



**Joulescope™ JS220+ User's Guide**  
**Precision Energy Analyzer with Enhanced Accuracy**

Revision 1.1

Last revised 2024 Apr 26



## 1. Introduction

The Joulescope JS220+ is a limited-edition, performance-enhanced version of the Joulescope JS220. The JS220+ achieves  $\pm 1$  nanoamp accuracy with exceptional temperature stability, all while providing the same best-in-class high-dynamic current range measurement as the standard JS220.

This limited document only describes the JS220+ improvements over the JS220. The JS220+ is operationally identical to the JS220. For instructions on how to operate your JS220+, see the [Joulescope JS220 User's Guide](#) and the [Joulescope UI User's Guide](#).

Some modern semiconductors now have sleep currents measured in nanoamps ( $1e-9$  A) or tens of nanoamps ( $1e-8$  A) with active currents in the tens of milliamps ( $1e-2$  A) and greater. These components typically require bypass capacitances of at least 100 nF ( $1e-7$  F). Total bypass capacitances of a power supply rail are typically 10  $\mu$ F to 400  $\mu$ F ( $1e-5$  F to  $4e-4$  F).

Many low-measurement instruments based on transimpedance amplifiers (feedback ammeters) can measure down to fA ( $1e-15$  A). However, these instruments are typically specified for a maximum capacitance, often around 10 nF ( $1e-8$  F), four orders of magnitude below what is needed.

The Joulescope JS220 is a shunt ammeter designed for extremely fast auto-ranging, perfect for the dynamic range requirements and large capacitive loads. Shunt ammeter accuracy is bounded by input bias currents, leakage currents, noise bandwidth, and offset temperature stability. By combining Jetperch's extensive experience in developing the JS110 and JS220 with newly available components, we can now deliver the JS220+ with nanoamp accuracy while retaining the fantastic performance of the existing Joulescope JS220.

## 2. Specifications

This section only gives the specification changes relative to the [Joulescope JS220 User's Guide](#). All other specifications remain the same as the JS220.

### Section 7.5: Current measurement specifications

Range	Accuracy	Resolution	Impedance	Guaranteed
10 A <sup>1</sup> (> 2 A)	±0.25% ± 1.5 mA	350 µA	0.01 Ω	±9.7 A
10 A (≤ 2 A)	±0.1% ± 300 µA	75 µA	0.01 Ω	±2.05 A
180 mA	±0.1% ± 30 µA	6.5 µA	0.11 Ω	±185 mA
18 mA	±0.1% ± 3.0 µA	650 nA	1.11 Ω	±18.5 mA
1.8 mA	±0.1% ± 300 nA	65 nA	11.1 Ω	±1.85 mA
180 µA	±0.1% ± 30 nA	6.5 nA	111 Ω	±185 µA
18 µA	±0.1% ± 3 nA <sup>2</sup>	0.65 nA	1111 Ω	±18.5 µA

<sup>1</sup> Max 3 A sustained. See the recommended operating conditions for higher current durations.

<sup>2</sup> ±1.0 nA for ±5 °C over 24 hours with trim offset calibration.

### Section 7.6: Voltage measurement specifications

Range	Accuracy	Resolution	Guaranteed
15 V	±0.1% ± 1 mV	500 µV	±14.5
2 V	±0.1% ± 150 µV	75 µV	±2.2

### Section 7.8: Parasitic effects specification

	Test condition	Min	Typical	Max	Unit
Current leakage (Voltage + to -)	25 °C, ±3.3V			200	pA
Current leakage (Voltage + to -)	25 °C, ±5V			200	pA
Current leakage (Voltage + to -)	25 °C, ±14V			300	pA
Shunt resistor voltage, max	-2 to 2 A, static		20	21	mV
Burden voltage (Current + to -)	1 A, banana jacks	0	25	35	mV
Burden voltage (Current + to -)	Shunt resistor, < ±2 A			±20	mV
Shunt switching time	Over-range < 200 ns rise time	0	1.0	1.5	µs
Measurement gap following a current range switch				0	µs
Input bias current Voltage+ & -	25 °C		±5	±20	pA
Input bias current, Current + & -	25 °C, 18 µA current range		±60	±600	pA

