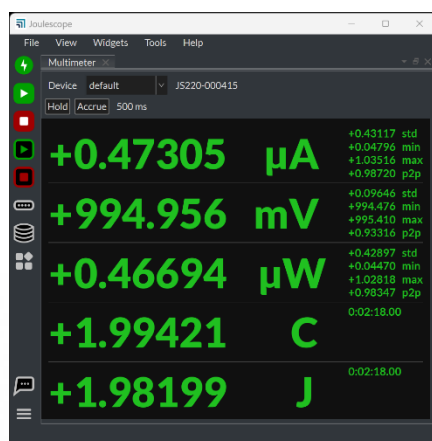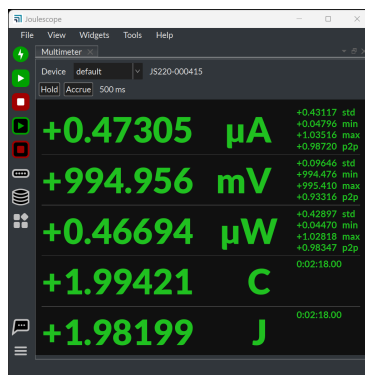# Joulescope™ User Interface (UI) User's Guide

Revision 1.7
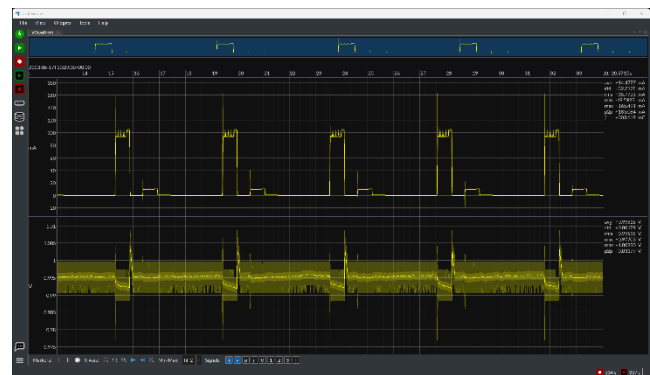
Last revised 2024 Oct 1

1. Introduction

Multimeter view

Oscilloscope view

The Joulescope User Interface displays measured data from instruments including the Joulescope JS220 and Joulescope JS110. These instruments provide high-dynamic range current measurements and voltage measurements to enable a variety of applications including:

- 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 UI is the quickest and easiest way to configure tests, capture data, and analyze the results.

The UI 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.

The UI also displays waveforms 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

- **Easy to use**: Simply install the UI on your host computer and connect your Joulescope. View live statistics and waveforms immediately. Easily access the data you need to make informed decisions.

- **View and analyze**: Explore, measure, and analyze captured data with a variety of included tools.

- **Record waveforms**: Record for as long as you like. The custom, open-source JLS file format makes exploring huge files quick and effortless.

- **Cross-platform**: The UI works with Microsoft® Windows® 10 & 11, Apple® macOS® 12, 13, 14 & 15, and Linux®. For Linux, only Ubuntu 22.04 LTS is officially supported. The UI only supports 64-bit operating systems with 64-bit Python 3.10+.

- **Open-source:** The UI is open-source on GitHub without annual maintenance fees. Buy your Joulescope today and use it on your terms.

- **Compatible:** Works with the Joulescope JS220 and original Joulescope JS110.

3. Table of contents

4. Installation

The Joulescope software is available to download at

> www.joulescope.com/download/

Click on the download link for your operating system and platform architecture. We recommend installing the Joulescope software on the native operating system, not under a virtual machine, due to Joulescope's demanding USB communication requirements.

See the appropriate section below for the installation for your operating system.

4.1. Microsoft® Windows 10 & 11

Click on the installer executable. Read and accept the license agreement, and click **Next**. Accept the default installation location or change it as need, then click **Next**. Select **Next** and **Install**. Finally, click **Finish** to complete the setup and launch the Joulescope UI.

4.2. Apple® macOS 12, 13, 14 & 15

On macOS, download the dmg file which supports both x86_64 (Intel) and arm64 (Apple Silicon) platforms. Open the dmg file and then drag **joulescope.app** to the **Applications** folder. Once the installation completes, you can eject the dmg file.

The macOS distribution is currently signed and notarized, but it is not distributed through the Apple Store. macOS should display that the application has been checked by Apple, but that it was downloaded from the web. It should install and run if you accept this warning.

If you receive a security warning, control-click the Joulescope application in Finder, then select **open** to bypass these security warnings. You will need to repeat the control-click, **open** process several times (usually twice) until macOS finally allows the Joulescope software to launch. After going through this process to grant permission once, subsequent runs will start normally.

4.3. Ubuntu 22.04 LTS (Linux)

Unpack the tar.gz file to the location of your choice. Then run the joulescope_launcher binary in the extracted directory. You may need to install additional dependencies.

```
sudo apt install libudev-dev libxcb-cursor0
```

Many Linux systems, including Ubuntu, use "udev" to manage devices and grant permissions. You will need to install a udev rule that grants Joulescope hardware access to your account. Download and follow the instructions in this file:

> https://raw.githubusercontent.com/jetperch/joulescope_driver/main/99-joulescope.rules

If you receive the error `Could not load the Qt platform plugin "xcb" in "" even though it was found`, then you need to install additional Qt6 dependencies. You can identify the missing dependencies by running `export QT_DEBUG_PLUGINS=1` before starting the Joulescope UI. Then install the missing dependencies with your package manager.

4.4.   Python (all platforms)

Follow the instructions for your platform to install python 3.10 or greater. Then install the Joulescope UI:

```
<python> -m pip install -U --upgrade-strategy=eager joulescope_ui
```

Replace <python> with path to your installed python binary.

Whenever you want to run the Joulescope UI, type:

```
<python> -m joulescope_ui
```

5. Meet the Joulescope UI

When you start the Joulescope UI for the first time or after updates, it greets you with the **Quick Start Guide**. Please read through this and click **OK** to continue. You will see the **Multimeter View**.

