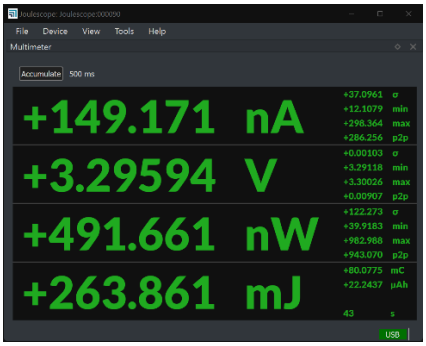
Joulescope™ JS220

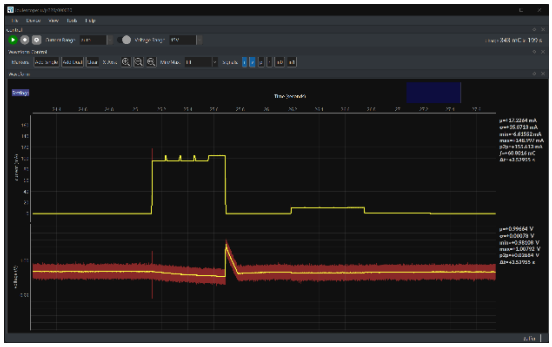
Precision DC Energy Analyzer

Datasheet

1. Affordable, easy-to-use, accurate and precise



Multimeter view



Oscilloscope view

Applications include:

- Microprocessor and microcontroller power profiling and optimization
- Hardware power optimization
- Microcontroller and device sleep current optimization
- Hardware and software troubleshooting
- Software characterization and interrupt service routine profiling
- USB inrush and suspend current pre-compliance testing
- General-purpose current, voltage, power, charge, and energy measurement

The Joulescope™ JS220 is the most affordable and easy-to-use precision DC energy analyzer. It measures current and voltage, then computes power and energy. Many modern battery-powered devices and IoT devices have a high dynamic current range, which makes accurate measurement difficult. When "sleeping" the devices consume nanoamps (nA) or microamps (µA), but when active, they consume milliamps (mA) or amps (A). Joulescope combines high-speed sampling and rapid dynamic current range switching to provide accurate and seamless current and energy measurements, even for devices with rapidly varying current consumption. The unprecedented accuracy and low-cost of Joulescope allows every engineer on the team to measure the energy consumed by the target device during development. Joulescope provides rapid feedback on how changes affect the overall product battery life.

Joulescope displays instantaneous voltage, current, power, and energy, like a multimeter. The multimeter provides a quick and easy summary of the present state of your device.

Joulescope displays waveforms of voltage and current over time, like an oscilloscope. This oscilloscope view allows you to identify and to troubleshoot dynamic behavior and short events, including inrush current, event handlers, and tasks.

2. Key benefits

- **Dynamic range**: The Joulescope JS220 accurately measures electrical current over ten orders of magnitude from amps down to nanoamps. This wide range allows accurate and precise current measurements for modern devices. Sleep modes are often just nanoamps (nA) or microamps (µA). Active modes are often milliamps (mA) or amps (A).
- **Low voltage drop**: Most multimeters and current meters have a significant voltage drop (sometimes called burden voltage or insertion loss), which affects the actual voltage delivered to the device under test. Joulescope has a total voltage drop of 25 mV at 1 A, which keeps your target device running correctly. Joulescope's extremely fast current range switching maintains low voltage drop even under rapidly varying current demands.
- **Makes the invisible visible**: The JS220 measures current and voltage 2 million times per second with 300 kHz bandwidth. This high sampling rate makes the power consumption of interrupt service routines, inrush currents, and other short events visible.
- **Easy to use**: The JS220 reports cumulative energy and charge consumption along with real-time current, voltage, and power. The multimeter view clearly shows the most recent value, while the oscilloscope view allows you to explore changes over time. Much simpler and more accurate than anything in its class!
- **Customizable:** The host software is open source on GitHub. You can also swap the banana jack front panel with front panels that have other connector types. The front panels are open source on GitHub.
- **Portable:** The JS220 fits in your backpack and only needs a small part of your desk. It provides precision measurements in a portable, unintrusive form factor.
- **Affordable:** The Joulescope JS220 is affordable and priced so that every developer on the team can have one at their desk. With such convenient access, Joulescopes allow developers to see the impact of their changes on energy consumption immediately. Developers can make informed choices to account for battery life during design. Eliminate power consumption surprises during final product testing!

3. Key features

- ±15V voltage range
- ±3A current range, continuous
- ±10A current pulses (<10 ms, < 3A average per second)
- Down to 0.5 nA resolution, equivalent to 34-bits of dynamic range
- Synchronously measures voltage and current at 2 million samples per second, 16-bit
- 300 kHz bandwidth
- Rapid 1 µs switching between shunt resistors
- Enwavify™ technology for consistent, accurate measurements through current range changes
- Computes power, energy, and charge
- Operates with minimal voltage disturbance between Current + and Current – ports
- Up to ±48V common-mode voltage between USB ground and sensing ports
- 4 general-purpose inputs and 2 general-purpose outputs
- 1 BNC trigger configurable for either input or output
- Programmable on/off for power cycling the target device and measuring inrush currents
- USB 2.0 high-speed host connectivity with modern USB C connector
- Host software support for Microsoft® Windows®, Apple® macOS®, and Linux®
- Host software user interface provides real-time graphs of current, voltage, and power over time
- Python library and scripting provided
- Host software is open source and available on GitHub
- Swappable front panel with open-source designs on GitHub
- Firmware upgradable

See Section 7 for the full specifications.

