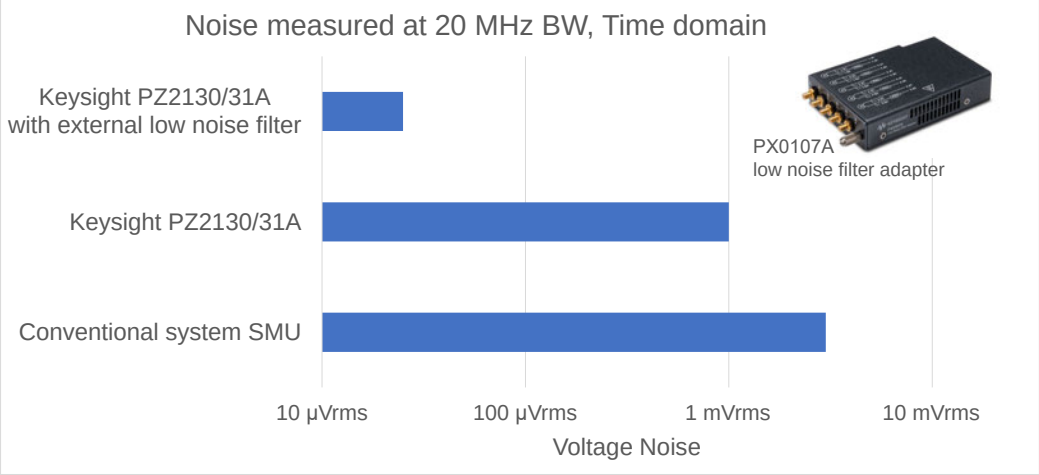


Figure 11. PX0107A dramatically reduces output noise

Single-Box Solution Offers Easy Integration and Time Efficiency

Single-box solution simplifies synchronization with multiple SMUs at <50 ns accuracy

Integrating the source and measurement resources in an SMU allows much tighter synchronization than is possible with separate instruments. In addition, the PZ2100 Series provides flexible triggering options that define the measurement points independently from the sourced current or voltage waveform. You can operate multiple channels in synchronization or independently.

The PZ2100 Series is a single-box solution that simplifies channel stacking and synchronization, which removes integration and coding complexity. The PZ2100A's 6 internal trigger lines enable synchronization among the channels at less than 50 ns accuracy without any cabling. The external trigger ports on the mainframe and modules allow it to synchronize with any external equipment flexibly and accurately. Because the SMUs function as precision power supplies and work synchronously with the other equipment in a wide range of applications, these essential capabilities enable the PZ2100 Series to meet the requirements of various applications.

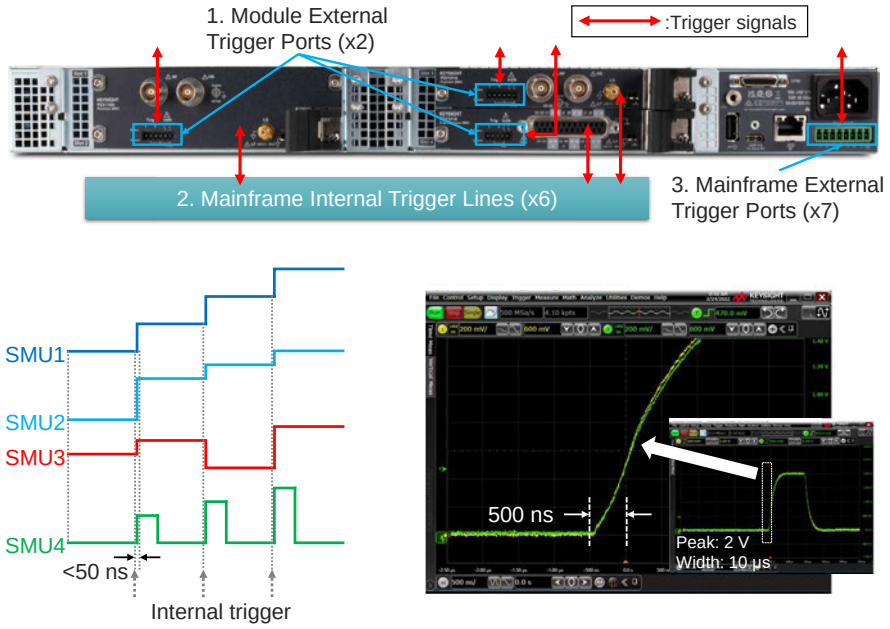


Figure 12. Internal trigger lines enable channel synchronization at less than 50 ns accuracy, and external trigger ports enable synchronization with any piece of external equipment

User-friendly GUI accelerates the test prototyping, debugging, and troubleshooting

The PZ2100 Series has a user-friendly graphical user interface (GUI) that provides two view modes, meter view, and menu view, and collectively manages a maximum of 20 channels. Select an appropriate view for your purpose to set and review the status of all the channels in a single interface; this helps you accelerate test prototyping, debugging, and troubleshooting.

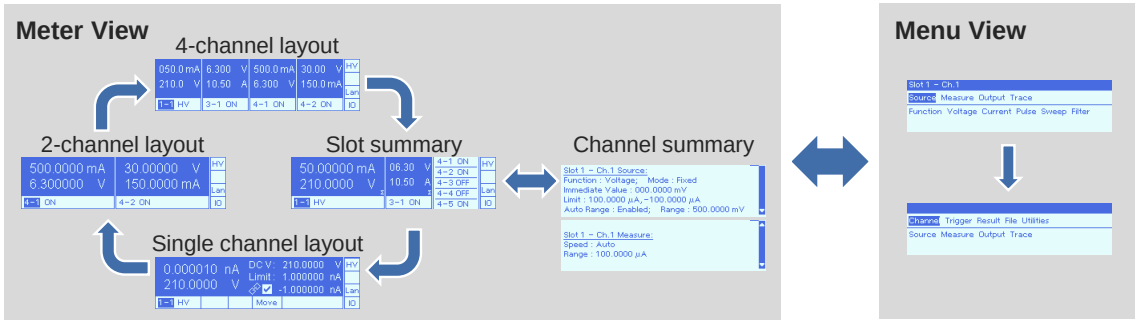


Figure 13. Graphical user interface collectively managing 20 channels at maximum

SCPI programming via LAN/USB/GPIB for easy adoption to various environments

The PZ2100 Series supports Standard Commands for Programmable Instruments (SCPI), a popular and easy-to-understand instrument control protocol commonly used among Keysight SMUs such as the B2900 Series. Because many of its commands are compatible with existing SMUs, you can minimize code conversion work and enable remote control through LAN / USB / GPIB using simple programming to align with various environments.

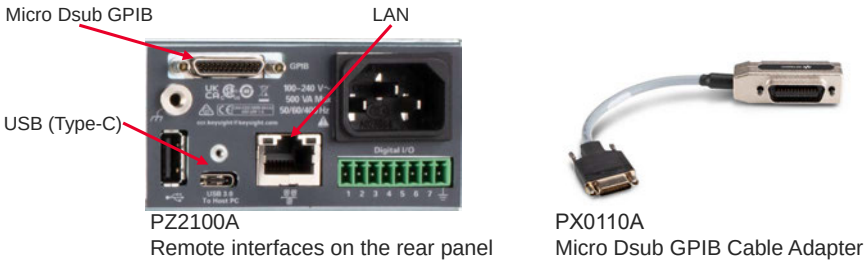


Figure 14. Remote interface on the PZ2100A rear panel and the PX0110A GPIB cable adapter

Remote control options enable quick measurements without programming

The PZ2100 Series can also be used hand-in-hand with remote control software. This software can accelerate your research, development, and design verification activities, enabling more accurate and reliable data acquisition and more efficient use of the equipment.

PW9251A PathWave IV Curve

The PW9251A PathWave IV Curve is a ready-made GUI software that performs a variety of synchronous current-voltage (IV) measurements on up to 20 channels of SMUs without programming. You can review test results immediately after making measurements using various analysis functions on graphs and tables. Export functions for graphs with markers and tables support efficient reporting. In addition, the test result files contain all the settings, allowing you to review and repeat a test accurately.

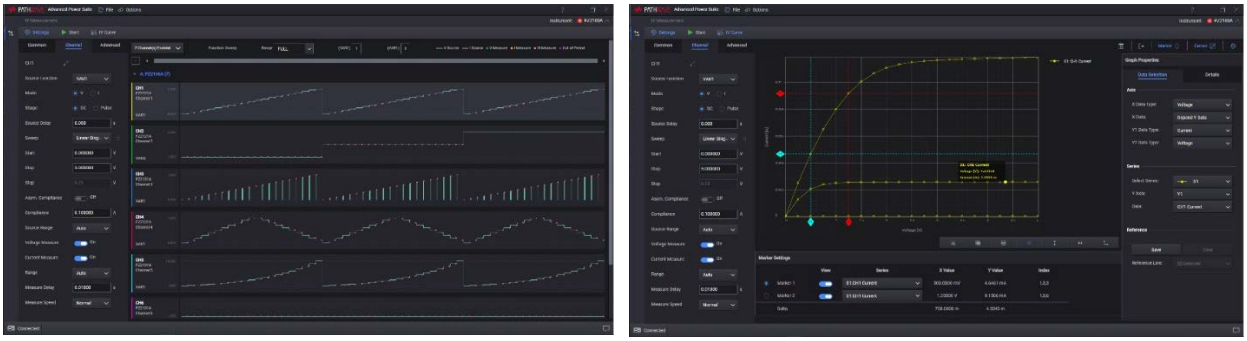


Figure 15. PathWave IV Curve Software

BV0003B PathWave BenchVue Power Supply Control App

The BV0003B PathWave BenchVue Power Supply Control App offers easy control of your power supplies, allowing you to effortlessly set parameters, visualize IV data, and quickly build automated tests. With this application, you can monitor and record your power supply output to assess the impact of power draw for specific events, supporting up to 20 channels of SMUs - all without the need for programming.

