DATA SHEET

M9614A and M9615A PXIe 5-Channel Precision Source/Measure Units

500 kSa/s, 100 pA/10 pA, 30 V, 500 mA

The single-slot PXIe SMUs are meant for broad applications requiring high channel density with wide output up to 30 V/500 mA and fast throughput at a low cost per channel.

Contents

Introduction

The Keysight M9614A and M9615A are PXIe five-channel precision source / measure units (SMUs). They support accurate measurement up to 30 V / 500 mA with resolution down to 6 uV / 10 pA. While a PXIe SMU improves channel density compared with a benchtop SMU, the M9614A and M9615A enable higher channel density in the same footprint. They also provide a wider output range than a conventional PXIe four-channel SMU at a lower cost per channel. Pulsed and sampling capabilities allow the M9614A and M9615A to perform a variety of measurements, from DC to pulsed measurements, with pulse width down to 100 µs at a sampling rate of 500 kSa/s. Their seamless current measurement ranging function reduces test duration by eliminating the time it takes to change the range and expands the dynamic range to cover four measurement ranges. These capabilities make the M9614A and M9615A suitable for applications that require high channel density, such as semiconductor reliability testing and integrated circuit (IC) tests.

Features	Benefits
5 channels, higher density per a single-slot module	Higher channel scalability and density at a lower cost in the same footprint
Lower cost per channel	
Wider output range, up to 30 V / 500 mA per channel	Broader application coverage by a single module
Minimum 10 pA resolution for low current measurement	
Accurate and flexible measurements, from DC to pulsed measurements, with pulse width down to 100 µs at 500 kSa/s sampling rate	
Seamless current measurement ranging	Faster throughput with PXIe advantages and seamless current measurement ranging
PXIe advantages such as increased test speed thanks to PCIe bus speed and embedded PC controller	

Overview

The M9614A and M9615A are suitable for a variety of applications that require multiple precision voltage or current sources, such as semiconductor reliability and IC testing. They enable higher channel scalability and density at a lower cost than conventional SMUs.

Best fit for high-channel-density applications — higher channel scalability and density at lower cost

Semiconductor process shrink makes device reliability testing more important than ever. As a result, the number of test items increases. Channel scalability is critical to increase the number of devices measured simultaneously and reduce test time, but benchtop SMUs cannot meet the requirements from a footprint perspective. In IC testing, as circuits become more highly integrated, circuit evaluation requires a larger number of precision power supplies. For those applications, channel density, test speed, and cost are becoming significant challenges for conventional SMUs.

A PXIe SMU improves channel density in the same footprint compared with a benchtop SMU, especially for applications requiring numerous SMU channels. In addition, the M9614A and M9615A provide five-channels-per-slot higher density at a lower cost per channel than conventional PXIe four-channel SMUs. That density improves the cost and space efficiency per channel and makes the M9614A and M9615A the best fit for high-channel-density applications.

Broader application coverage from a single module

Highly integrated circuit evaluations require multiple models of precision power supplies, depending on the requirements of the applications and circuit elements, because of the limited output range of conventional PXIe four-channel SMUs. The M9614A and M9615A enable accurate and flexible I/V measurements from DC to pulsed. They also enable the use of a single model for a variety of applications and circuit elements.

The M9614A and M9615A have five SMU channels in a single-slot PXIe module (Figure 1). Each channel has the capability of wide output range up to 30 V / 500 mA with resolution down to 6 uV / 10 pA, pulsed measurement capability with pulse width down to 100 µs, and high maximum sampling rate up to 500 kSa/s per channel.

The M9614A and M9615A have multiple ranges, enabling them to measure the different operating states of a device or circuit. The seamless current measurement ranging function expands the dynamic range. Select either of two ranging groups according to the characteristics of your device or circuit to cover four ranges in a measurement concurrently. This capability enables the M9614A and M9615A to evaluate static characteristics of the devices in both off and on states precisely. Users can capture the dynamic behavior of circuits, such as standby / sleep / active states, with a wide dynamic range from nA to sub-A or from pA to mA, depending on the selected ranging group.