Before diving into the views, let's take a quick look at the window structure:
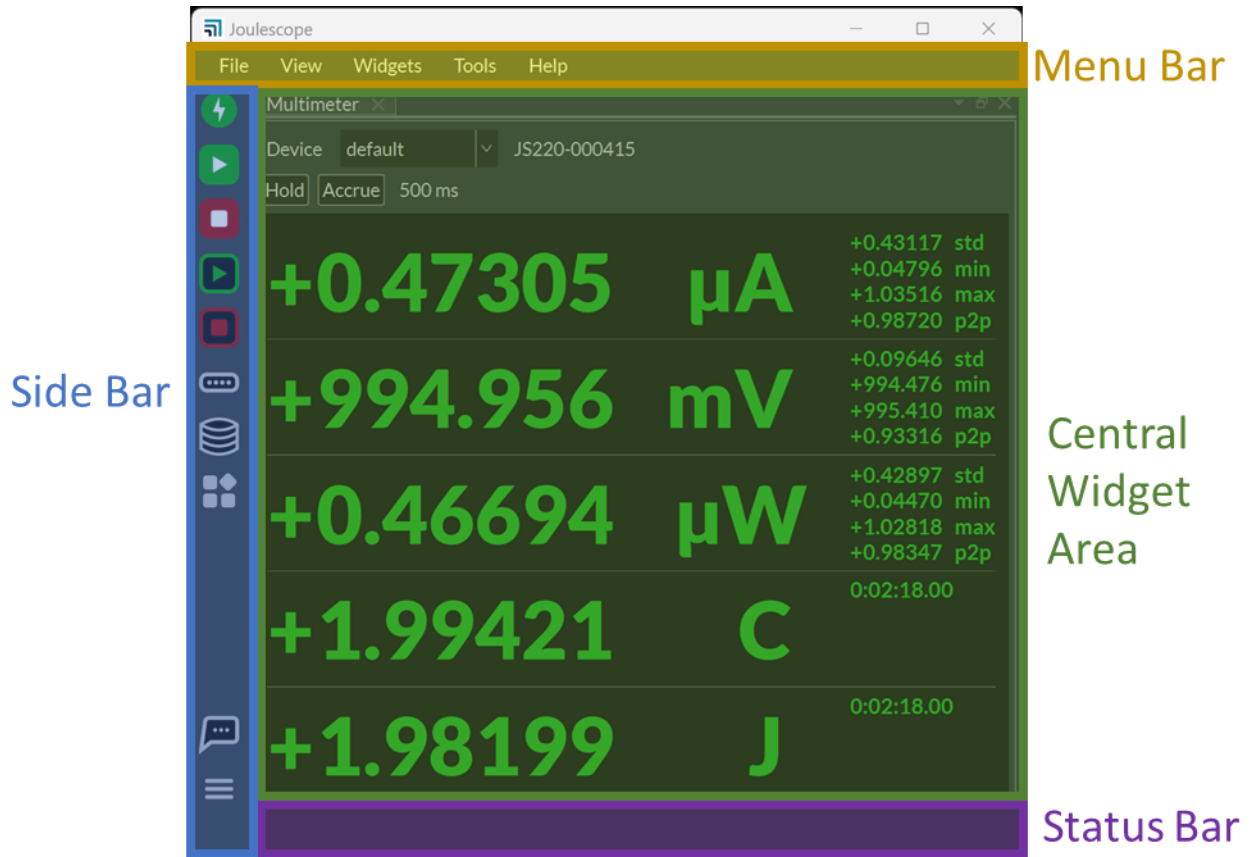
The **Menu Bar** allows quick access to commonly used features and settings:

Item	Description
File	Open recordings and exit application.
View	Select the active view and manage (add, delete, reorder) views.
Widgets	Add a widget to the active view.
Tools	Additional tools.
Help	Get help and more information.

The **Side Bar** allows quick access to commonly used features and settings:

Icon	Definition	Description
⚡	Target power	Toggle the power to target devices.
▣	Fuse engaged	Clear engaged fuses. Turns red & blinks when any fuse engaged.
▶	Signal sample streaming	Enable/disable sample streaming (pause waveform display)

■	Signal sample recording	Enable/disable sample stream recording.
▶	Statistics display	Enable/disable statistics streaming (pause multimeter display)
■	Statistics recording	Enable/disable statistics stream recording.
■■■	Device control	Show device control settings for every connected instrument.
⬓	Memory buffer settings	Show memory buffering settings.
⬓	Application settings	Show all application settings.
💬	Get help	Show a number of ways to get help with links.
≡	Additional settings and actions	Additional settings and actions.

The **Status Bar** shows current activity. For example, it shows the recording duration for any active recordings.

The **Central Widget Area** is where you can add, remove, and rearrange widgets. You can also undock widgets into other Windows.

When in doubt about a UI feature, hover the mouse over it, which often displays a **Tooltip**. Note that this only works when the Joulescope UI is also the active window. If you click on another application, you have to click on the Joulescope UI to make it active.

Want to configure something? Right-click (control-click on macOS) with the mouse to bring up a context-sensitive menu that varies based upon what you click.

5.1. Multimeter View
The **Multimeter View** provides the present operating state at a glance.
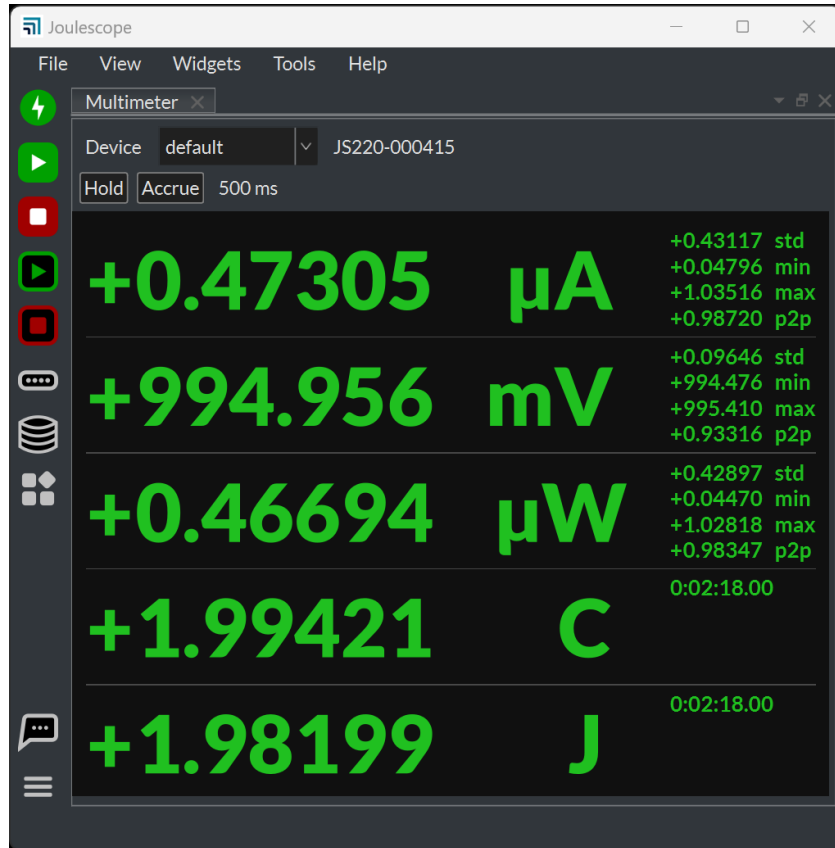
The multimeter view displays several quantities:

- Electrical current in amperes (A)
- Electrical voltage in volts (V)
- Power in watts (W)
- Charge in either coulombs I or amp-hours (Ah).
- Energy in joules (J) or watt-hours (Wh).