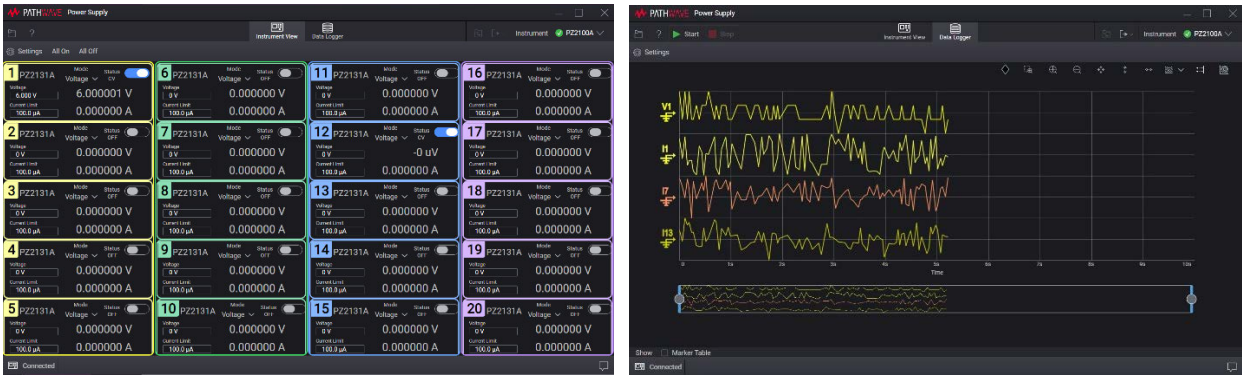


Figure 16. PathWave BenchVue Power Supply Control App

Comparison Table by Model

		PZ2110A	PZ2120A	PZ2121A	PZ2130A	PZ2131A
Number of channels		1	1		5	
Number of slots		2	1		1	
Output range	Max. voltage	210 V	60 V		30 V	
	Max. current (DC)	315 mA	3.5 A		500 mA	
	Max. current (Pulse)	315 mA	10.5 A		N/A	500 mA
Resolution	Min. voltage	500 nV	6 µV		6 µV	
	Min. current	10 fA	100 fA		100 pA	10 pA
Current measurement noise RMS (1 PLC)		30 fArms	400 fArms		75 pArms	35 pArms
Voltage source noise	Peak-to-peak (0.1 - 10 Hz)	< 4 µV	< 12 µV		< 20 µV	
	Peak-to-peak (20 MHz)	< 25 mV	< 30 mV		< 12 mV	
	RMS (20 MHz)	< 3 mVrms	< 2.5 mVrms		< 1 mVrms (< 25 µVrms with PX0107A)	
	RMS (200 MHz)	< 5 mVrms	< 4.5 mVrms		< 3.3 mVrms	
Min. pulse width		20 µs	50 µs	10 µs	N/A	100 µs
Max. slew rate		1.4 V/µs	3.5 V/µs		0.15 V/µs	
Digitizer mode		Yes	Yes		No	Yes
Max. sampling rate		1.25 MSa/s	1 MSa/s	15 MSa/s	250 kSa/s	500 kSa/s
Auto measurement ranging		Yes	Yes		Yes	
Seamless current measurement ranging		No	Yes		Yes	
Remote sense (4-wire connection)		Yes	Yes		Yes	
Guard shield port for low current measurement		Yes	Yes		Yes	
Operation mode	Normal mode	Yes	Yes		Yes	
	PS mode	Yes	Yes		Yes	
	High capacitance mode	No	Yes		No	
	Laser diode mode	No	Yes		No	

Specification

Specification conditions

The measurement and programming accuracy are specified at the module front-panel connector terminals. Accuracy is specified under the following conditions:

Key conditions	PZ2110A	PZ2120/21A	PZ2130/31A
Temperature	23 °C ± 5 °C [1]	0 °C to 50 °C	
Humidity [2]	20% to 60% [3]	10% to 80% [4]	
Warm-up time	40 minutes		
Self-calibration	Performed within the last 24 hours. Ambient temperature changes less than ± 5 °C after self-calibration execution.		
Calibration period	One year		
Aperture time	1 PLC [5] (100 nA to 300 mA ranges, voltage ranges) 10 PLC (1 nA and 10 nA ranges)	1 PLC	
Terminal connection	Kelvin connection		

1. Double for 0 °C to 18 °C, and 28 °C to 40 °C unless noted otherwise.
2. Relative Humidity, non-condensing.
3. double for 60% to 70% unless noted otherwise.
4. The maximum % Relative Humidity is up to 40°C and decreases linearly to 48% RH at 50 °C. From 40°C to 50°C, it follows the line of constant dew point.
5. Power line cycle.

PZ2110A Maximum voltage and current

Maximum voltage	Maximum current	Maximum power
± 21 V	± 315 mA	6.6 W
± 105 V	± 105 mA	11 W
± 210 V	± 50 mA	10.5 W

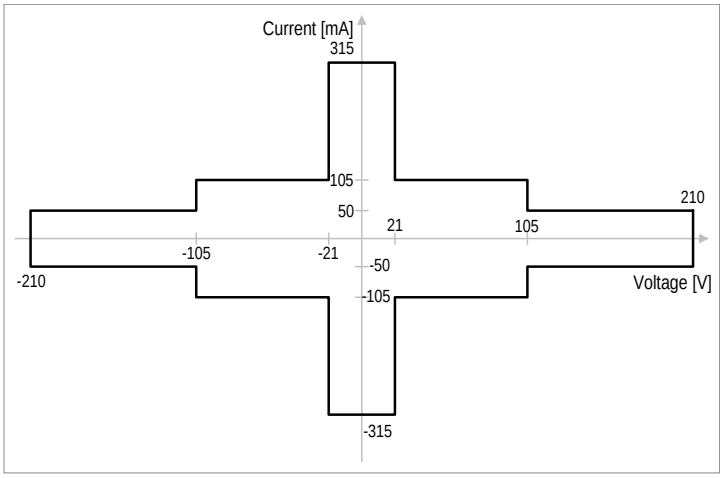


Figure 17. PZ2110A DC voltage and current output capability

PZ2120/21A Maximum voltage and current

DC output capability

Voltage capability		Current capability	
Min	**Max**	**Min**	**Max**
- 0.6 V	+ 5.5 V	- 130 mA	+ 3.5 A
- 2 V	+ 6.3 V		+ 3 A
- 2 V	+ 14 V		+ 2 A
- 6.3 V	+ 20 V		+ 1.5 A
- 12 V	+ 20 V		+ 0.8 A
- 20 V	+ 20 V		+ 0.5 A
- 50 V	+ 50 V		+ 130 mA
- 60 V	- 50 V		+ 100 mA
+ 50 V	+ 60 V	- 100 mA	+ 130 mA

