Measure Ready

M81 SSM

SMU-10

Low-noise DC/AC SMU

Lake Shore CRYOTRONICS

First DC/AC SMU with ultra-sensitive lock-in detection

The source measure unit (SMU-10) is the latest module addition to the MeasureReady™ M81-SSM synchronous source measure system. It is specifically designed to handle the delicate nature of nano and ultra-cold samples with exceptionally low source noise and high measurement sensitivity. The SMU-10 offers both DC and AC capabilities and an integrated lock-in, providing a comprehensive suite of measurements tailored to advanced research applications.

The SMU-10 is the latest module addition to the M81-SSM system

Ultra-low noise

DC & AC capabilities

Integrated lock-in

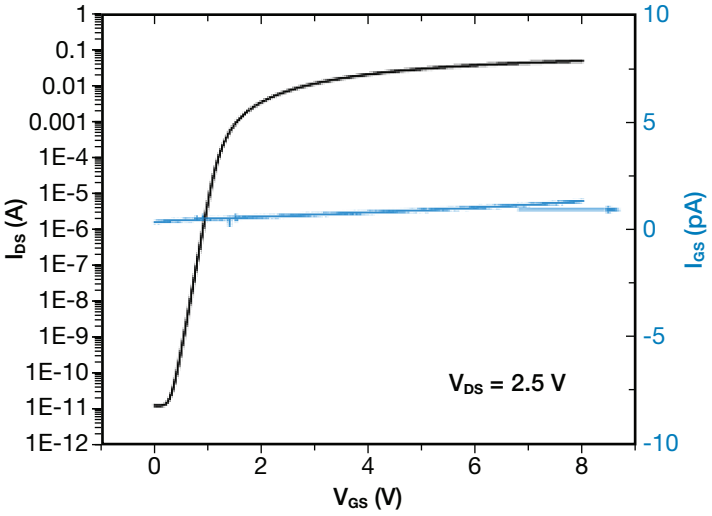
All-in-one precision tool

The SMU-10 integrates 6 instruments into a unified solution

Measurement	Measure	Source
DC current	Down to <100 fA	Up to 100 mA
DC voltage	Down to microvolts	Up to 10 V
AC current	Sine (up to 100 kHz), triangle (up to 5 kHz), square (up to 5 kHz)	
AC voltage	Sine (up to 100 kHz), triangle (up to 5 kHz), square (up to 5 kHz)	
Lock-in	Down to nanovolts	N/A
Resistance	Milliohms to 100 GΩ	

Ideal for multi-terminal device testing

Three-terminal FET DC transfer curve



Source/measure

When testing multi-terminal devices in a cryogenic probe station, use the M81-SSM with SMU-10 modules to apply voltage or current to the DUT and measure the corresponding current or voltage. The SMU's topology reduces the number of probe arms by half, significantly minimizing thermal impact. Set compliance limits to protect the DUT from accidental overloads.

Advanced resistance

The M81-SSM's advanced resistance mode compensates for phase shifts caused by parasitic capacitance in cryogenic environments, ensuring more accurate resistance measurements. This technique reduces errors significantly, improving measurement accuracy.