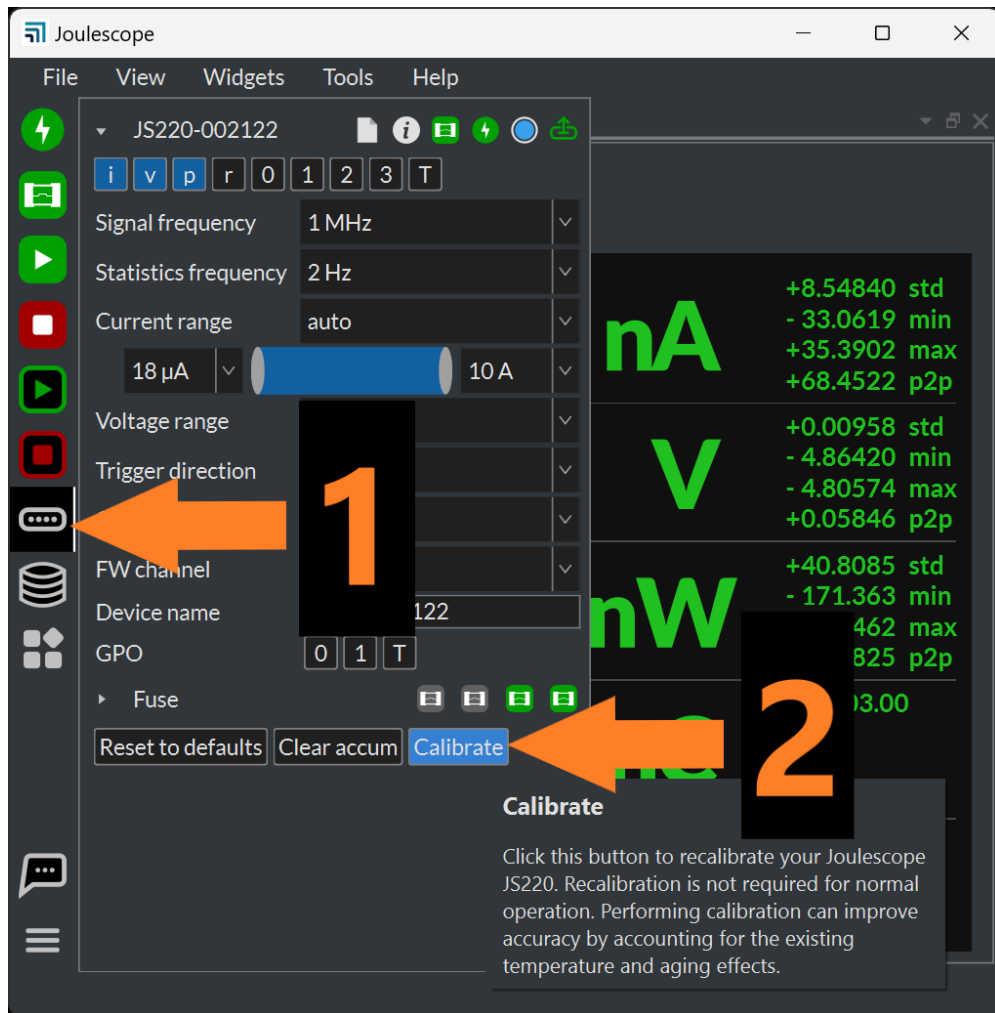
Resolution is given for 10 kHz measurement bandwidth (20 ksp/s).

The JS220+ includes a safety banana jack front panel rather than binding posts.

### 3. Trim Calibration

While the JS220+ offers significant offset performance improvements relative to the JS220, it may require trim calibration to achieve the full offset accuracy performance.

The Joulescope UI 1.0.40 and later includes offset trim calibration. Before starting a trim calibration, please run your JS220+ for at least 5 minutes to allow the temperature to stabilize. To start a current offset trim calibration, select the **Device Control** widget in the sidebar, then press **Calibrate**:



Press **Start** for **Current offset**, and follow the onscreen instructions.

The JS220+ uses an internal fixed-point representation of 5Q31 for current samples.  $2^{-31}$  represents an accuracy of  $\pm 0.5$  nA. After performing trim calibration, the instrument offset may be off by up to  $\pm 0.25$  nA. However, the trim offset calibration specification accounts for this initial error.

## 4. Technology

The JS220+ leverages new components and techniques to achieve nanoamp accuracy. The improvements include:

- Improved guard traces for reduced leakage.
- Replaced the 18  $\mu\text{A}$  current range selection MOSFET for one with lower gate-source leakage.
- Redesigned analog front-end for lower input bias current and better temperature stability.
- Redesigned anti-aliasing filter for improved temperature stability.
- Redesigned ADC reference and level shift for improved temperature stability.
- Redesigned voltage ESD solution, dramatically reducing leakage currents.
- Migrated to Rogers 4003C PCB material for both the main PCB and front panel PCB. Rogers 4003C has 1000x higher resistivity than FR4 for significantly reduced current leakage.



## 5. Ordering Information

The JS220+ orderable part number is:

**JS220-K002**

Note that the JS220+ comes with ISO 17025:2017 calibration. Unlike the JS220, we do not offer a factory calibration only option.

The JS220+ is now available for sale in very limited quantities. Visit the [Joulescope store](#) to place your order today.

## 6. User's guide information

This section contains information regarding this document. See the other sections of this document for information regarding the Joulescope product.

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The information in this User's Guide is subject to change. The most up-to-date version of this User's Guide can be retrieved from <http://www.joulescope.com/>.

## 6.4. Change log

Revision	Date	Description
1.1	2024 Apr 26	Updated for sale: ISO 17025 now available.
1.0	2024 Mar 5	Initial public release.