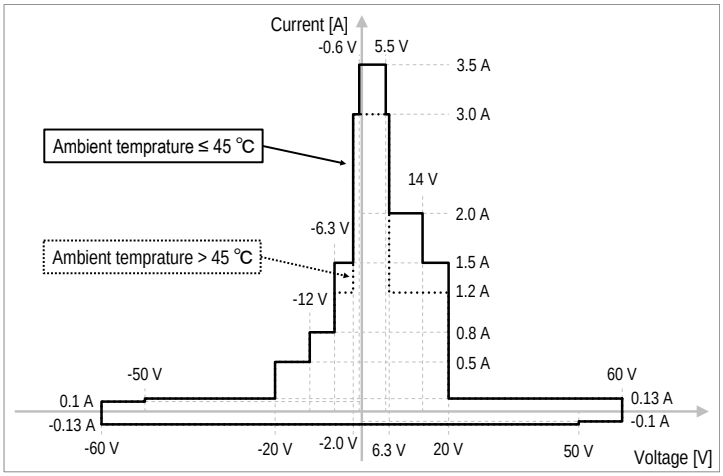


Figure 18. PZ2120/21A DC voltage and current output capability

Pulsed output capability

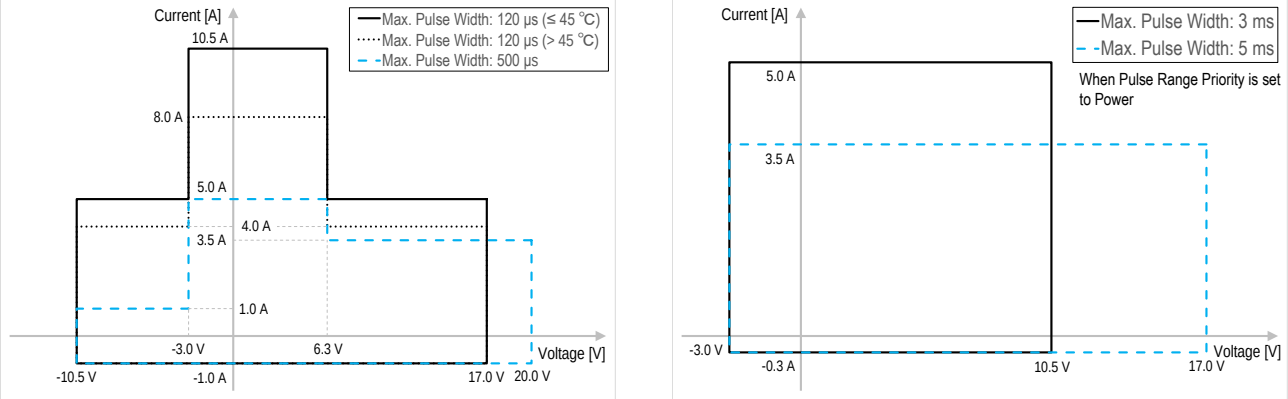


Figure 19. PZ2120/21A pulsed voltage and current output capability

PZ2130/31A Maximum voltage and current

Maximum voltage and current per channel

Maximum voltage	Channel	Maximum current	Maximum power
± 6.3 V	1, 2	+ 750 mA [1], - 500 mA	+ 4.7 W, -3.2 W
± 6.3 V	3, 4, 5	± 500 mA	± 3.2 W
± 30 V	1, 2, 3, 4, 5	± 150 mA	± 4.5 W

1. Over range (150% of 500 mA range) for positive current.

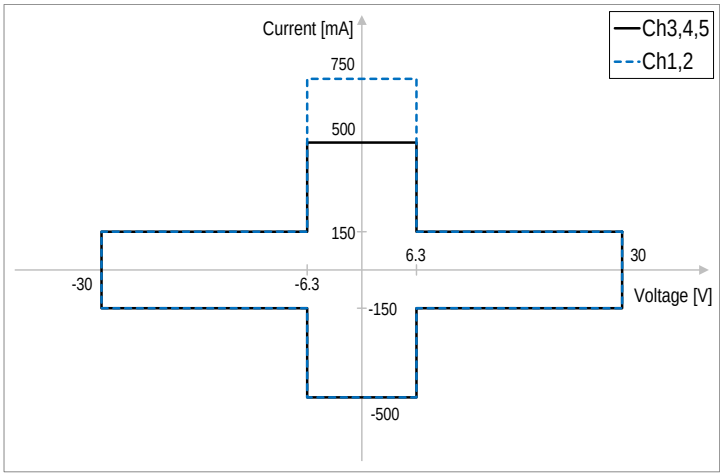


Figure 20. PZ2130/31A voltage and current output capability per channel

Maximum voltage and current per module

Limit current per module to satisfy the equation as below:

Quadrant	Maximum current per module (when channels work with ranges below)		
	6 V range	30 V range	6 V and 30 V ranges mixed
1st	3 A	750 mA	$(I_{total\_p(6V)}) / 3 + (I_{total\_n(6V)}) / 2 + (I_{total(30V)}) / 0.75 \leq 1$
2nd to 4th	2 A	750 mA	

$I_{total\_p(6V)}$, $I_{total\_n(6V)}$, $I_{total(30V)}$ are the sum of the following parameters for the channels working within the specified voltage range. Where $+I_{comp}$ / $-I_{comp}$ are the positive/negative current compliance values.

Parameter	Range	Source function		Value
		Mode	Polarity	
$I_{total\_p(6V)}$	6 V	Voltage	Either	$+I_{comp}$ when $+I_{comp} \geq 1.4 \times abs(-I_{comp})$
		Current	Positive	The source value
$I_{total\_n(6V)}$	6 V	Voltage	Either	The absolute $-I_{comp}$ when $+I_{comp} < 1.4 \times abs(-I_{comp})$
		Current	Negative	The absolute source value
$I_{total(30V)}$	30 V	Voltage	Either	The larger one of absolute $+I_{comp}/-I_{comp}$
		Current	Either	The absolute source value

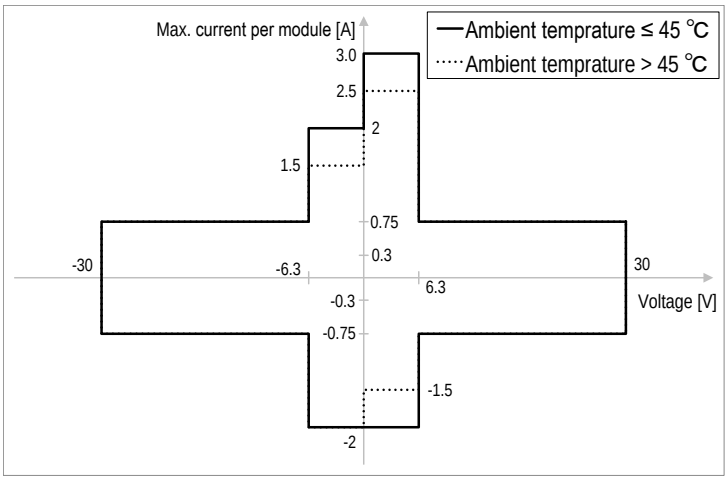


Figure 21. PZ2130/31A voltage and total current output capability per module

PZ2110A Source/measurement specifications and characteristics

Voltage source/measurement specifications

Range	Programming and measurement		Source noise (peak to peak) 0.1 Hz to 10 Hz [2]	Max current
	Resolution	Accuracy (% of reading + offset) 23 °C ± 5 °C [1]		
± 0.5 V	0.5 µV	± (0.015% + 120 µV)	< 4 µV	± 315 mA
± 2 V	2 µV	± (0.015% + 140 µV)	< 5 µV	± 315 mA
± 6 V	6 µV	± (0.015% + 250 µV)	< 5 µV	± 315 mA
± 20 V	20 µV	± (0.015% + 900 µV)	< 15 µV	± 315 mA
± 40 V	40 µV	± (0.015% + 1 mV)	< 30 µV	[3]
± 100 V	100 µV	± (0.015% + 2.5 mV)	< 60 µV	[3]
± 200 V	200 µV	± (0.015% + 2.8 mV)	< 100 µV	± 50 mA (100 mA or less ranges)

1. Double for 0 °C to 18 °C, and 28 °C to 40 °C unless noted otherwise.
2. Supplemental characteristics, 0 V sourced, 10 mA or less ranges.
3. ± 315 mA (-21 V ≤ V_o ≤ 21V), ± 105 mA (V_o < -21 V, V_o > 21 V).

Current source/measurement specifications

Range	Programming and measurement		Source noise (peak to peak) 0.1 Hz to 10 Hz [2]	Max current
	Resolution	Accuracy (% of reading + offset) 23 °C ± 5 °C [1]		
± 1 nA	10 fA	± (0.1% + 1.5 pA + 1 fA x V_o) [3]	< 200 fA	± 210 V
± 10 nA	10 fA	± (0.1% + 3 pA + 10 fA x V_o) [3]	< 200 fA	± 210 V
± 100 nA	100 fA	± (0.05% + 20 pA)	< 2 pA	± 210 V
± 1 µA	1 pA	± (0.05% + 100 pA)	< 2 pA	± 210 V
± 10 µA	10 pA	± (0.04% + 2 nA)	< 80 pA	± 210 V
± 100 µA	100 pA	± (0.03% + 3 nA)	< 90 pA	± 210 V
± 1 mA	1 nA	± (0.03% + 60 nA)	< 8 nA	± 210 V
± 10 mA	10 nA	± (0.03% + 200 nA)	< 10 nA	± 210 V
± 100 mA	100 nA	± (0.04% + 6 µA)	< 200 nA	[4]
± 300 mA	300 nA	± (0.04% + 20 µA)	< 1 µA	± 21 V (100 V or less ranges)

1. Double for 0 °C to 18 °C, and 28 °C to 40 °C unless noted otherwise.
2. Supplemental characteristics, 0 A sourced.
3. Aperture time: 10 PLC.
4. ± 210 V (-50 mA ≤ I_o ≤ 50 mA), ± 105 V (I_o < -50 mA, I_o > 50 mA).

Operation mode

Operation mode	
Normal mode	Default mode.
PS mode	Only V source mode is available.