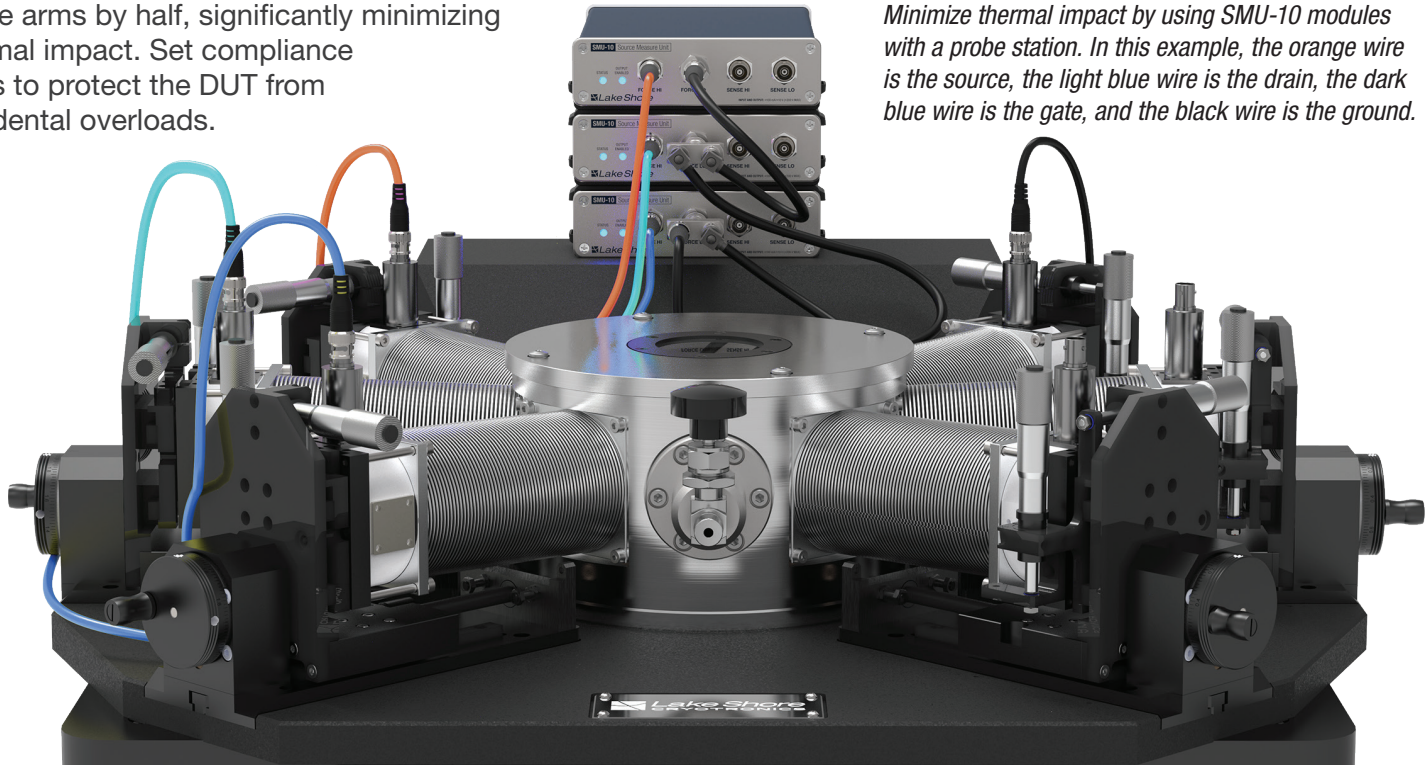
Four-wire voltage monitoring

Ideal for high-current devices. The Sense-HI and Sense-LO leads enable 4-wire measurements for built-in device voltage monitoring while sourcing currents.

Synchronized sampling

Patented MeasureSync™ technology ensures perfect timing coordination for AC or DC measurements across multiple SMU-10 modules, eliminating data misalignment errors.

Minimize thermal impact by using SMU-10 modules with a probe station. In this example, the orange wire is the source, the light blue wire is the drain, the dark blue wire is the gate, and the black wire is the ground.



Specifications

Voltage	Current
Ranges: 10 mV, 100 mV, 1 V, 10 V **Measure sensitivity:** <3 nV[1] **Source noise (DC to 10 MHz):** <0.2 mV RMS, <1.2 mV p-p (typical)	**Ranges:** 1 nA, 10 nA, 100 nA, 1 µA, 10 µA, 100 µA, 1 mA, 10 mA, 100 mA **Measure sensitivity:** <1 fA[1] **DC output resistance:** >10 TΩ (typical) **Source noise (DC to 10 MHz):** <5 nA RMS, <25 nA p-p (typical)