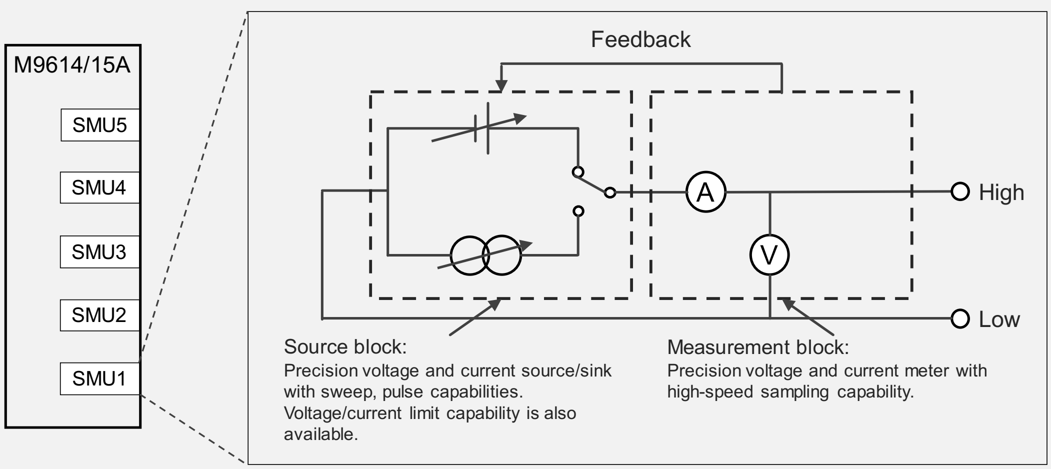

Figure 1. Simplified block diagram of the SMU channel in the M9614A and M9615A

Faster throughput with PXIe advantages and seamless current measurement ranging

Because conventional PXIe SMUs work with the fixed measurement range operation, you must continually measure and change ranges to make wide dynamic range measurements and to find the range that provides the most precise results. That process increases test time.

The seamless current measurement ranging function of the M9614A and M9615A 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. As a result, the SMU channels can eliminate the time it takes to change the range, which reduces test time. The M9614A and M9615A fully utilize PXIe advantages such as increased test speed thanks to PCIe bus speed and embedded PC controller, improving test throughput.

Drivers and soft front panel

The M9614A and M9615A come with IVI-C, IVI.NET, and LabVIEW software drivers for Microsoft Windows 7 Professional SP1 or later (32-bit and 64-bit), Windows 8.1 Professional or later (32-bit and 64-bit), and Windows 10 (32-bit and 64-bit). These software drivers work in the most common test and measurement development environments, including Visual Studio (VB.NET, C#, C, and C++), LabVIEW, MATLAB, and VEE.

The soft front panel provides easy-to-use instrument control (Figure 2). Its user-friendly graphical user interface guides developers through module setup so users can quickly configure the SMUs.

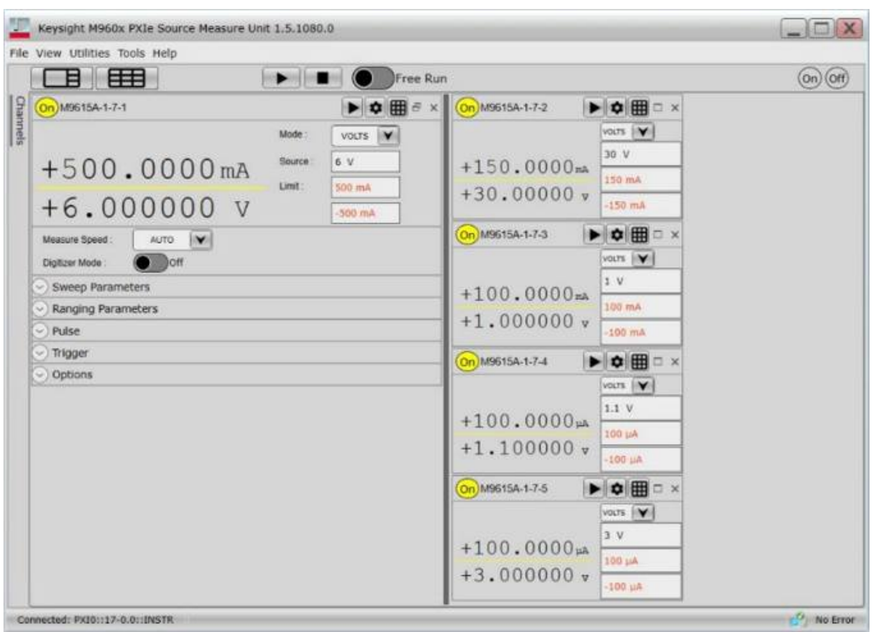

Figure 2. The M9615A's soft front panel

Specification

Specification conditions

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

Temperature		0 °C to 55 °C
Humidity	Minimum	10% RH, non-condensing
	Maximum	80% RH up to 40°C, decreases linearly to 35% RH at 55°C[1], non-condensing
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[2]
Terminal connection		Kelvin connection

[1] From 40°C to 55°C, the maximum % Relative Humidity follows the line of constant dew point.