Source supplemental characteristics

Source supplemental characteristics				
Max output power and source/sink limits			11 W (± 21 V at ± 315 mA, ± 105 V at ± 105 mA, ± 210 V at ± 50 mA, four quadrant source or sink operation)	
Current compliance setting accuracy			Accuracy is same as current source; minimum value is 1% of range (100 nA to 300 mA ranges) 1 nA (1 nA, 10 nA ranges)	
Voltage compliance setting accuracy			Accuracy is same as voltage source; minimum value is 1% of range (6 V to 200 V ranges) 50 mV (500 mV, 2 V ranges)	
Over range	Voltage	All ranges	105% of range	
	Current	300 mA range	105% of range	
		Other ranges	115% of range	
Over-temperature protection			Output turns off then resets at over temperature sensed internally.	
Voltage output settling time			Time required to reach within 0.1% of final value at described load condition; step is 10% to 90% range with 10 mA compliance, filter auto settings < 45 µs (500 mV to 40 V ranges, open load) < 100 µs (100 V range, 100 kΩ load) < 200 µs (200 V range, 100 kΩ load)	
Slew rate			Step is 0 V to + 200 V at open load condition 1.4 V/µs (PS mode with 50 mA compliance) 1 V/µs (Normal mode with 10 mA compliance)	
Current output settling time			Time required to reach within 0.1% [1] of final value at described load condition; step is 10% to 90% range with 6 V compliance, filter auto settings < 18 ms (1 nA, 10 nA ranges, 50 MΩ load) < 1.2 ms (100 nA, 1 µA ranges, 500 kΩ load) < 400 µs (10 µA, 100 µA ranges, 5 kΩ load) < 70 µs (1 mA range, 50 Ω load) < 40 µs (10 mA range, 50 Ω load) < 40 µs (100 mA range, 500 mΩ load) < 40 µs (300 mA range, 100 mΩ load)	
V source noise (BW = 20 MHz)			< 3 mVrms, < 25 mVp-p, 20 V range, 0 V sourced (10 mA or less ranges) < 6 mVrms, < 40 mVp-p, 20 V range, 0 V sourced (100 mA, 300 mA ranges)	
V source noise (BW = 200 MHz)			< 5 mVrms, < 50 mVp-p, 20 V range, 0 V sourced	
Voltage range switching transient noise			< 250 mV, 100 kΩ load, 20 MHz bandwidth	
Current range switching transient noise			< 70 mV, 100 kΩ load, 20 MHz bandwidth, V source mode, 20 V range	
Load transient response time in voltage source mode			Time to recover to within the settling band With 2.2 µF cap (ESR = 50 mΩ) at load, remote sensing at cap 6 V range with 5 V source, 300 mA compliance in Normal/PS mode	
			Rise time (10% to 90%)	1 µs
			Settling band (with a step from 30 mA to 270 mA)	± 20 mV
			Recovery time	< 70 µs
Voltage load regulation			Load regulation error is included in voltage accuracy specification (typical)	
Current load regulation			Load regulation error is included in current accuracy specification (typical)	

1. 0.3% for 100 mA, 300 mA ranges.

Measurement supplemental characteristics

Measurement supplemental characteristics			
Over range	Voltage	200 V range	105% of range
		Other ranges	110% of range
	Current	300 mA range	105% of range
		Other ranges	115% of range
Current measurement noise (1 PLC, 10 nA range) [1]			30 fArms, 220 fAp-p

1. Observed data.

Current measurement noise (observed data)

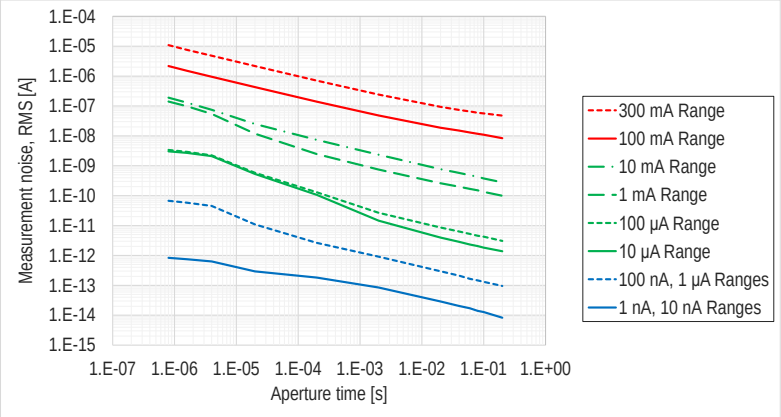


Figure 22. Current measurement noise

Programmable output resistance [1]

In its default state, the PZ2110A behaves like either an ideal voltage source with a negligibly small source resistance or an ideal current source with a huge source resistance. The programmable output resistance feature allows you to specify a particular output resistance.

Mode	Constant resistance
Series resistance (R_s) at voltage source	- (Load Resistance/2) ≤ R_s ≤ Load Resistance, for resistive load
	R_s ≤ 2 kΩ at 1 mA,10 mA,100 mA, and 300 mA ranges, ≤ 40 kΩ at 10 µA and 100 µA ranges, ≤ 200 kΩ at 1 µA range, or ≤ 100 kΩ at other ranges.
	R_s can be limited by capacitive load
Shunt resistance (R_{sh}) at current source	Load Resistance ≤ R_{sh} ≤ 2 GΩ, for resistive load
	R_{sh} ≥ 100 kΩ at 1 nA and 10 nA range, ≥ 10 kΩ at 100 nA and 1 µA range, ≥ 1 kΩ at 10 µA and 100 µA range, or ≥ 200Ω at other ranges.
	R_{sh} can be limited by capacitive load

1. Programmable output resistance is only available for DC output.

PZ2120/21A Source/measurement specifications and characteristics

Voltage source/measurement specifications

Range	Programming and measurement			Source noise (peak to peak) 0.1 Hz to 10 Hz [2]	Max current
	Resolution	Accuracy (% of reading + offset), Tcal [1] ± 5 °C	Tempco (% of reading + offset) / °C, 0 °C to 50 °C		
± 6 V	6 µV	± (0.02% + 300 µV)	± (0.0005%+1 µV)	< 12 µV	Varies [3]
± 20 V	60 µV	± (0.02% + 3 mV)	± (0.0005%+1 µV)	< 75 µV	Varies [3]
± 60 V	60 µV	± (0.02% + 3 mV)	± (0.0005%+1 µV)	< 75 µV	Varies [3]

1. Tcal: Ambient temperature when self-calibration was performed.
2. Supplemental characteristics, 0 V sourced, 10 mA range.
3. See Figure X and Y.

Current source/measurement specifications

Range	Programming and measurement			Source noise (peak to peak) 0.1 Hz to 10 Hz [2]	Max voltage
	Resolution	Accuracy (% of reading + offset), Tcal [1] ± 5 °C	Tempco (% of reading + offset) / °C, 0 °C to 50 °C		
± 100 nA	100 fA	± (0.07% + 100 pA)	± (0.0006% + 2 pA)	< 1.5 pA	± 60 V
± 1 µA	1 pA	± (0.07% + 100 pA)	± (0.0006% + 4 pA)	< 2.5 pA	± 60 V
± 10 µA	10 pA	± (0.05% + 700 pA)	± (0.0006% + 135 pA)	< 30 pA	± 60 V
± 100 µA	100 pA	± (0.05% + 6 nA)	± (0.0006% + 200 pA)	< 200 pA	± 60 V
± 1 mA	1 nA	± (0.05% + 60 nA)	± (0.0006% + 2 nA)	< 3 nA	± 60 V
± 10 mA	10 nA	± (0.05% + 600 nA)	± (0.0006% + 20 nA)	< 20 nA	± 60 V
± 500 mA	500 nA	± (0.13% + 30 µA)	± (0.0006% + 1 µA)	< 1.5 µA	Varies [3]
± 1 A	1 µA	± (0.13% + 60 µA)	± (0.0006% + 2 µA)	< 2.5 µA	Varies [3]
± 3 A	3.5 µA	± (0.3% + 1 mA)	± (0.0025% + 33 µA)	< 25 µA	Varies [3]
± 3.5 A	3.5 µA	± (0.3% + 1 mA)	± (0.0025% + 33 µA)	< 25 µA	Varies [3]
± 5 A	5 µA	± (0.13% + 1 mA) [4, 5]	± (0.002% + 33 µA) [4, 5]	N/A	-10.5 V, 17 V
		± (0.3% + 1 mA) [6]	± (0.002% + 33 µA) [6]	N/A	-3 V, +10.5 V
± 10 A [4]	10 µA	± (0.13% + 1 mA) [5]	± (0.002% + 33 µA) [5]	N/A	-3 V, + 6.3 V

1. Tcal: Ambient temperature when self-calibration was performed.
2. Supplemental characteristics, 0 A sourced, 6 V range.
3. See Figure X and Y.
4. Typical. Only current source mode is available.
5. Aperture time: 0.002 PLC (40 µs). Repeat measurements 10 times and average them.
6. When Pulse Range Priority is set to Power. Aperture time: 0.1 PLC (2 ms). Repeat measurements 10 times and average them.

Remote transient voltage measurement specifications

Range	Programming and measurement		
	Resolution	Accuracy (% of reading + offset), Tcal [1] ± 5 °C	Tempco (% of reading + offset) / °C, 0 °C to 50 °C
± 6 V	6 µV	± (0.055% + 300 µV)	± (0.0005%+1 µV)
± 20 V	60 µV	± (0.055% + 3 mV)	± (0.0005%+1 µV)
± 60 V	60 µV	± (0.055% + 3 mV)	± (0.0005%+1 µV)

1. Tcal: Ambient temperature when self-calibration was performed.

Seamless current measurement ranging specifications

The seamless current measurement ranging function enables the SMU channels to make a wide dynamic range measurement without range changing. It automatically detects which current measurement range will return the most precise measurement.