This display, along with all other value displays in the Joulescope software, the SI standard prefixes for orders of magnitude:

Prefix	Power	Name
G	10^9	giga-
M	10^6	mega-
k	10^3	kilo-
m	10^{-3}	milli-
μ	10^{-6}	micro-
n	10^{-9}	nano-
p	10^{-12}	pico-

The multimeter view updates every half second (0.5 seconds) by default. The software computes and displays the statistics over each half-second time window. The large numbers are the mean (also called average) value of that quantity over the window. The software also displays:

- std: The standard deviation
- min: The minimum value
- max: The maximum value
- p2p: The peak-to-peak value, which is equal to (max – min)

Note that charge and energy only display the time since the integration started since these other statistics are not meaningful.

Every update represents only the data recorded over the last half-second.

Press the **Hold** button to pause the display update. The charge and energy accumulators will continue to run properly in the background. You can press the Statistics Display ▶ button, which holds all widgets that display these statistics.

Press the **Accumulate** button to compute the statistics indefinitely until you press the button again. While **Accumulate** is active, the software extends the statistics to combine each new window without discarding results from previous windows.

5.2.   Oscilloscope View

The software includes an **Oscilloscope View** that displays waveforms over time.   To enter this view, select **View → Oscilloscope**.


The Oscilloscope view consists of the **Waveform Widget**. The **Waveform Widget** has several regions moving top to bottom:

- **Waveform summary**: shows the waveform to the full available time extents. The blue region highlights the time domain visible below.

- **x-axis**: Displays the time in UTC. The first line shows the relative UTC offset. The next line shows the values relative to the offset.
- **Signal waveforms**: The plot for each selected signal showing the signal value over time.
- **Control**: Settings that affect the waveform display.

When you first select the **Oscilloscope View** with a connected Joulescope, it will display the live streaming data from the instrument. You can click the Play ▶ button at the top left to pause the waveform buffer. Press again to resume.

You can easily navigate the collected data. Move the mouse over the plot of interest, and use the scroll wheel to zoom. Hold the left mouse button and drag the mouse cursor to pan. Alternatively, hold the shift key while using the mouse scroll wheel.

For the y-axis, the display automatically adjust to display the available data. However, you can manually control the y-axis view range. Hold the Ctrl key (command ⌘ on macOS) and use the mouse wheel to zoom. Hold Ctrl, hold the left mouse button, and drag the mouse cursor to pan. Alternatively, hold Shift + Ctrl while using the mouse scroll wheel. To return the automatic view range behavior, right-click on the plot area and select **Y-axis auto range**.

Right-click on any region for more options. You can add annotations, including:

- **x-axis single marke**rs: Display the average value and range for all samples represented by a pixel.
- **x-axis dual markers**: Display the statistics over a region of interest. Right-click on the dual markers for additional analysis options.
- **y-axis single mark**ers: Display the y-axis value
- **y-axis dual markers**: Display the y-axis values and delta.
- **Text annotations**: Add shapes and text to denote areas of interest.

The software computes statistics quantities over the full-time window shown in the present view for each waveform. The software displays the statistics on the right edge of the window. The statistical quantities are:

- avg: The mean (also called average) value
- std: The standard deviation
- rms: The root-mean-square value
- min: The minimum value
- max: The maximum value
- p2p: The peak-to-peak value (max – min)
- ∫: The integral over the time window

The control area contains a variety of buttons that affect the display. You can hover the mouse cursor over each to display a tooltip. The tooltip contains additional information for each option.

You can use x-axis dual markers to perform further analysis. Right-click one of the dual markers and select **Analysis** for the available options:
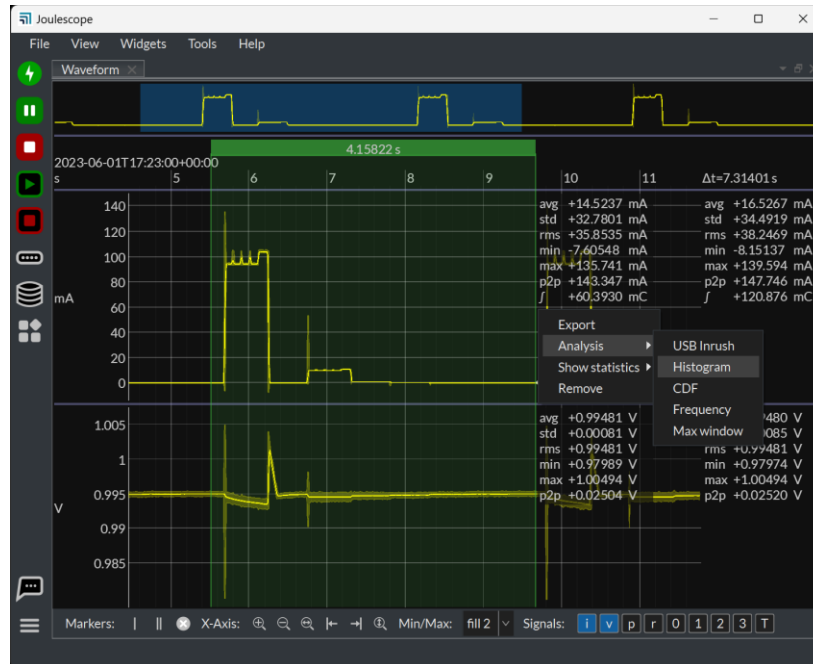
5.3. Energy and Charge

Joulescopes measure current and voltage at 2,000,000 samples per second. It then multiplies current by voltage to compute power. Joulescopes then integrate current to compute charge and integrate power over time to compute energy. The Joulescope UI displays charge and energy in both the **Multimeter View** and **Oscilloscope View**. This value starts accumulating when the software starts. Use **Tools → Clear Accumulators** to reset them to zero at any time.

The energy value and charge value provide a simple measurement to observe changes, especially for software. You can baseline the performance of an operation by recording the measured energy or charge value. You can then make changes, repeat the test, and observe the new energy or charge value. The **Oscilloscope View** enables you to investigate in further detail.

5.4. Signal Management

Instruments and recordings provide signals that can then be viewed or recorded. The Joulescope UI contains several features to manage signals.