SMU-10 front view

Overvoltage protection: ±200 VDC

Maximum power: 1 W, 4-quadrant operation

Magnetic field exposure: Operational up to 50 mT DC

Size: 142 mm (5.58 in) W × 38.9 mm (1.53 in) H × 245 mm (9.63 in) L

Noise

	Range	Source		Measure	
		0.1 Hz to 10 Hz	1 kHz	0.1 Hz to 10 Hz	1 kHz
Voltage noise (typical)	10 mV	250 nV RMS	30 nV/√Hz	250 nV RMS	27 nV/√Hz
	100 mV	300 nV RMS	30 nV/√Hz	300 nV RMS	28 nV/√Hz
	1 V	550 nV RMS	30 nV/√Hz	550 nV RMS	35 nV/√Hz
	10 V	5 µV RMS	80 nV/√Hz	5 µV RMS	165 nV/√Hz
Current noise (typical)	1 nA	100 fA RMS (500 fA p-p)	6 fA/√Hz (at 10 Hz)	15 fA RMS (75 fA p-p)	6 fA/√Hz (at 10 Hz)
	10 nA	100 fA RMS (500 fA p-p)	20 fA/√Hz (at 100 Hz)	45 fA RMS (225 fA p-p)	20 fA/√Hz (at 100 Hz)
	100 nA	300 fA RMS (1.5 pA p-p)	60 fA/√Hz (at 100 Hz)	175 fA RMS (875 fA p-p)	60 fA/√Hz (at 100 Hz)
	1 µA	1 pA RMS (5 pA p-p)	200 fA/√Hz	1 pA RMS (5 pA p-p)	200 fA/√Hz
	10 µA	5 pA RMS (25 pA p-p)	1 pA/√Hz	6 pA RMS (30 pA p-p)	1 pA/√Hz
	100 µA	50 pA RMS (250 pA p-p)	3 pA/√Hz	60 pA RMS (300 pA p-p)	2 pA/√Hz
	1 mA	500 pA RMS (2.5 nA p-p)	30 pA/√Hz	550 pA RMS (2.75 nA p-p)	20 pA/√Hz
	10 mA	5 nA RMS (25 nA p-p)	300 pA/√Hz	5.5 nA RMS (27.5 nA p-p)	200 pA/√Hz
	100 mA	50 nA RMS (250 nA p-p)	3 nA/√Hz	55 nA RMS (1.375 µA p-p)	2 nA/√Hz

[1] 10 s time constant, 24 dB roll-off

Accuracy

	Range	Source		Measure	
		DC[2] ± (% rdg + offset)	Lock-in[2,3] ± (% rdg + offset)	DC[2] ± (% rdg + offset)	Lock-in[2,3] ± (% rdg + offset)
Voltage accuracy	10 mV	0.15% + 300 µV	0.15% + 50 nV	0.15% + 300 µV	0.15% + 50 nV
	100 mV	0.1% + 300 µV	0.1% + 500 nV	0.1% + 300 µV	0.1% + 500 nV
	1 V	0.05% + 300 µV	0.05% + 5 µV	0.05% + 300 µV	0.05% + 5 µV
	10 V	0.05% + 500 µV	0.05% + 50 µV	0.05% + 500 µV	0.05% + 50 µV
Current accuracy	1 nA	0.5% + 300 fA	0.5% + 5 fA	0.5% + 300 fA	0.5% + 5 fA
	10 nA	0.1% + 300 fA	0.1% + 50 fA	0.1% + 300 fA	0.1% + 50 fA
	100 nA	0.1% + 300 pA	0.1% + 500 fA	0.1% + 300 pA	0.1% + 500 fA
	1 µA	0.1% + 300 pA	0.1% + 5 pA	0.1% + 300 pA	0.1% + 5 pA
	10 µA	0.05% + 3 nA	0.05% + 50 pA	0.05% + 3 nA	0.05% + 50 pA
	100 µA	0.05% + 30 nA	0.05% + 500 pA	0.05% + 30 nA	0.05% + 500 pA
	1 mA	0.05% + 300 nA	0.05% + 5 nA	0.05% + 300 nA	0.05% + 5 nA
	10 mA	0.05% + 3 µA	0.05% + 50 nA	0.05% + 3 µA	0.05% + 50 nA
	100 mA	0.05% + 10 µA	0.05% + 500 nA	0.05% + 10 µA	0.05% + 500 nA