Range	Programming and measurement		
	Resolution	Accuracy (% of reading + offset), Tcal [1] ± 5 °C	Tempco (% of reading + offset) / °C, 0 °C to 50 °C
± 10 mA	10 nA	± (0.23% + 5.5 µA)	± (0.0006% + 20 nA)

1. Tcal: Ambient temperature when self-calibration was performed.

Example of calculating accuracy with temperature coefficient

Calculate the accuracy of a 500 µA output in the 1 mA range. Assume the ambient temperature is 15 °C within the last 24 hours after self-calibration was performed at 19 °C. The ambient temperature changes less than ± 5 °C after self-calibration execution but falls outside of 23 °C ± 5 °C.

$$\text{Temperature Variation} = (23℃ - 5℃) - 15℃ = 3℃$$

$$\text{Accuracy} = (500\ \mu\text{A} * 0.03\% + 60\ \text{nA}) + \frac{500\ \mu\text{A} * 0.0006\% + 2\ \text{nA}}{1℃} * 3℃$$

$$= 210\ \text{nA} + 15\ \text{nA} = 225\ \text{nA}$$

Therefore, the actual output will fall within 225 nA of 500 µA.

Operation mode

Operation mode	
Normal mode	Default mode.
PS mode	Only V source mode is available.
High capacitance mode	Only V source mode is available. Current ranges from 10 µA to 3.5 A are available.
Laser diode mode	Both V and I source modes are available in applying pulse with the fast rise time.

Source supplemental characteristics

Source supplemental characteristics				
Max output power and source/sink limits			30 W (+ 20V at + 1.5 A), + 3.5 A at + 5.5 V in 1st quadrant 10 W (- 20 V at +0.5 A), + 3.5 A at - 0.6 V in 2nd quadrant 7.8 W (- 60 V at - 130 mA), - 130 mA at - 60 V in 3rd quadrant 6.5 W (50 V at - 130 mA), - 130 mA at + 50 V in 4th quadrant)	
Current compliance setting accuracy			Accuracy is same as current source; minimum value is 1% of range (100 nA to 3.5 A ranges)	
Voltage compliance setting accuracy			Accuracy is same as voltage source; minimum value is 1% of range (6 V to 60 V ranges)	
Over range	Voltage	6 V range	105% of range	
		Other ranges	100% of range	
	Current	10 A range	105% of range for positive current 10% of range for negative current	
		5 A range	100% of range for positive current 20% of range for negative current (6% when Pulse Range Priority is set to Power)	
		3 A, 3.5 A ranges	100% of range for positive current (Negative current is limited to -130 mA)	
		500 mA, 1 A ranges	105% of range for positive current (Negative current is limited to -130 mA)	
		Other ranges	105% of range	
Over-temperature protection			SMU shutdowns at over temperature sensed internally	
Voltage output settling time			Time required to reach within 0.1% of final value at described load condition; step is 10% to 90% range with 10 mA compliance, filter auto settings < 10 µs (6 V range, open load) < 13 µs (20 V range, 50 kΩ load) < 26 µs (60 V range, 200 kΩ load)	
Slew rate			Step is 0 V to 60 V at open load condition 3.5 V/µs (PS mode with 500 mA range 130 mA compliance) 2.3 V/µs (Normal mode with 10 mA range 10.5 mA compliance)	
Current output settling time (DC)			Time required to reach within 0.1% of final value at described load condition; step is 10% to 90% range; with 6 V or 5.5 V compliance, filter auto settings < 3.2 ms (100 nA, 1 µA ranges, 500 kΩ load) < 600 µs (10 uA, 100 µA ranges, 5 kΩ load) < 80 µs (1 mA, 10 mA ranges, 50 Ω load) < 20 µs (500 mA, 1 A ranges, 100 mΩ load) < 70 µs (3 A, 3.5 A ranges, 100 mΩ load)	
Current output settling time (Pulse)			Time required to reach within 1% of final value at described load condition; step is 100 mA to 90% range for transient priority mode and is 10% to 90% range for power priority mode; with 6 V compliance; load is connected through 1.5 m low inductance BNC cable (PX0105A-001) < 50 µs (Power priority mode, 5 A range, 100 mΩ load) < 4.5 µs (transient priority mode, 5 A range, 100 mΩ load) < 6 µs (transient priority mode, 10 A range, 100 mΩ load)	
V source noise (BW = 20 MHz)	≤10 mA ranges		< 2.5 mVrms, < 30 mVp-p, 0 V sourced	
	>10 mA ranges		< 3.5 mVrms, < 40 mVp-p, 0 V sourced	
V source noise (BW = 200 MHz)	≤10 mA ranges		< 4.5 mVrms, < 60 mVp-p, 0 V sourced	
	>10 mA ranges		< 6 mVrms, < 70 mVp-p, 0 V sourced	
Load transient response time in voltage source mode			Time to recover to within the settling band With 4.7 µF cap (ESR = 50 mΩ) at load, remote sensing at cap 6 V range with 4 V source, + 3.5 A/- 130 mA compliance in Normal mode	
			Rise time (10% to 90%)	1 µs
			Settling band (with a step from 0.3 A/1.5 A to 1.5 A/0.3 A)	± 20 mV
			Recovery time	< 20 µs
Voltage load regulation			Load regulation error is included in voltage accuracy specification (typical)	
Current load regulation [1]			Load regulation error is included in current accuracy specification as specification for $\|V_o\| \leq 40$ V, as typical for 40 V < $\|V_o\|$	

1. Vo is the output voltage.

Measurement supplemental characteristics

Measurement supplemental characteristics

Over range	Voltage	6 V range	105% of range
		Other ranges	100% of range
	Current	10 A range	105% of range for positive current 10% of range for negative current
		5 A range	100% of range for positive current 20% of range for negative current (6% when Pulse Range Priority is set to Power)
		3 A, 3.5 A ranges	100% of range for positive current (Negative current is limited to -130 mA)
		500 mA, 1 A ranges	105% of range for positive current (Negative current is limited to -130 mA)
		Other ranges	105% of range
Current measurement noise (1 PLC)			400 fArms (100 nA range), 600 fArms (1 µA range)

PZ2130/31A Source/measurement specifications and characteristics

Voltage source/measurement specifications

Range	Programming and measurement			Source noise (peak to peak) 0.1 Hz to 10 Hz [2]	Max current
	Resolution	Accuracy (% of reading + offset), Tcal [1] ± 5 °C	Tempco (% of reading + offset) / °C, 0 °C to 50 °C		
± 6 V	6 µV	± (0.015% + 600 µV)	± (0.0005%+1 µV)	< 20 µV	Varies [3]
± 30 V	30 µV	± (0.015% + 1.2 mV)	± (0.0005%+1 µV)	< 85 µV	± 150 mA

1. Tcal: Ambient temperature when self-calibration was performed.
2. Supplemental characteristics, 0 V sourced, 500 mA range.
3. 750 mA and -500 mA for channels 1 and 2; ± 500 mA for channels 3, 4, and 5.

Current source/measurement specifications

Range	Programming and measurement			Source noise (peak to peak) 0.1 Hz to 10 Hz [2]	Max voltage
	Resolution	Accuracy (% of reading + offset), Tcal [1] ± 5 °C	Tempco (% of reading + offset) / °C, 0 °C to 50 °C		
± 10 µA [3]	10 pA	± (0.03% + 1.6 nA)	± (0.002% + 10 pA)	< 170 pA	Varies [4]
± 100 µA	100 pA	± (0.03% + 16 nA)	± (0.002% + 100 pA)	< 440 pA	Varies [4]
± 1 mA	1 nA	± (0.03% + 160 nA)	± (0.002% + 1 nA)	< 30 nA	Varies [4]
± 10 mA	10 nA	± (0.03% + 1.6 µA)	± (0.002% + 10 nA)	< 35 nA	Varies [4]
± 100 mA	100 nA	± (0.03% + 24 µA)	± (0.002% + 150 nA)	< 2.5 µA	Varies [4]
± 500 mA	500 nA	± (0.05% + 125 µA)	± (0.004% + 1 µA)	< 3.5 µA	± 6.3 V

1. Tcal: Ambient temperature when self-calibration was performed.
2. Supplemental characteristics, 0 A sourced, 6 V range.
3. 10 µA range is available only with the PZ2131A.
4. ± 30 V for voltage source, ± 31.5 V for voltage measurement.

Example of calculating accuracy with temperature coefficient

Calculate the accuracy of 500 µA output in the 1 mA range. Assume the ambient temperature is 15 °C within the last 24 hours after self-calibration was performed at 19 °C. The ambient temperature changes less than ± 5 °C after self-calibration execution but falls outside of 23 °C ± 5 °C.

$$\text{Temperature Variation} = (23℃ - 5℃) - 15℃ = 3℃$$

$$\text{Accuracy} = (500\ \mu\text{A} * 0.03\% + 160\ \text{nA}) + \frac{500\ \mu\text{A} * 0.002\% + 1\ \text{nA}}{1℃} * 3℃$$

$$= 310\ \text{nA} + 33\ \text{nA} = 343\ \text{nA}$$

Therefore, the actual output will be within 343 nA of 500 µA.