Each device allows signal customization. Click the **Device Control** icon on the **Sidebar** to manage the signals provided by each device:
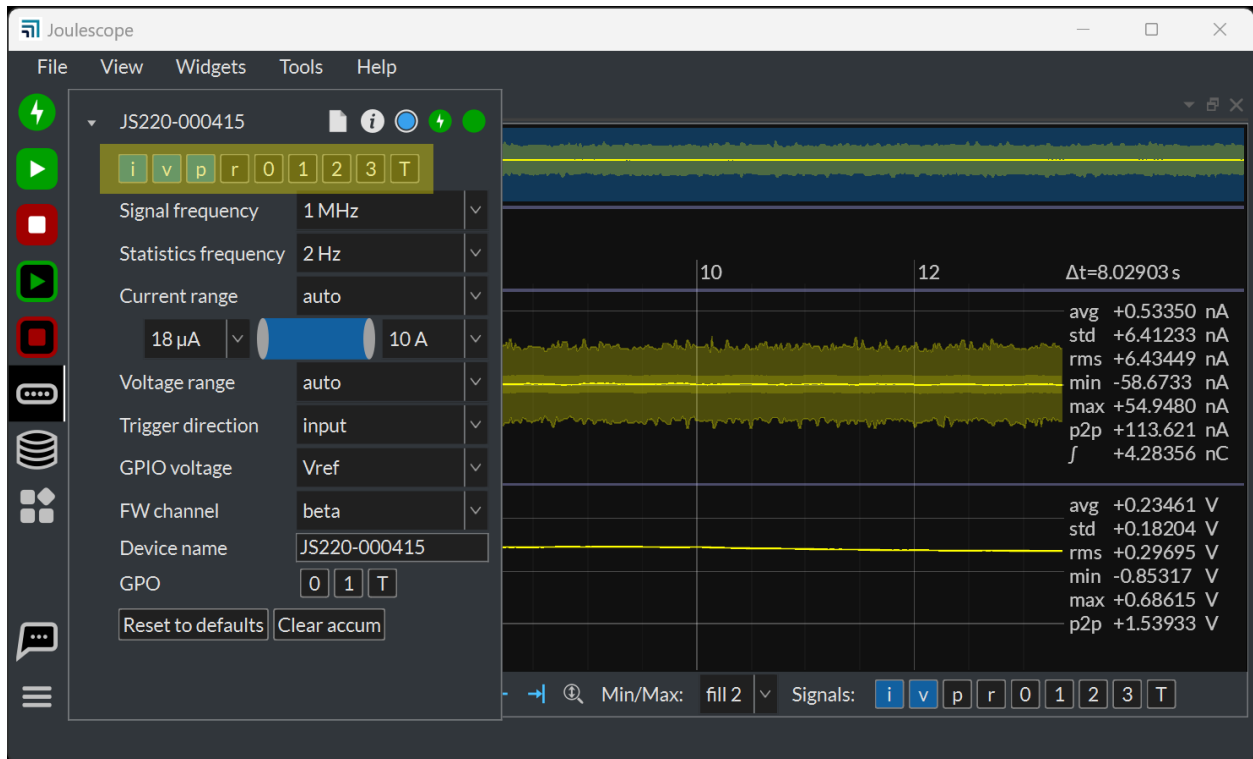
The Waveform Widget separately allows you to select which Signals it displays:
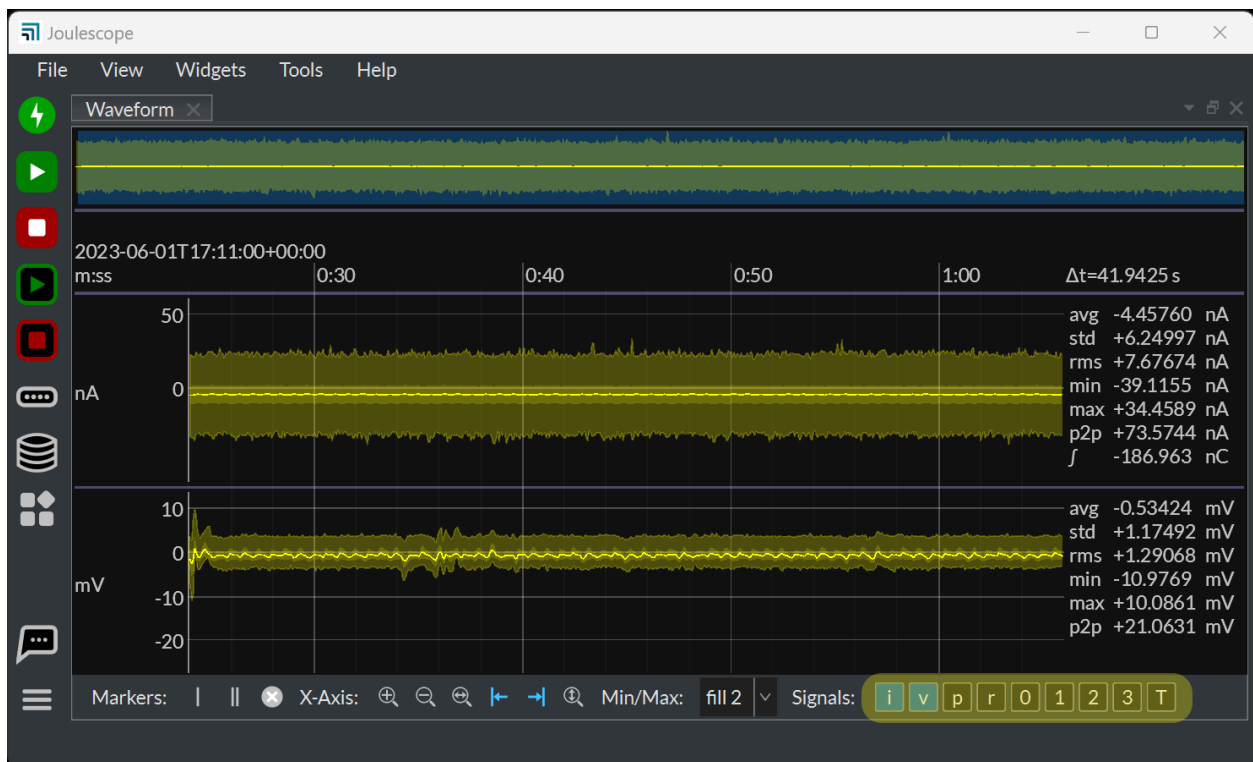
When you record a JLS file, the dialog allows you to select the signals to record:
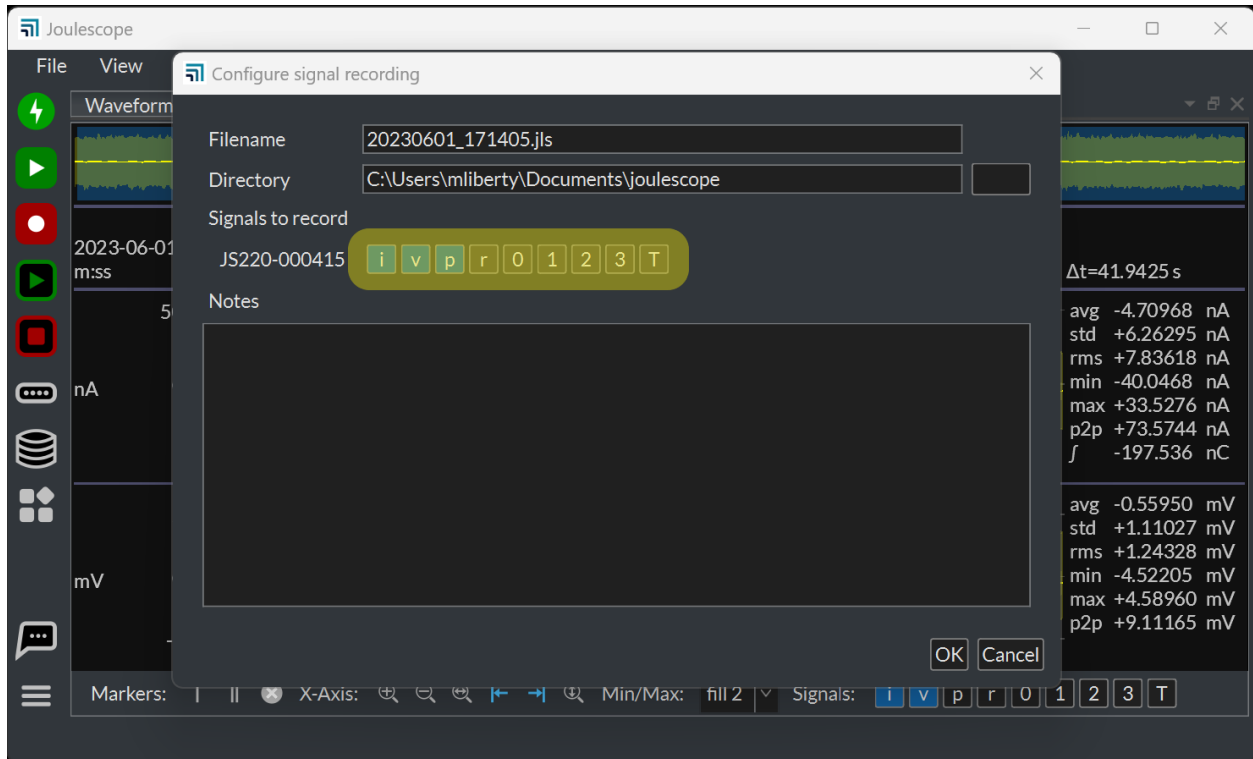
Recording more signals requires more storage space. To keep your storage space to a minimum, only select the signals you need.