Settable resolution

	Range	Source	
		DC	AC[4]
Voltage settable resolution	10 mV	1 µV	100 nV
	100 mV	1 µV	300 nV
	1 V	10 µV	3 µV
	10 V	100 µV	100 µV
Current settable resolution	1 nA	10 fA	3 fA
	10 nA	100 fA	30 fA
	100 nA	1 pA	300 fA
	1 µA	10 pA	3 pA
	10 µA	100 pA	30 pA
	100 µA	1 nA	300 pA
	1 mA	10 nA	3 nA
	10 mA	100 nA	30 nA
	100 mA	1 µA	300 nA

[2] Total system accuracy, 1 year and ±5 °C from Lake Shore calibration, 24 h and ±1 °C from self-calibration, 95% confidence
[3] DC to 1 kHz or 10% of source range bandwidth, whichever is lower
[4] Averaging over 60 NPLCs

Temperature coefficient

	Range	Source[2,3] ± (ppm rdg/°C + offset/°C)	Measure[2,3] ± (% rdg + offset)
Voltage temperature coefficient	10 mV	20 ppm/°C + 25 µV/°C	25 ppm/°C + 25 µV/°C
	100 mV	20 ppm/°C + 25 µV/°C	25 ppm/°C + 25 µV/°C
	1 V	20 ppm/°C + 25 µV/°C	25 ppm/°C + 25 µV/°C
	10 V	20 ppm/°C + 25 µV/°C	25 ppm/°C + 25 µV/°C
Current temperature coefficient[1,2]	1 nA	500 ppm/°C + 25 fA/°C	500 ppm/°C + 25 fA/°C
	10 nA	30 ppm/°C + 250 fA/°C	35 ppm/°C + 250 fA/°C
	100 nA	30 ppm/°C + 3 pA/°C	35 ppm/°C + 2.5 pA/°C
	1 µA	55 ppm/°C + 25 pA/°C	55 ppm/°C + 25 pA/°C
	10 µA	20 ppm/°C + 130 pA/°C	25 ppm/°C + 125 pA/°C
	100 µA	20 ppm/°C + 1.5 nA/°C	25 ppm/°C + 1.5 nA/°C
	1 mA	20 ppm/°C + 15 nA/°C	25 ppm/°C + 15 nA/°C
	10 mA	20 ppm/°C + 100 nA/°C	25 ppm/°C + 150 nA/°C
	100 mA	20 ppm/°C + 1.5 µA/°C	30 ppm/°C + 1.5 µA/°C