Operation mode

Operation mode	
Normal mode	Default mode.
PS mode	Only V source mode is available.

Seamless current measurement ranging

The seamless current measurement ranging function enables the SMU channels to make a wide dynamic range measurement without range changing. It automatically detects which current measurement range will return the most precise measurement.

Range group	Available ranges
High group	500 mA, 100 mA, 10 mA, 1 mA ranges
Low group	10 mA, 1 mA, 10 µA ranges

Note:

- The range group is selected automatically by the compliance setting value. When it is set to more than 10 mA, the range group is set to 'High'. Otherwise, it is set to 'Low'.
- When the range group is set to ‘Low’, 5% (typical) error is added to its compliance setting accuracy.

Source supplemental characteristics

Source supplemental characteristics

Max output power and source/sink limits			17.6 W, 3 A in 1st quadrant, 12.6 W, 2 A in the other quadrants (6 V range) 22.5 W, 0.75 A (30 V range)	
Current compliance setting accuracy			Accuracy is same as current source; minimum value is 1% of range (10 µA to 500 mA ranges)	
Voltage compliance setting accuracy			Accuracy is same as voltage source; minimum value is 1% of range (6 V to 30 V ranges)	
Over range	Voltage	6 V range	105% of range	
		30 V range	100% of range	
	Current	500 mA range	150% of range with positive current for Ch 1, 2 100% of range with negative current for Ch 1, 2 100% of range for Ch 3, 4, 5	
		Other ranges	105% of range 100% of range for 1 mA, 10 mA ranges if used with seamless measurement ranging function enabled with low group	
Over-temperature protection			SMU shutdowns at over temperature sensed internally	
Voltage output settling time			Time required to reach within 0.1% of final value at described load condition; step is 10% to 90% range with compliance set to 100% of the range, filter auto settings < 85 µs (PS mode with 6 V range, 1 mA or more ranges, open load)	
Slew rate			Step is 0 V to 30 V at open load condition 0.15 V/µs (PS mode with 10 mA compliance) 0.1 V/µs (Normal mode with 10 mA compliance)	
Current output settling time			Time required to reach within 0.1% of final value at described load condition; step is 10% to 90% range with 6 V compliance, filter auto settings < 2.0 ms (10 µA range, 1 kΩ load) < 1.4 ms (100 µA range, 1 kΩ load) < 200 µs (1 mA range, 10 Ω load) < 140 µs (10 mA range, 10 Ω load) < 110 µs (100 mA range, 100 mΩ load) < 90 µs (500 mA range, 100 mΩ load)	
V source noise (BW = 20 MHz)			< 1 mVrms, < 12 mVp-p, 6 V range (100 mA range, 30 mA compliance)	
V source noise (BW = 200 MHz)			< 3.3 mVrms, < 40 mVp-p, 6 V range (100 mA range, 30 mA compliance)	
Load transient response time in voltage source mode			Time to recover to within the settling band With 2.2 µF cap (ESR = 50 mΩ) at load, remote sensing at cap 6 V range with 500 mA compliance in PS mode	
			Rise time (10% to 90%)	1 µs
			Settling band (with a step from 50 mA to 450 mA)	± 20 mV
			Recovery time	< 70 µs
Remote sense maximum lead drop			Up to 1 V drop per lead	
			6 V range	Hi-Lo: ± 6.5 V maximum
			30 V range	Hi-Lo: ± 25.5 V maximum (Seamless current measurement ranging function enabled with Low Group)
				Hi-Lo: ± 30.5 V maximum (For the other conditions)
Voltage load regulation			Load regulation error is included in voltage accuracy specification (typical)	
Current load regulation [1]			1 mA, 100 mA ranges	$\lvert V_o \rvert \leq 10$ V: 0 ppm
				10 V < $\lvert V_o \rvert \leq 20$ V: ($\lvert V_o \rvert$ -10 V) * 5 ppm of range
				20 V < $\lvert V_o \rvert$: (($\lvert V_o \rvert$ -20 V) * 10 ppm + 50 ppm) of range
			Other ranges	0 ppm

1. V_o is the output voltage.

Measurement supplemental characteristics

Measurement supplemental characteristics

Over range	Voltage	6 V range	105% of range
		30 V range	105% of range for measurement
	Current	500 mA range	150% of range with positive current for Ch 1, 2 100% of range with negative current for Ch 1, 2 100% of range for Ch 3, 4, 5
		Other ranges	105% of range 100% of range for 1 mA, 10 mA ranges if used with seamless measurement ranging function enabled with low group
Current measurement noise (1 PLC)			35 pArms for 10 µA range, and 75 pArms for 100 µA range

External low noise filter supplemental characteristics

The PZ2130A and PZ2131A support a dedicated external low-noise filter (PX0107A); it is available as an accessory. It connects to the Dsub-25 outputs of the PZ2130A and PZ2131A output channels.

External low noise filter supplemental characteristics

Maximum output range		30 V / 150 mA (DC)
Output connector		SMB
Output residual resistance		65 mΩ nominal
Voltage source noise	0.1 to 10 Hz	Same as voltage specification
	10 Hz to 20 MHz	25 µVrms (6 V range), 110 µVrms (30 V range)
Voltage source settling time [1]		5.5 ms (6 V range), 17.5 ms (30 V range)
Supported ranges	Voltage	6 V, 30 V ranges
	Current	10 µA to 500 mA ranges (± 150 mA maximum)
Maximum capacitive load		5 µF
Dimensions		19.5 mm (W) x 62.7 mm (H) x 94.8 mm (D). Depth including connector: 107.5 mm.
Weight		0.17 kg

1. Time required to reach within 0.1 % of final value at open load condition. Step is 10 % to 90 % range. At 6 V / 30 V ranges, 100 mA limit/100 mA range.

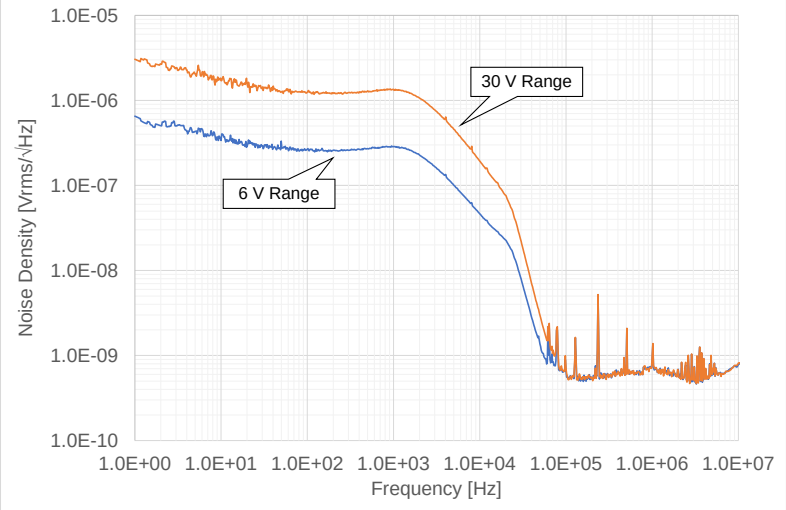


Figure 23. Voltage source noise density of the PZ2130/31A with the PX0107A external low noise filter (Observed data)

Pulse source supplemental characteristics

	PZ2110A	PZ2120A	PZ2121A	PZ2130A	PZ2131A
Programmable pulse width	20 µs to 1 s	50 µs to 1 s	5 µs to 1 s	N/A	50 µs to 1 s
Minimum pulse width programming resolution	0.2 µs				
Pulse width programming accuracy	0.5 % ± 2 µs				
Pulse period programming accuracy	0.5 % ± 4 µs				
Pulse width definition	The time from 10% leading to 90% trailing edge (Figure 24)				

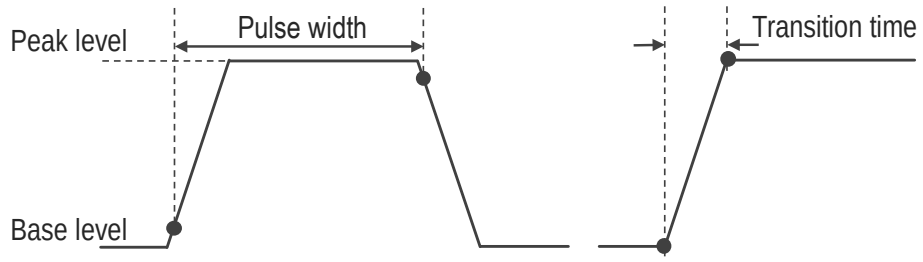


Figure 24. Definition of the pulse parameters and the transition time

Note: Transition time is defined as the time from “Source settling band” to “100% - Source settling band” leading edges (Figure 24).

PZ2110A

Transition time at the given voltage, current and settling conditions (observed data)

Source value	Limit value	Operation mode	Load	Source settling band (% of range)	Transition time [1]
200 V	50 mA	Standard	100 kΩ	0.1%	2.5 ms
300 mA	6 V	Standard	100 mΩ	0.3%	40 µs

1. Transition time is defined as the time from “Source settling band” to “100% - Source settling band” leading edges (Figure 24).