5.5.   Triggers

Joulescope UI 1.1 and newer include a **Trigger** widget. The **Trigger** widget can detect start and stop conditions, and perform start and stop actions. The Trigger can run in either **Single** or **Continuous** mode. After configuring the desired operation, click the button at the top right to start the Trigger operation.

Joulescope UI 1.1 performs the trigger condition detection on the host. This detection includes communication latency from the Joulescope to the host computer. The **Set output** operation may have a significant delay (on the order of 100 milliseconds) between the actual condition and the output change. We do plan to move the condition detection to the JS220's FPGA for significantly reduced latency.

6. Multiple Instrument Support

The Joulescope UI supports multiple simultaneously connected Joulescope instruments. The UI includes the concept of a **default** device.
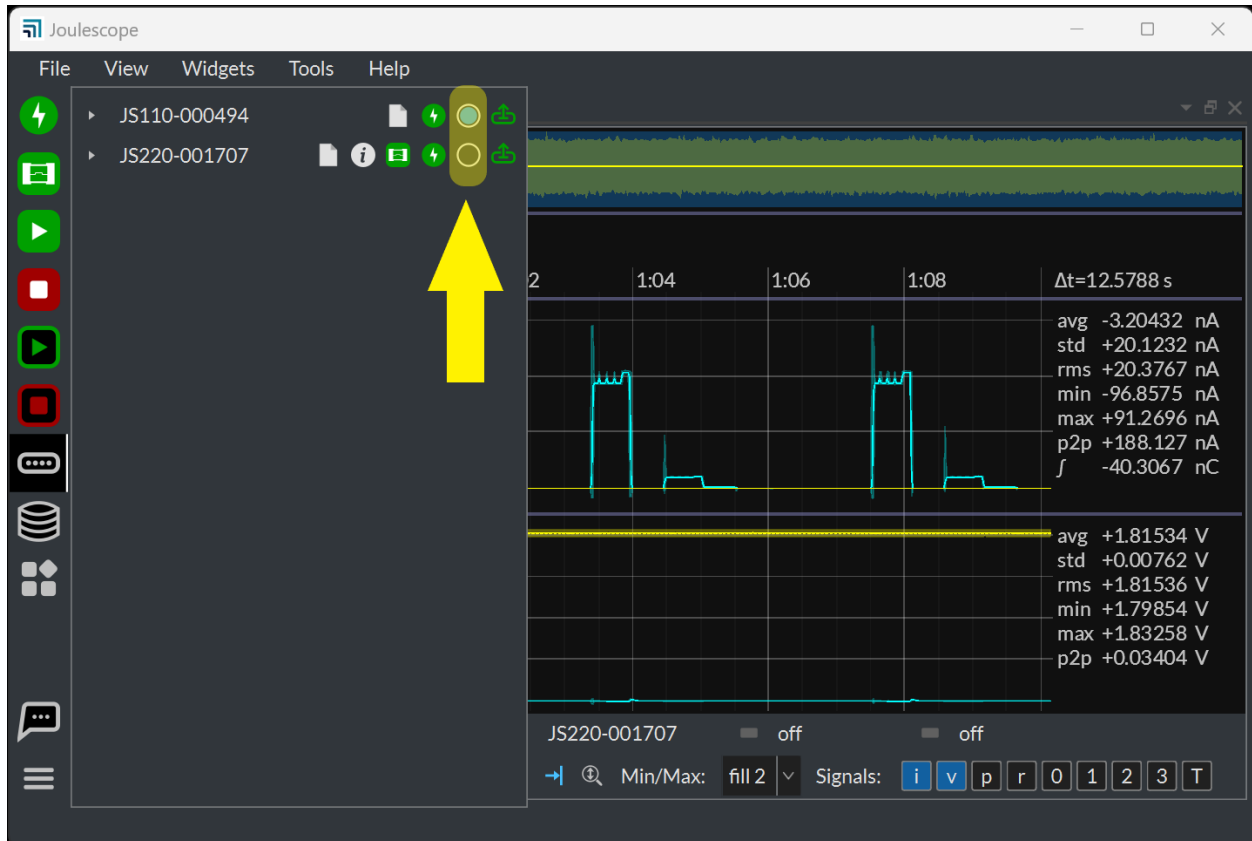
The UI will automatically select the initial **default** device. Change the **default** device using the **Device Control** widget.