[2] Power line cycle

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

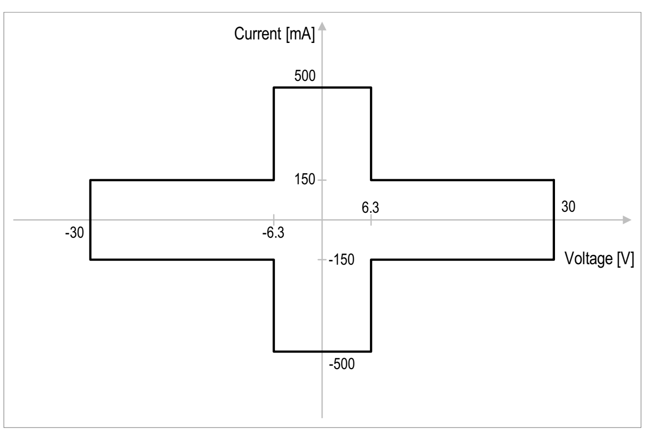

Figure 3. Voltage and current output range per channel

Maximum voltage and current per module

Limit current per module to satisfy the equation as below:

Backplane pin current capacity of the chassis (12 V rail)	Quadrant	Maximum current per module (when channels work with ranges below)		
		6 V range	30 V range	6 V and 30 V ranges mixed[1]
4 A	All	1.3 A	300 mA	$(I_{total(6V)}) / 1.3 + (I_{total(30V)}) / 0.3 \le 1$
6 A[2]	1st	2.8 A	750 mA	$(I_{total\_p(6V)}) / 2.8 + (I_{total\_n(6V)}) / 2 + (I_{total(30V)}) / 0.75 \le 1$
	2nd to 4th	2 A	750 mA	

[1] $I_{total(6V)}$, $I_{total\_p(6V)}$, $I_{total\_n(6V)}$, $I_{total(30V)}$ are the sum of the following parameters for the channels working within the specified voltage range:

	Range	Source function		Parameter
		Mode	Polarity	
$I_{total(6V)}$	6 V	Voltage	Either	The larger one of absolute $+I_{comp}/-I_{comp}$
		Current	Either	The absolute source value
$I_{total\_p(6V)}$	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

Where $+I_{comp}/–I_{comp}$ are the positive / negative current compliance values

[2] When a module works under temperatures lower than 45 °C. Keysight M9018B, M9019A or the other chassis supporting 6 A current capacity for 12 V rail. The M9614A and M9615A use an XJ4 connector manufactured by ERNI (PN 214443).

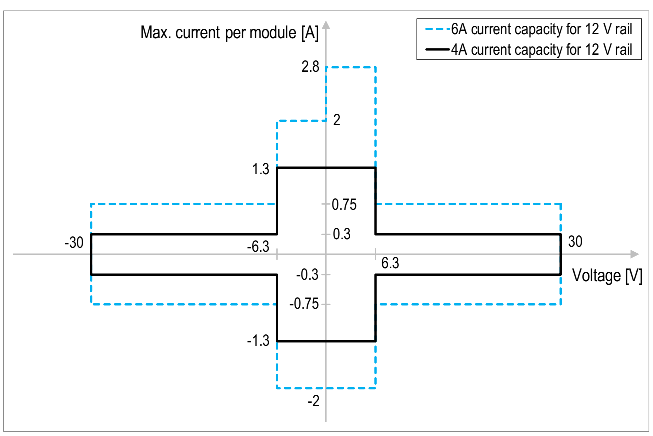

Figure 4. Voltage and total current output range per module

Source/measurement specifications and characteristics

Voltage source/measurement specifications

Range	Programming and measurement		Tempco (% of reading + offset) / °C, 0 °C to 55 °C	Source noise (peak to peak) 0.1 Hz to 10 Hz[1]	Max current
	Resolution	Accuracy (% of reading + offset), 23 °C ± 5 °C			
± 6 V	6 µV	± (0.015% + 600 µV)	± (0.0005%+1 µV)	≤ 20 µV	Varies[2]
± 30 V	30 µV	± (0.015% + 1.2 mV)	± (0.0005%+1 µV)	≤ 85 µV	± 150 mA

[1] Supplemental characteristics, 0 V sourced, 500 mA range

[2] 750 mA and -500 mA for channels 1 and 2; ±500 mA for channels 3, 4, and 5

Over range (% of range)	6 V range	105%
	30 V range	100% for source 105% for measurement