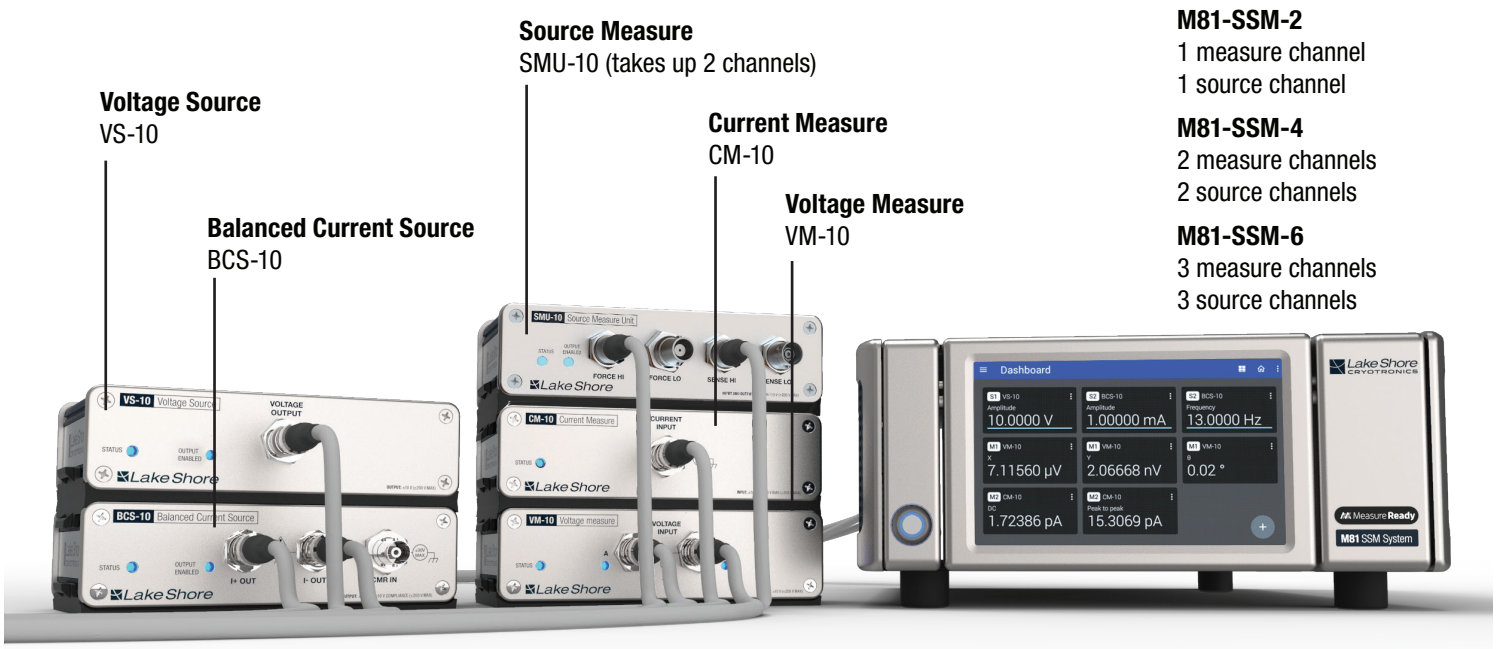
Impedance and bandwidth

	Range	Impedance		Bandwidth (typical)	
		Output (source)	Input (measure)	Source	Measure
Voltage	10 mV	<10 mΩ	>500 GΩ (typical)	60 kHz	60 kHz
	100 mV				
	1 V				
	10 V				
Current	1 nA	>10 TΩ	100 kΩ	100 Hz	350 Hz
	10 nA	>1 TΩ	10 kΩ	500 Hz	1.1 kHz
	100 nA	>100 GΩ	1 kΩ	1 kHz	2 kHz
	1 µA	>10 GΩ	100 Ω	4 kHz	10 kHz
	10 µA	>1 GΩ	10 Ω	10 kHz	25 kHz
	100 µA	>100 MΩ	1 Ω	50 kHz	65 kHz
	1 mA	>10 MΩ	100 mΩ	100 kHz	>100 kHz
	10 mA	>1 MΩ	20 mΩ	100 kHz	>100 kHz
	100 mA	>100 kΩ	10 mΩ	100 kHz	>100 kHz

M81-SSM system summary

The MeasureReady™ M81-SSM provides a reliable and streamlined approach for advanced measurement applications. Its modular design allows multiple compact modules to connect to the main M81-SSM instrument, enabling a variety of source and measure configurations. Available with two, four, or six channels, the M81-SSM dedicates half of its channels to measure modules and the other half to source modules.

The SMU-10, which occupies two channels (one for sourcing and one for measuring), exemplifies this flexibility. While it can operate on a single source channel, that setup limits its measurement functionality. The M81-SSM simplifies complex instrumentation setups by integrating DC/AC sourcing, DC/AC measuring, resistance measurements, and lock-in capabilities into a single, ultra low-noise solution.



Available modules	Modes	Range	Ideal for
Source measure SMU-10	DC, sine (up to 100 kHz), triangle (up to 5 kHz), square (up to 5 kHz); current/voltage, lock-in	0 mV to 10 V 1 nA to 100 mA	Monitoring current while forcing voltage, simplifying wiring, and multi-terminal device measurements
Current measure CM-10	DC, AC, lock-in	1 nA to 100 mA	Ultra-low noise current measurements
Voltage measure VM-10	DC, AC, lock-in	0 mV to 10 V	Differential measurements that minimize environmental noise and seamless ranging
Voltage source VS-10	DC, sine (up to 100 kHz), triangle (up to 5 kHz), square (up to 5 kHz)	10 mV to 10 V	Sourcing small AC signals on large DC offsets with the lowest noise
Balanced current source BCS-10	DC, sine (up to 100 kHz), triangle (up to 5 kHz), square (up to 5 kHz)	10 nA to 100 mA	Differential measurements that minimize environmental noise

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Questions? Answers?

Visit http://forums.lakeshore.com/ and become part of the conversation!

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