When multiple instruments are connected, the **Waveform** widget displays an additional channel control widget.
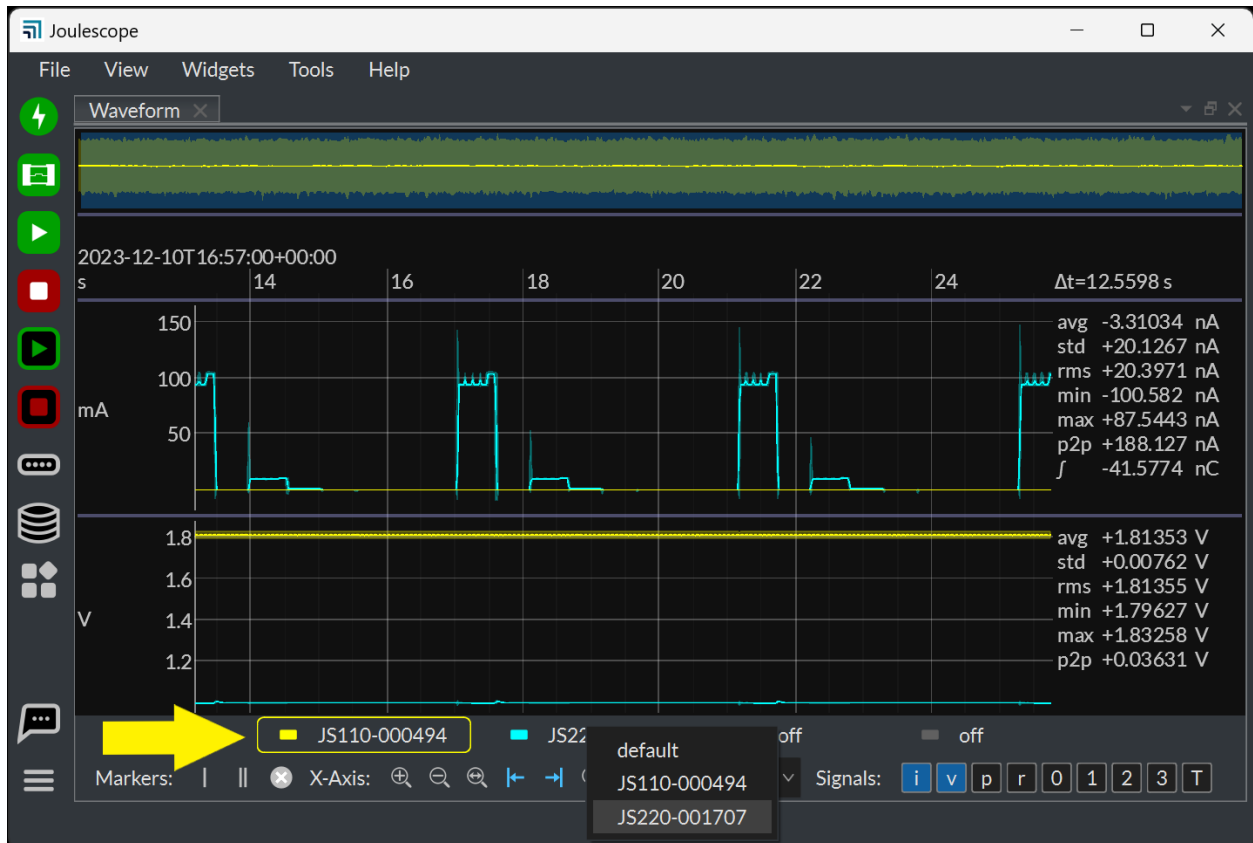
Click on the color bar to enable or disable the channel. Right-click on the channel name to select a different device. Click on the channel to select the active channel.

The Waveform widget uses the active channel to compute the right-hand side statistics and marker statistics. Changing the active channel will change the statistics computations. The active channel also determines the y-axis labels for the current range signal.

7. Graphics configuration

The Joulescope UI will use the default graphics configuration. On macOS and Linux, this works seamlessly.

Unfortunately, Windows has a known issue with integrated Intel graphics that can cause application crashes. If your computer only has integrated Intel graphics, we recommend that you update your Intel graphics drive to the latest. If you still see crashes, you can try using the software OpenGL renderer. The UI will prompt you to make the switch, which only takes effect after you close and reopen the application. You can later configure the OpenGL renderer by selecting **Widgets → Settings → Common → opengl**.