PZ2120/21A

Range	Pulsed				
	Max voltage	Max peak current	Max base current	Programmable pulse width [1]	Max duty cycle
DC ranges	+ 60 V	+130 mA	+130 mA	5 µs to 1 s	99.9999%
	+ 20 V	+ 1.5 A	+ 1.5 A	5 µs to 1 s	99.9999%
	+ 14 V	+ 2 A	+ 2 A	5 µs to 1 s	99.9999%
	+ 6.3 V	+ 3 A	+ 3 A	5 µs to 1 s	99.9999%
	+ 5.5 V	+ 3.5 A	+ 3.5 A	5 µs to 1 s	99.9999%
Pulse ranges	+ 6.3 V	+10.5 A	105 mA	5 µs to 120 µs	1%
	+ 6.3 V	+ 5 A	105 mA	5 µs to 500 µs	3%
	+ 17 V	+ 5 A	105 mA	5 µs to 120 µs	1%
	+ 20 V	+ 3.5 A	105 mA	5 µs to 500 µs	5%
	+ 20 V	+ 1 A	105 mA	5 µs to 500 µs	3%
	+ 10.5 V [2]	+ 5 A [2]	1.05 A [2]	5 µs to 3 ms [2]	10% [2]
	+ 17 V [2]	+ 3.5 A [2]	1.05 A [2]	5 µs to 5 ms [2]	15% [2]

1. Minimum programmable pulse width is 50 µs for the PX2120A.
2. When Pulse Range Priority is set to Power with 5 A range.

Transition time at the given voltage, current and settling conditions (observed data)

Source value	Limit value	Operation mode	Load	Source settling band (% of range)	Transition time [1]
60 V	130 mA	Standard	200 kΩ	0.1%	1.1 ms
60 V	130 mA	PS	200 kΩ	0.1%	30 µs
3.5 A	6 V	Standard	100 mΩ	1%	40 µs
5 A	6 V	Standard	100 mΩ	5%	30 µs

1. Transition time is defined as the time from “Source settling band” to “100% - Source settling band” leading edges (Figure 24)

PZ2131A

Transition time at the given voltage, current and settling conditions (observed data)

Source value	Limit value	Operation mode	Load	Source settling band (% of range)	Transition time [1]
6.3 V	500 mA	Standard	15 Ω	0.1%	270 µs
6.3 V	500 mA	PS	15 Ω	0.1%	75 µs
30 V	150 mA	Standard	220 Ω	0.1%	4.9 ms
30 V	150 mA	PS	220 Ω	0.1%	230 µs
500 mA	6 V	Standard	100 mΩ	0.1%	85 µs

1. Transition time is defined as the time from “Source settling band” to “100% - Source settling band” leading edges (Figure 24)

Timer and triggering supplemental characteristics

Timer		
Timestamp		Timer value automatically saved when each measurement is triggered
Trigger timing resolution		4 µs to 100 ms
Accuracy		± 100 ppm
Arm/trigger delay		0 µs to 100,000 s
Arm/trigger interval		4 µs to 100,000 s
Arm/trigger event	PZ2110A	1 to 1,000,000 (count)
	PZ2120/21A	1 to 500,000 (count)
	PZ2130/31A	1 to 200,000 (count)

Model	Available sampling rates [1]
PZ2110A	(1.25 MSa/s)/N where N=1, 2, 3, …, 2^{24}
PZ2120A	(1 MSa/s)/N where N=1, 2, 3, …, 2^{21}
PZ2121A	(15 MSa/s)/N where N=1, 2, 3, …, 2^{25}
PZ2130A	(250 kSa/s)/N where N=1, 2, 3, …, 2^{19}
PZ2131A	(500 kSa/s)/N where N=1, 2, 3, …, 2^{20}

1. Specification.

Triggering parameter		PZ2110A	PZ2120A	PZ2121A	PZ2130A	PZ2131A
DIO Trigger Input trigger to	Source/sense trigger delay	≤ 5 µs				
	Source/sense trigger jitter	≤ 4.5 µs				
SMU External Trigger Input trigger to	Source/sense trigger delay	≤ 5 µs				
	Source/sense trigger jitter	≤ 4 µs				
SMU External Trigger 1,2 (Input Triggers)	Polarity	Configurable				
	Minimum pulse width	200 ns, nominal				
	Level	3.3 V CMOS				
SMU External Trigger 1,2 (Output Triggers)	Polarity	Configurable				
	Minimum pulse width	Configurable between 200 ns and 12.8 µs, nominal				
	Level	3.3 V CMOS				
Synchronization by internal trigger line		< 50 ns				
Minimum trigger interval	Digitizer Mode ON	800 ns	1 µs	67 ns	N/A	2 µs
	Digitizer Mode OFF	4 µs				

Other supplemental characteristics

Input/output characteristics

		PZ2110A	PZ2120/21A	PZ2130/31A
Sensing modes		2-wire or 4-wire (remote-sensing) connections		
Low terminal connection		Chassis grounded or floating		
Output connectors		Triaxial jack for high force and high sense SMB jack for low sense		Dsub 25 pin jack
External I/O		Phoenix Contact COMBICON Compact PTSM (TRIG1, TRIG2, Int Lock, Frame GND)		
		6 Position Terminal Block Header	6 Position Terminal Block Header	5 Position Terminal Block Header
Maximum guard offset voltage		< 2 mV		
Remote sense operation range (Maximum voltage between force and sense)	High	1 V		
	Low	1 V	0.3 V	1 V
Voltage source output resistance		< 0.3 Ω (non-kelvin)	< 0.02 Ω (≥ 10 µA range) < 300 Ω (< 10 µA range)	< 0.2 Ω (≥ 1 mA range) < 1.3 Ω [1] (< 1 mA range)
Current source output resistance		> 10 TΩ (1 nA range)	> 0.6 TΩ (100 nA range)	> 10 GΩ (10 µA range)
Maximum allowable cable resistance	Sense	10 Ω	1 Ω	1 Ω
	Force	10 Ω (I_o ≤ 100 mA), 3 Ω (I_o > 100 mA)	3 Ω (I_o ≤ 100 mA) 0.3 V/I_o Ω (I_o > 100 mA)	10 Ω (I_o ≤ 100 mA) 1 V/I_o Ω (I_o > 100 mA)
Maximum load capacitance		100 µF (ESR ≥ 25 mΩ) [2]	100 µF (ESR ≥ 25 mΩ) [3]	10 µF (ESR ≥ 50 mΩ)
Guard output impedance		610 Ω (nominal)	3.1 kΩ (nominal)	6.8 kΩ (nominal)
Maximum DC floating voltage		± 40 V between low force and chassis		

1. Valid for Low group when seamless current measurement ranging function is enabled as well.
2. 100 mA to 300 mA ranges.
3. 1 mA or more ranges in Normal Mode. 10 µA or more ranges in High capacitance mode.

System Speeds

Maximum sweep operation reading rates (reading/second) for 50 Hz.

Measure speed	Measure to memory	Measure to HiSLIP	Measure to GPIB	Source measure to memory	Source measure to HiSLIP	Source measure to GPIB
< 0.001 PLC	> 102,000	> 99,100	> 26,400	> 99,800	> 97,200	> 26,200
0.001 PLC	> 38,800	> 38,300	> 18,500	> 38,400	> 38,000	> 18,500
0.01 PLC	5,000	4,990	4,380	4,990	4,980	4,380
0.1 PLC	500	500	493	500	500	493
1 PLC	50	50	50	50	50	50

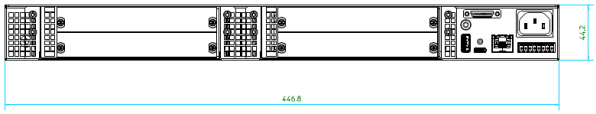
Operation reading rate varies by type of modules and number of sweep steps.
Digitizer mode is set off. Number of sweep steps is specified.

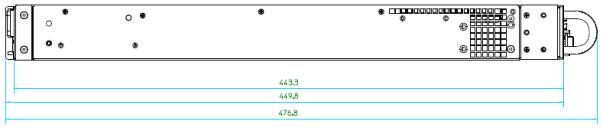
Environmental specifications

Environment for use in indoor facilities		PZ2100A	PZ2110A	PZ2120/21A	PZ2130/31A
Operating	Temperature	0 °C to 55 °C	0 °C to 40 °C	0 °C to 50 °C	
	Humidity [1]	10% to 80% [2]	15% to 70%	10% to 80% [3]	
Storage	Temperature	-30 °C to 70 °C	-20 °C to 60 °C	-30 °C to 70 °C	
	Humidity [1]	5% to 90%			
Altitude		Operating: 0 m to 2,000 m; storage: 0 to 4,600 m			
Power supply		50/60 Hz (frequency tolerance +/-5%) 100-240V (voltage tolerance +/-10%), 400Hz (frequency tolerance +/-10%) 100-120V (voltage tolerance +/-10%) 500 VA maximum			
EMC		IEC61326-1/EN61326-1, CISPR11/EN55011 Group 1 Class A, ICES-001 Group 1 Class A, AS/NZS CISPR11 Group 1 Class A, KN61000-6-1, KN11 Group 1 Class A			
Safety		IEC61010-1/EN61010-1, UL 61010-1, CAN/CSA-C22.2 No. 61010-1			
Overvoltage category		II (for AC mains only)			
Pollution degree		2			
Compliance and certifications		CE, UKCA, cCSAus [4], RCM, ICES/NMB-001, KC			
Warm-up		40 minutes			

1. Relative Humidity, non-condensing.
2. The maximum % Relative Humidity is up to 40°C and decreases linearly to 38% RH at 55 °C. From 40°C to 55°C, it follows the line of constant dew point.
3. The maximum % Relative Humidity is up to 40°C and decreases linearly to 48% RH at 50 °C. From 40°C to 50°C, it follows the line of constant dew point.
4. Valid for PZ2100/10/20/21A.