4. Specifications

4.1. Absolute maximum ratings

	Min	Max	Unit
USB voltage	-0.3	6	V
Max voltage applied between any port Current +, Current -, Voltage +, Voltage -	-20	20	V
Max voltage to USB ground from any port Current +, Current -, Voltage +, Voltage -	-48	48	V
Input current (powered, burst)	-10	10	A
Input current (powered, sustained)	-3	3	A
Input current (unpowered)	N/A (off)	N/A (off)	A
Storage temperature	-40	80	°C
Operating temperature	0	50	°C
Relative humidity (non-condensing)	0	95	%
Altitude from sea level	-100	2500	m
Max voltage applied to GPI relative to USB ground	-10	10	V

4.2. Mechanical

4.2.1. Instrument Only

	Typical	Unit
Weight	190	grams
Width	99	mm
Length (including binding posts and BNC connector)	126	mm
Height	28	mm

4.2.2. Complete product kit

	Typical	Unit
Weight	510	grams
Width	190	mm
Length	200	mm
Height	60	mm

4.3. Recommended operating conditions

	Test condition	Min	Typical	Max	Unit
Operating temperature		10		40	°C
USB supply voltage		4.5	5.0	5.5	V
USB supply current				500	mA
Voltage applied across Voltage + and Voltage -		-14.5		14.5	V
Voltage applied across Current + and Current -	Current range off	-15		15	V
Input current	continuous	-3		3	A
Input current pulse	< 50 milliseconds, < 3A average	-10*		10*	A
Input current pulse	< 250 milliseconds < 3A average	-5*		5*	A

* Suitable for handling inrush currents when connecting capacitive loads.

4.4. Specification conditions

Temperature	23 °C ± 10 °C
Humidity	20% to 80% RH, non-condensing
Calibration interval	1 year*

* Recommended to comply with industry-standard practices, but the Joulescope JS220 is designed not to need recalibration.

4.5. Current measurement specifications

Range	Accuracy	Resolution	Impedance	Guaranteed
10 A*	±0.25% ±1.50 mA	175 µA	0.01 Ω	±9.7 A
180 mA	±0.25% ±150 µA	15 µA	0.11 Ω	±185 mA
18 mA	±0.25% ±15 µA	1.5 µA	1.11 Ω	±18.5 mA
1.8 mA	±0.25% ±1.5 µA	150 nA	11.1 Ω	±1.85 mA
180 µA	±0.25% ±150 nA	15 nA	111 Ω	±185 µA
18 µA	±0.25% ±30 nA	1.5 nA	1111 Ω	±18.5 µA

* Joulescope is designed for 3 A sustained. See the recommended operating conditions for maximum durations for higher currents.

Test current measurement bandwidth by varying the effective load impedance. Due to load capacitance, altering the source voltage is not a valid method of testing current bandwidth.

The JS220 is sensitive to RF radiation which induces real current in test setups. When tested with EN61326-1 and 3 V RMS/m, the JS220 measured up to 10 µA (observed, not guaranteed of current at several frequencies. The exact frequency susceptibility varies with cable length and configuration.

4.6. Voltage measurement specifications

Range	Accuracy	Resolution	Guaranteed
15 V	±0.1% ±10 mV	1.2 mV	±14.5*
2V	±0.1% ±2 mV	180 µV	±1.98

* Beta units are limited to ±13.6 V.

The JS220 is sensitive to RF radiation which induces real voltages in test setups. When tested with EN61326-1 and 3 V RMS/m, the JS220 error increased by 10 mV (observed, not guaranteed) at several frequencies. The exact frequency susceptibility varies with cable length and configuration.

4.7. General specifications

	Test condition	Min	Typical	Max	Unit
Sampling frequency	25 °C		2000000		sps
Sampling frequency	25 °C	-25		25	ppm
Measurement bandwidth	- 3 dB	280	310	350	kHz
Front panel insertions				100	

4.8. Parasitic effects specifications

	Test condition	Min	Typical	Max	Unit
Current leakage (Voltage + to -)	25 °C, ±3.3V		2		nA
Current leakage (Voltage + to -)	25 °C, ±5V		2		nA
Current leakage (Voltage + to -)	25 °C, ±15V		3		nA
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	0.8	1.2	µs
Measurement gap following a current range switch				0	µs

4.9. Software-controlled fuse specifications

	Test condition	Min	Typical	Max	Unit
Current leakage (Current + to -)	25 °C, 3.3V		±5		nA
Current leakage (Current + to -)	25 °C, 5V		±7		nA
Current leakage (Current + to -)	25 °C, 15V		±28	±5000	nA

4.10. General Purpose Inputs & Outputs

	Test condition	Min	Typical	Max	Unit
Internal 3.3V reference		3.135	3.3	3.465	V
External reference	Vref < (VUSB – 0.5 V)	Vref - 0.1	Vref	Vref + 0.1	V
Input leakage per pin	25 °C			±10	nA
Input leakage per pin				±100	nA
Output voltage high	-100 µA	Vcco - 0.1			V
Output impedance	10 mA	45	50	80	Ω
GPI sample rate			2		MSPS
Continuous output current	Per pin			±50	mA
Total power dissipation	Over output impedance			0.25	W