Even Windows computers with discrete graphics cards sometimes select Intel graphics depending upon the power settings. In this case, you can manually configure the Joulescope UI to use the high-performance discrete graphics card. Open Windows Settings. Select **System → Display → Graphics**. Select the joulescope.exe executable.
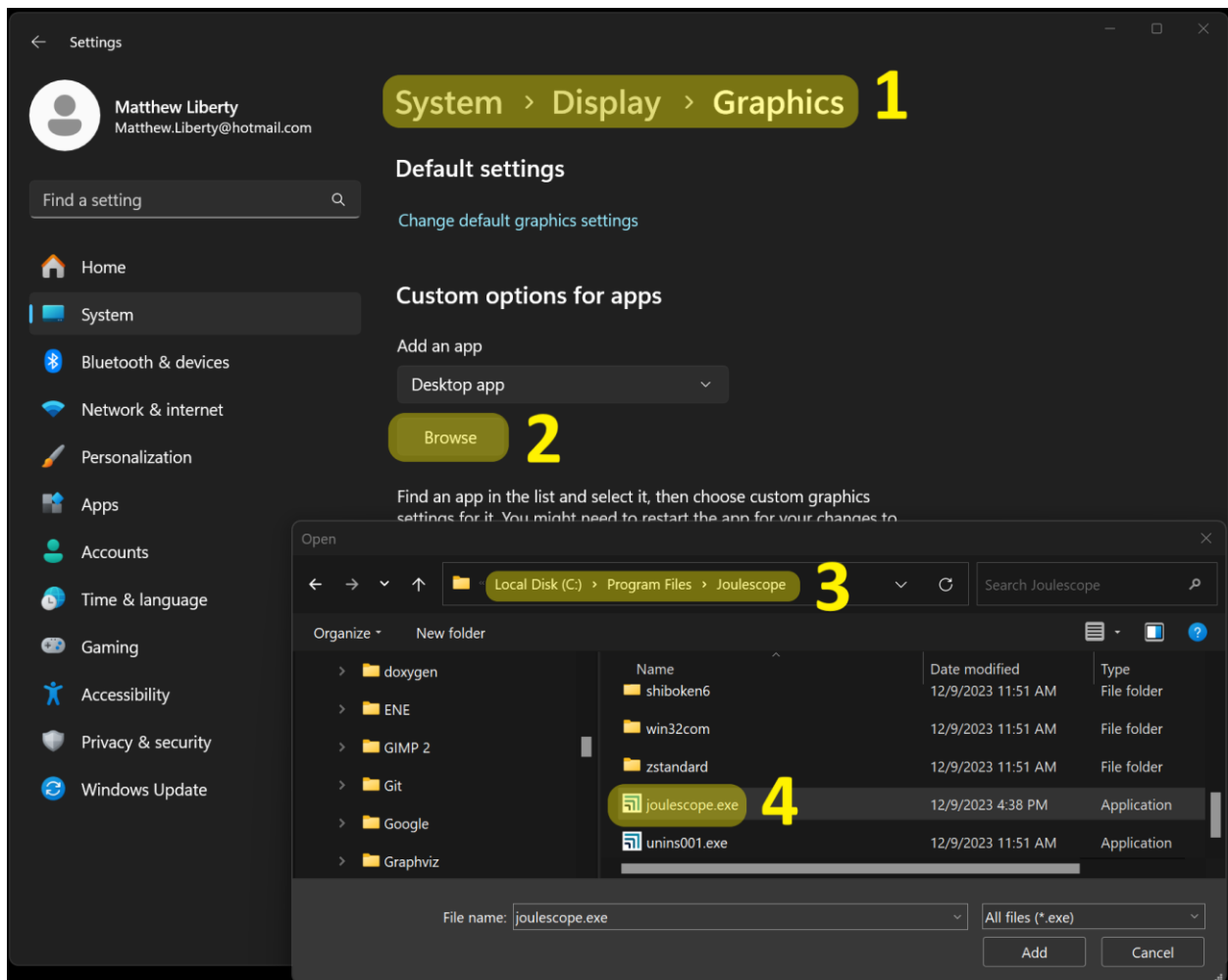
This will add the Joulescope UI to the list. Select **Joulescope UI** and press **Options**. Select **High performance** and press **Save**.
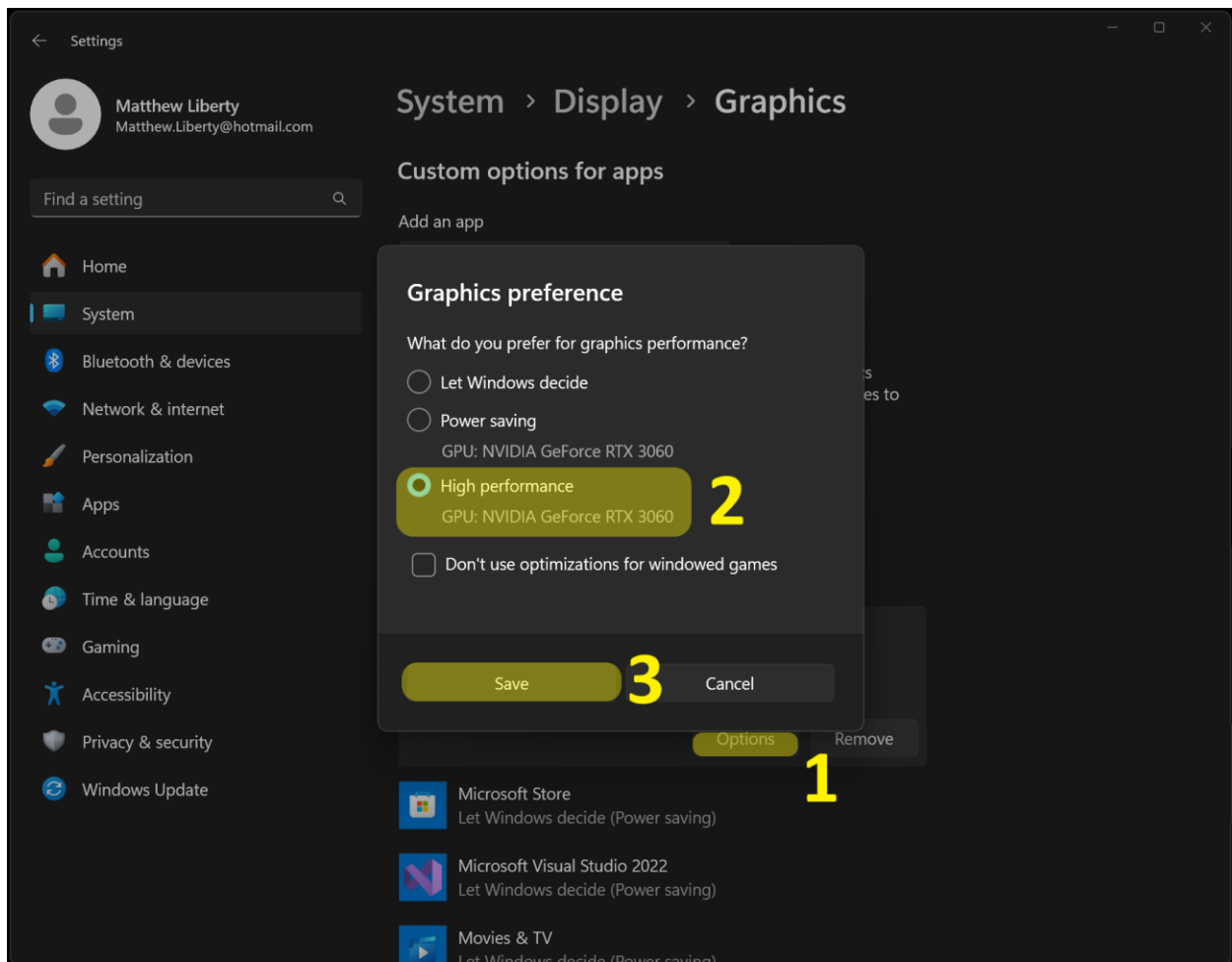
The next time you start the Joulescope UI, it will use the discrete graphics card.

8. Internationalization and Localization

Joulescope UI 1.1 introduced translations to several languages including:

Code	Language	Language
ar	Arabic	العربية
de	German	Deutsch
el	Greek	ελληνικά
en	English (US)	English
es	Spanish	español
fr	French	français
it	Italian	italiano
ja	Japanese	日本語
ko	Korean	한국어
zh	Chinese (simplified)	中文

By default, the UI will use the OS language configuration.

You can change the language by selecting **Help → Language**. **Help** is the last menu bar item and **Language** is the second item from the top. The UI will close when you click OK. The language change will take effect when you launch the UI again. This feature was added in 1.1.11.

Alternatively, you can also set the **LANG_JOULESCOPE_UI** environment variable, which will override the OS language. Use the 2-letter language codes above. At this time, the UI only offers basic language translations without country codes.

As of Joulescope UI 1.1.11, the UI does not offer further locale customizations, such as number formats.

All language translations were generated primarily by DeepL with some contributions from the Joulescope community. Please open a GitHub issue to submit corrections. Please include the language. For each correction, please list the existing language string and the recommended corrected string. If you are comfortable with GitHub pull requests, simply open a pull request with the fixes to the appropriate file:

    joulescope_ui/locale/*locale*/LC_MESSAGES/joulescope_ui.po

Alternatively, contact us with the same information.

9. Source Code

The UI is open source and written in Python 3.10+. The UI consists of several layers:

Repo name	Python package name	Description
pyjoulescope_ui	joulescope_ui	The Joulescope User Interface written in Qt6/PySide6
pyjoulescope	joulescope	The Joulescope Python "driver" with pyjoulescope_driver adapter for JS110 applications. The UI only uses this package to provide JLS v1 read support.
joulescope_driver	pyjoulescope_driver	Native JS220 and JS110 driver with Python bindings
jls	pyjls	High performance file storage for Joulescope data

The Joulescope package was designed so that you can script custom Joulescope actions and integrate Joulescope into your applications.