Current source/measurement specifications

Range	Programming and measurement		Tempco (% of reading + offset) / °C, 0 °C to 55 °C	Source noise (peak to peak) 0.1 Hz to 10 Hz[1]	Max voltage
	Resolution	Accuracy (% of reading + offset), 23 °C ± 5 °C			
± 10 µA[2]	10 pA	± (0.03% + 1.6 nA)	± (0.002% + 10 pA)	≤ 170 pA	Varies[3]
± 100 µA	100 pA	± (0.03% + 16 nA)	± (0.002% + 100 pA)	≤ 440 pA	Varies[3]
± 1 mA	1 nA	± (0.03% + 160 nA)	± (0.002% + 1 nA)	≤ 30 nA	Varies[3]
± 10 mA	10 nA	± (0.03% + 1.6 µA)	± (0.002% + 10 nA)	≤ 35 nA	Varies[3]
± 100 mA	100 nA	± (0.03% + 24 µA)	± (0.002% + 150 nA)	≤ 2.5 µA	Varies[3]
± 500 mA	500 nA	± (0.05% + 125 µA)	± (0.004% + 1 µA)	≤ 3.5 µA	± 6.3 V

[1] Supplemental characteristics, 0 A sourced

[2] 10 µA range is available only with the M9615A

[3] ± 30 V for voltage source, ± 31.5 V for voltage measurement

Over range (% of range)	500 mA range	150% with positive current for Ch 1, 2
		100% with negative current for Ch 1, 2
		100% for Ch 3, 4, 5
	Other ranges	105% 100% for 1 mA, 10 mA ranges if used with seamless measurement ranging function enabled with low group

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.

Source supplemental characteristics

Max output power and source / sink limits per module	4 A current capacity[1]	6 V range	8.2 W, 1.3 A
		30 V range	9 W, 0.3 A
	6 A current capacity[2]	6 V range	17.6 W, 2.8 A in 1st quadrant 12.6 W, 2 A in the other quadrants
		30 V range	22.5 W, 0.75 A
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-temperature protection	SMU shutdowns at over temperature sensed internally.		
Voltage output settling time	< 85 μs (PS mode with 6 V range, 1 mA or more ranges, open load) 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		
Slew rate	0.15 V/μs (PS mode with 10 mA compliance) 0.1 V/μs (Standard mode with 10 mA compliance) Step is 0 V to 30 V at open load condition		

[1] For the chassis supporting 4 A backplane pin current capacity for 12 V rail

[2] For Keysight M9018B, M9019A or the other chassis supporting 6 A backplane pin current capacity for 12 V rail, when a module works under temperatures lower than 45 °C. The M9614A and M9615A use an XJ4 connector manufactured by ERNI (PN 214443).

Current output settling time		< 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) Time required to reach within 0.1% of final value at described load condition; step is 10% to 90% range with 6V compliance, filter auto settings	
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	± 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)
Current load regulation	1 mA, 100 mA ranges	|V_o[3]| ≤ 10 V	0 ppm
		10 V < |V_o| ≤ 20 V	(|V_o| -10 V) * 5 ppm of range
		20 V < |V_o|	((|V_o| -20 V) * 10 ppm + 50 ppm) of range
	Other ranges	0 ppm	

[3] V_o is the output voltage.

Pulse source supplemental characteristics

Programmable pulse width	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 5)

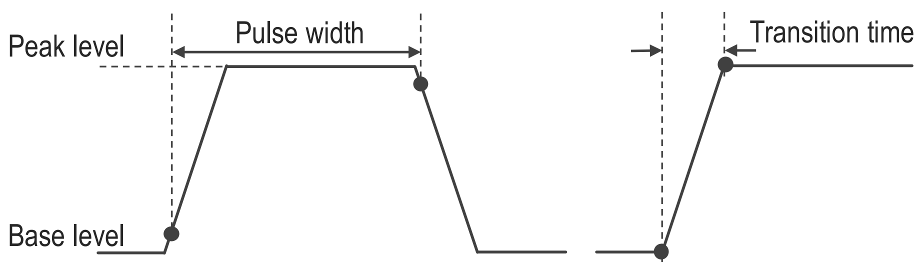

Figure 5. Definition of the pulse parameters and the transition time

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
6.3 V	500 mA	Standard	15 Ω	0.1%	270 μ s
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

Transition time definition: The time from “Source settling band” to “100% — Source settling band” leading edges (Figure 5)

Measurement supplemental characteristics

Measurement noise (1 PLC)	35 pArms for 10 µA range, and 75 pArms for 100 µA range

Measurement and timing characteristics

Available sampling rates		(500 kSa/s)/N where N=1, 2, 3, …, 2^{20}
Sample rate accuracy		Frequency accuracy is inherited from PXIe_CLK100
Maximum measure rate to host		500 kSa/s
Maximum source update rate		250 kSa/s
Input trigger to	Source / sense trigger delay	≤ 5 µs
	Source / sense trigger jitter	≤ 4 µs

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.