Model	Dimensions	Weight	Slot
PZ2100A	Height 44.2 mm x depth 443.3 mm x width 446.8 mm	7.2 kg	4
PZ2110A	Height 40.1 mm x depth 210 mm x width 131 mm, 2-slot module	0.55 kg	2
PZ2120/21A	Height 20.1 mm x depth 210 mm x width 131 mm, 1-slot module	0.28 kg	1
PZ2130/31A	Height 20.1 mm x depth 210 mm x width 131 mm, 1-slot module	0.28 kg	1





Acoustical emissions [1]	Idle mode	Operating mode	Worst case mode
Sound pressure level [2] (referenced to 20 µPa)	45 dBA	56 dBA	60 dBA
Sound power (referenced to 1 pW)	56 dBA	65 dBA	69 dBA

1. Supplemental characteristics. Fan speed is controlled automatically for reduced acoustic noise when the ambient temperature and SMU load do not require full cooling capability.
2. At operator position.

Front panel operation	
Front panel interface	LCD 256x64 dots with keypad
View mode	Meter view (Single-channel, 2-channel, 4-channel, Slot summary, Channel summary), Menu view
Hard keys	Meter, Channel, Help, Menu, Back, Erase, Channel On/Off, Voltage, Current, 10-key, Enter
Front panel LED	Single LED besides On/Off switch. Green or amber.

Source/measurement capabilities

		PZ2110A	PZ2120A	PZ2121A	PZ2130A	PZ2131A
Sweep measurement	Number of steps	1 to 1,000,000	1 to 2,000			
	Sweep mode	Linear, logarithmic (log) or list				
	Sweep direction	Single or double				
	Type	DC or pulse			DC	DC or pulse
	Min programmable value to create list sweep waveform	4 µs				
Digitizing/sampling measurement	Digitizer mode	Yes	Yes	Yes	N/A	Yes
	Max sampling rate	1.25 MSa/s	1 MSa/s	15 MSa/s	250 kSa/s	500 kSa/s
	Max buffer size	1,000,000 points	500,000 points [1, 2, 3]		200,000 points	

1. Limited to 100,000 points when measuring with the rate at 15 MSa/s.
2. Limited to 300,000 points when enabling Remote Transient Voltage Measurement function and setting Trigger Count to >1.
3. Limited to 30,000 points when enabling Remote Transient Voltage Measurement function and measuring with the rate at 15 MSa/s.

PZ2100A Input/output connectivity

GPIB		Micro Dsub connector. IEEE-488.1 compliant. Supports IEEE-488.2 common commands and status model topology.
Ethernet		LAN RJ-45 connector, supports 10Base-T, 100Base-T, and 1000Base-T
USB		USB 2.0 Type-A Host Controller x1 USB 3.0 Type-C Device Interface x1
Digital I/O [1]	Maximum voltage ratings	+16.5 VDC / -5 VDC between pins (pin 8 is internally connected to chassis ground.)
	Pins 1 and 2 as FLT output	Maximum low-level output voltage = 0.5 V @ 4 mA Maximum low-level sink current = 4 mA Typical high-level leakage current = 1 mA @ 16.5 VDC
	Pins 1 - 7 as digital/trigger outputs	Maximum low-level output voltage = 0.5 V @ 4 mA; 1 V @ 50 mA; 1.75 V @ 100 mA Maximum low-level sink current = 100 mA Typical high-level leakage current = 0.8 mA @ 16.5 VDC
	Pins 1-7 as digital/trigger inputs and pin 3 as INH input(pin 8 = common)	Maximum low-level input voltage = 0.8 V Minimum high-level input voltage = 2 V Typical low-level current = 2 mA @ 0 V (internal 2.2k pull-up) Typical high-level leakage current = 0.12 mA @ 16.5 VDC
Ground		Chassis ground binding post

1. Supplemental characteristics.

Program, software, and drivers

Programming	SCPI
Program memory	Program code. Up to 256 byte per execution. Sum of all program size in the program memory must be up to 100 KB. Maximum of 100 programs can be memorized.
LXI compliance	1.5 LXI Device Specification 2016
Software available	PathWave IV Curve, PathWave BenchVue Power Supply Control App
Standard-compliant drivers	IVI-C, IVI.NET, LabVIEW

Software prerequisites

PW9251A PathWave IV Curve	Operating system	Windows 10(64 bit), version 1809 or later Windows 11
	CPU	Intel Core i5 (or equivalent)
	RAM	8 GB
	Storage drive	900 MB free space for Windows
	Display resolution	1766 x 768 minimum
	Interfaces	USB, GPIB, LAN
BV0003B PathWave BenchVue Power Supply App	Operating system	Windows 10 64-bit, version 1809 or later Windows 11 64-bit, version 22H2 or later
	CPU	Intel Core i5 (or equivalent)
	RAM	8 GB
	Storage drive	900 MB free space for Windows
	Display resolution	1920 x 1080 minimum
	Interfaces	USB, GPIB, LAN

Furnished Accessories

Model number	Furnished accessories
PZ2100A	Power cable, Connector-terminal block (3.5mm 8-terminal), Filler panels (4 ea.), Slot blockers (2 ea.), Quick Reference
PZ2110A	Connector-terminal block (2.5mm 6-terminal), Short bar, Quick Reference
PZ2120A	Connector-terminal block (2.5mm 6-terminal), Short bar, Quick Reference
PZ2121A	Connector-terminal block (2.5mm 6-terminal), Short bar, Quick Reference
PZ2130A	Connector-terminal block (2.5mm 5-terminal), Short bar, Quick Reference
PZ2131A	Connector-terminal block (2.5mm 5-terminal), Short bar, Quick Reference

Ordering Information

Model number	Description
PZ2100A	Precision Source/Measure Unit Mainframe, 4 slots, 1U
PZ2110A	Precision Source/Measure Unit, 1.25 MSa/s, 10 fA, 210 V, 315 mA DC/pulse
PZ2120A	Precision Source/Measure Unit, 1 MSa/s, 100 fA, 60 V, 3.5 A DC/10.5 A pulse
PZ2121A	Precision Source/Measure Unit, 15 MSa/s, 100 fA, 60 V, 3.5 A DC/10.5 A pulse
PZ2130A	5ch Precision Source/Measure Unit, 100 pA, 30 V, 500 mA DC
PZ2131A	5ch Precision Source/Measure Unit, 500 kSa/s, 10 pA, 30 V, 500 mA DC/pulse

Option	Description
1A7	Calibration + uncertainties + guardbanding (not accredited)
A6J	ANSI Z540-1-1994 calibration
UK6	Commercial calibration certificate with test data

Model number	Description
PX0101A-001	BNC to Ferrule Terminal Cable, 1.5m, VOLT:DC 3.3V
PX0101A-002	BNC to Ferrule Terminal Cable, 3m, VOLT:DC 3.3V
PX0102A-001	Low Noise Triaxial Cable, 1.5m
PX0102A-002	Low Noise Triaxial Cable, 3m
PX0103A-001	Triaxial to SMB Cable, 1.5m, VOLT:DC 210V
PX0103A-002	Triaxial to SMB Cable, 3m, VOLT:DC 210V
PX0104A-001	High Current Triaxial Cable, 4 A, 1.5m, VOLT:DC 60V
PX0104A-002	High Current Triaxial Cable, 4 A, 3m, VOLT:DC 60V
PX0105A-001	Low Inductance BNC Cable, 1.5m, VOLT:DC 60V
PX0105A-002	Low Inductance BNC Cable, 3m, VOLT:DC 60V
PX0106A	Dsub25 to 5 SMB Adapter
PX0107A	Low Noise Filter Adapter
PX0108A-001	BNC to SMB Cable, 1.5m, VOLT:DC 60V
PX0108A-002	BNC to SMB Cable, 3m, VOLT:DC 60V
PX0110A	Micro Dsub GPIB Cable Adapter For PZ2100A, 0.25m
PX0111A	Slot Blocker For PZ2100A, Qty 2
PX0112A	Filler Panel Kit For PZ2100A, Qty 4
PX0113A	Rack Mount Kit For PZ2100A
PX0114A	Micro Dsub GPIB Cable For PZ2100A, 1m

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