See the GitHub repositories for the latest details.

- https://github.com/jetperch/pyjoulescope_ui
- https://github.com/jetperch/pyjoulescope
- https://github.com/jetperch/joulescope_driver
- https://github.com/jetperch/jls

You can find examples of how to use Joulescope in your Python application at:

https://github.com/jetperch/pyjoulescope_examples

See the documentation:

https://joulescope.readthedocs.io/

The Joulescope software depends upon other software and libraries. See CREDITS.html for pyjoulescope_ui and pyjoulescope.

10. Plugin Support

The Joulescope UI supports plugins beginning with version 1.1. A plugin adds features and functionalities to the Joulescope UI without modifying the UI source code. You can install plugins even when using the Joulescope UI distributions.

⚠ Plugins run with the same permissions as the Joulescope UI. Active plugins have full access to run arbitrary code on this computer. Make sure you trust a plugin before activating it.

The UI currently does not yet have a mechanism to discover available plugins.

See the doc/plugin.md for additional documentation, including plugin development.

11. Troubleshooting

11.1. Reporting issues

While we work diligently to ensure that the Joulescope UI is stable, sometimes the unexpected happens. If the Joulescope UI fails to launch or crashes, it may prompt you to report the issue. Please report issues and include your email in the report so that we can work with you to solve the issue.

If the Joulescope UI crashes but does not prompt you to report the issue, please manually report the issue when you next start the Joulescope UI. Select **Help → Report Issue**. Please include your email so that we can work with you to solve the issue.

11.2. Windows memory compression

Microsoft Windows includes memory compression by default. While this is normally not an issue, it can slow down performance on Windows, especially if you increase the Joulescope memory buffer size on computers with large RAM.

To check if memory compression is enabled, launch PowerShell as Administrator and type:

```
Get-MMAgent
```

If MemoryCompression is True, then memory compression is enabled on your computer.

To disable memory compression, launch PowerShell as Administrator and type:

```
Disable-MMAgent -mc
```

11.3. Virtual Machines

We do not support running the Joulescope UI in virtual machines. The Joulescope UI requires low-latency USB communication which can be problematic under virtual machines. If you find that running the Joulescope UI within your virtual machine works, great! If not, please install the Joulescope UI on the native operating system.

11.4. Recording to Network Storage

Joulescopes at full sample rate generate a lot of data. When recording, we strongly recommend recording to a local solid-state drive (SSD) or hard disk drive (HDD). If your computer lacks sufficient storage, you can purchase an external HDD, which is very affordable.

Networks and network storage are often not able to keep up with the Joulescope data rates. If you need to put your recording to network storage, we recommend copying it over after the recording completes.

11.5. UI opens to white / blank window

ASUS Sonic Studio 3 and ASUS Sonic Radar 3 cause a known issue with all OpenGL applications in dual-monitor setups. If you close the Joulescope UI with a Waveform widget on the second monitor and then restart the UI, it will appear as a blank, white window. The workaround is to either keep the UI on the primary monitor or uninstall both ASUS Sonic Studio 3 and ASUS Sonic Radar 3. For more details, see issue #252 on GitHub.

12.   Contact

To purchase a Joulescope product, visit:
https://www.joulescope.com

If you have questions regarding operation of Joulescope, search the website at:
https://www.joulescope.com/

And visit the forum:
https://forum.joulescope.com/

If you wish to contact Jetperch regarding the operation of your Joulescope, contact us through email at:
support@joulescope.com

Location

Jetperch LLC
3470 Olney – Laytonsville Rd.
Suite 104
Olney, MD 20832-1734
USA

13. Glossary

Accuracy
The average variation in the bias between measurements and truth. Good measurements are both accurate and precise.

Ammeter
A device that measures electrical current.

Burden Voltage
The voltage drop that occurs through the test equipment device. For shunt ammeters, the burden voltage includes the voltage across the shunt resistor, connectors, fuses, and any additional resistance in the device.

Current
The flow of electric charge per time from positive voltage to negative voltage, measured in amperes (A), often called amps. One amp is one coloumb of charge flowing per second. One coloumb is approximately 6.242×10^{18} electrons, but electric current is defined opposite to the electron flow.

Energy
The total power exerted over time, measured in joules (J). Energy is the time integral of power.

Insertion Loss
The loss in signal power due to a device in the signal path, most commonly used in reference to radio frequency (RF) or telecommunications. See **Burden Voltage**.

Multimeter
A multifunction device that usually incorporates a voltmeter and shunt ammeter, at a minimum. A standard multimeter supports only one measurement quantity at a time.

Ohm's Law
The equation that relates voltage, current and resistance: $V = I * R$

Oscilloscope
A device that graphically displays a one or more signals, usually voltages, varying over time as a two-dimensional plot with time on the x-axis and the signal on the y-axis.

Power
The time-rate of doing work, measured in watts (W). Power is voltage multiplied by current.

Precision
The amount of variation between measurements of the same value relative to each other. Good measurements are both accurate and precise.

Resistance
The quantity of opposition to the flow of electric current.

Shunt Ammeter

An ammeter that measures the voltage across a resistor, and then uses Ohm's Law to compute current.

Shunt Resistor

The resistor used by "Shunt Ammeters" to detect current using Ohm's Law: I = V / R. Given a known R and a measured V, the ammeter computes I.

Universal Serial Bus (USB)

The now ubiquitous standard for connecting computers and peripherals. Joulescope connects to the host computer using USB 2.0 high-speed operating at 480 Mbps.

Voltage

The electric potential difference, measured in volts (V).

Voltmeter

A device that measures electrical voltage.

14. User's guide information

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

14.1. Copyright notice

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14.2. Publisher

Jetperch LLC
3470 Olney – Laytonsville Rd
Suite 104
Olney, MD 20832-1734
USA

14.3. Warranty

The Joulescope UI User's Guide is provided AS-IS with no other representations or warranties, expressed or implied, of any kind including, but not limited to, any implied warranty of merchantability of fitness for a particular purpose. Jetperch LLC does make reasonable efforts to present accurate and reliable information in this Joulescope UI User's Guide.

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/.

14.4. Change log

Revision	Date	Description
1.7	2024 Oct 1	Updated i8n to describe new Help → Language Indicated macOS 15 support in addition to 12-14
1.6	2024 Apr 25	Updated for Joulescope UI 1.1: Triggers, translations & plugins
1.5	2024 Feb 12	Added troubleshooting blank / white screen. Bumped required python from 3.9 to 3.10. Update macOS text to include 14 support. Updated copyright dates.
1.4	2023 Dec 11	Updated multiple, simultaneous device support section Added Graphics configuration section.
1.3	2023 Oct 9	Added troubleshooting section
1.2	2023 Jun 16	Updated Linux installation instructions.
1.1	2023 Jun 15	Updated macOS support (added 12, universal2)
1.0	2023 Jun 1	Initial version