Other supplemental characteristics

Timer	
Timestamp	Timer value automatically saved when each measurement is triggered
Trigger timing resolution	4 µs to 100 ms
Clock source	PXIe_CLK100
Arm / trigger delay	0 µs to 100,000 s
Arm / trigger interval	4 µs to 100,000 s
Arm / trigger event	1 to 1,000,000 (count)

Input triggers		
Sources (PXI trigger lines 0 to 7, external trigger 0 and 1)	Polarity	Configurable
	Minimum pulse width	200 ns, nominal

Output triggers		
Destinations (PXI trigger lines 0 to 7, external trigger 0 and 1)	Polarity	Configurable
	Pulse width	Configurable between 200 ns and 12.8 µs, nominal

Output characteristics	
Sensing modes	2-wire or 4-wire (remote-sensing) connections
Low terminal connection	Chassis grounded or floating
Output connectors	Dsub 25 pin jack
Maximum guard offset voltage	< 2 mV
Remote sense operation range	Max voltage between high force and high sense = 1 V Max voltage between low force and low sense = 1 V
Maximum load capacitance	10 µF (ESR ≥ 50 mΩ)
Guard output impedance	6.8 kΩ (nominal)
Maximum DC floating voltage	± 40 V between low force and chassis

Environmental specifications

Environment			For indoor use
Operating	Temperature		0 °C to 55 °C
	Humidity	Minimum	10% RH, non-condensing
		Maximum	80% RH up to 40°C, decreases linearly to 35% RH at 55°C[1], non-condensing
Storage	Temperature		-40 °C to 70 °C
	Humidity		5% to 90% RH, non-condensing
Altitude			Operating: 0 m to 2,000 m; storage: 0 to 4,600 m
Power consumption			+ 3.3 V ± 5%, 1 A + 12 V ± 5%, 4 A[2] or 6 A[3]
EMC			IEC61326-1/EN61326-1, CISPR 11/EN55011 Group 1 Class A, ICES-001, AS/NZS CISPR11, KN61000-6-1, KN11
Safety			IEC61010-1/EN61010-1, IEC61010-2-030/EN61010-2-030
Compliance and certifications			CE, RCM, KC
Warm-up			40 minutes
Dimensions			3U, 1-slot PXIe module Height 20.1 mm x depth 131 mm x width 210 mm
Weight			0.28 kg

[1] From 40°C to 55°C, the maximum % Relative Humidity follows the line of constant dew point.

[2] With mode for the chassis supporting 4 A backplane pin current capacity for 12 V rail

[3] With mode for Keysight M9018B or the other chassis supporting 6 A backplane pin current capacity for 12 V rail

Source / measurement capabilities

Sweep measurement	
Number of steps	1 to 2,000
Sweep mode	Linear or list
Sweep direction	Single or double
Type	DC or pulse
Min programmable value to create list sweep waveform	4 µs
Digitizing / sampling measurement	
Max sampling rate	500 kSa/s
Data buffers	
Max buffer size	500,000 points

Program, software, and drivers	
Supported operating systems	Microsoft Windows 7 Professional SP1 or later (32-bit/64-bit), Windows 8.1 Professional (32-bit/64-bit), Windows 10 (32-bit/64-bit)
Standard-compliant drivers	IVI-C, IVI.NET, LabVIEW
Supported application development environment (ADE)	Visual Studio (VB.NET, C#, C/C++), LabVIEW, MATLAB, VEE
.NET Framework	Microsoft .NET Framework 4.5.2 or later
Keysight IO libraries	Keysight IO Libraries Suite 2019 or later

Furnished Accessories

Furnished accessories
Short bar, connector-terminal block 2.5 mm 5-terminal, certificate of calibration (without test data), quick startup poster

Ordering Information

Model number	
M9614A	PXIe 5-channel SMU, 500 kSa/s, 100 pA, 30 V, 500 mA
M9615A	PXIe 5-channel precision SMU, 500 kSa/s, 10 pA, 30 V, 500 mA
Options	
1A7	Calibration + uncertainties + guardbanding (not accredited)
A6J	ANSI Z540-1-1994 calibration
UK6	Commercial calibration certificate with test data
Accessories	
PX0101A-001	BNC-to-ferrule terminal cable, 1.5 m
PX0101A-002	BNC-to-ferrule terminal cable, 3 m
PX0106A	Dsub25-to-5 SMB adapter for M9614A/15A
PX0108A-001	BNC-to-SMB cable, 1.5 m
PX0108A-002	BNC-to-SMB cable, 3 m