
Phasor Explorer

Release 0.4.1.3

X. Michalet

Nov 09, 2021

CONTENTS:

1	Overview	1
2	Windows	3
3	Analysis	11
4	Download & Installation	13
5	Version History	15
6	Bibliography	17
7	Acknowledgments	19
8	Support	21

OVERVIEW

1.1 Credit

Phasor Explorer was developed to accompany an article discussing the properties of the phasor of continuous or discrete binned or time-gated periodic decays:

X. Michalet, “Continuous and discrete phasor analysis of binned or time-gated periodic decays”

AIP Advances *11*, 035331 (2021); <https://doi.org/10.1063/5.0027834>

Please cite this article if you use Phasor Explorer in your work.

1.2 Overview of the User Interface

The user interface consists in a main window with a top menu bar (File, Windows, Edit, Analysis).

The user interface elements (graphs, buttons, numeric controls and indicators, etc.) displayed on the window can be modified with the help of a pull-down menu below the menu bar, offering the following options:

- Phasor Plot
- Pseudo Phasor Lifetime
- Decay, Gate & Gated Decay

In addition to the main window, the Windows menu gives access to 4 other windows

- Notebook
- Settings
- Context Help
- About

These different UI elements and their functions are described in separate sections of the manual.

WINDOWS

Phasor Explorer is comprised of one main Window and 2 child windows accessible from the top Windows menu. These different windows are briefly described next. For further information, please check the User Guide.

2.1 Main Window

The main window's appearance depends on the selected pull-down menu option located below the menu bar.

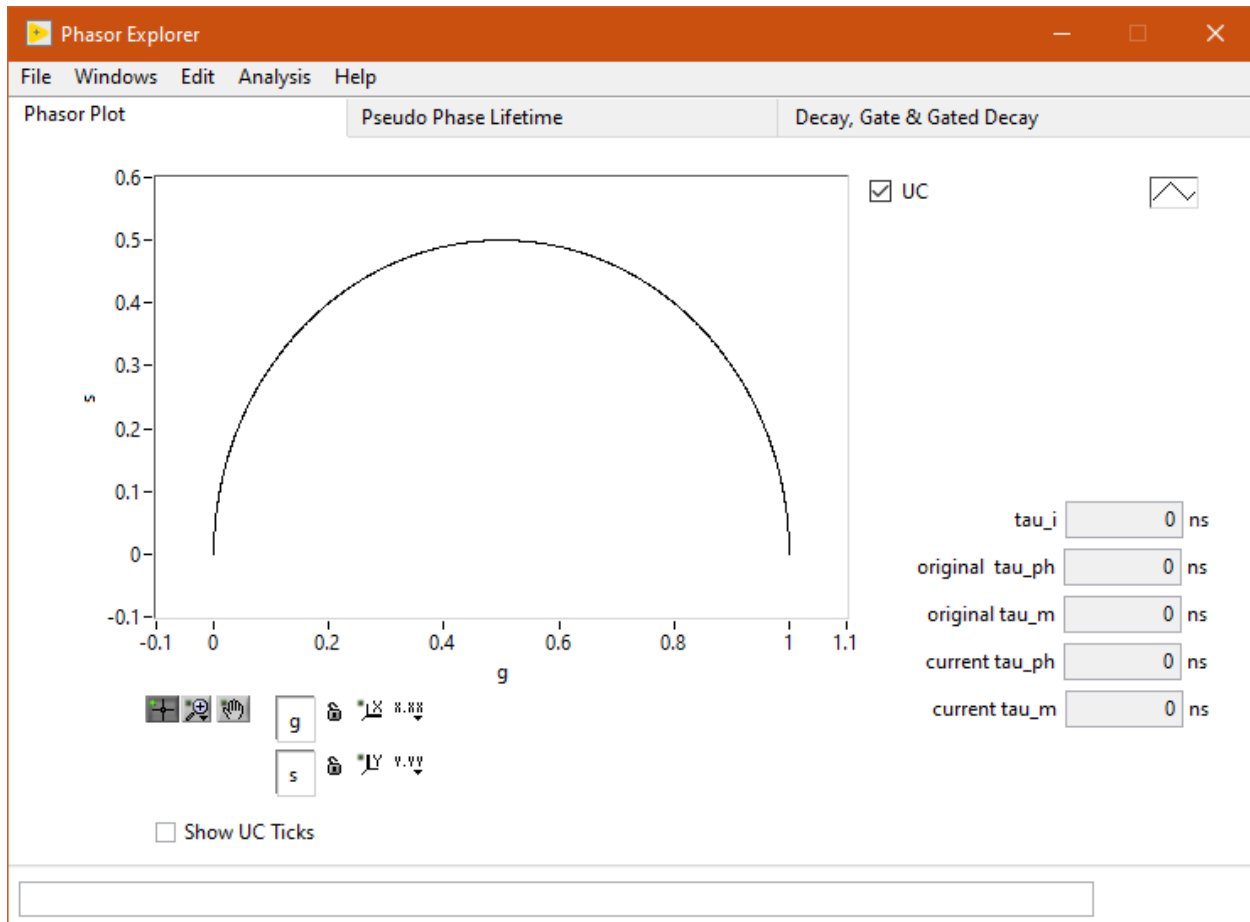
The different Analysis sections in the manual describe the functions of the corresponding controls.

Generally, each panel shows one graph and a few controls (numeric controls or indicators, check boxes).

Each graph is a feature-rich LabVIEW object allowing many interactions with each individual or groups of plots, including saving or loading them as ASCII files.

Right-clicking a graph and choosing Copy Data will copy a bitmap image of the Graph, which can then be pasted into the Notebook (or elsewhere) for documentation.

Because of the finite resolution of such an image, it is generally recommended to save the raw data contained in each Graph (or individual plots) as ASCII files, and re-open them in a dedicated data representation software for publication quality results.



The top menu bar gives access to the following functions:

- **File**
 - Quit
- **Windows**
 - Settings (Ctrl+E)
 - Notebook (Ctrl+N)
- **Edit**
- **Analysis**
 - Phasor Plot (Ctrl+P)
 - Pseudo Phase Lifetime Plot (Ctrl+L)
 - Decay, Gate & Gated Decay Plots (Ctrl+D)
- **Help**
 - Show Context Help (Ctrl+H)
 - About

The main window's appearance depends on the selected tab located below the menu bar.

The different Analysis sections in the manual describe the functions of the corresponding controls.

Generally, each tab shows one graph and a few controls (numeric controls or indicators, check boxes).

Each graph is a feature-rich LabVIEW object allowing many interactions with each individual or groups of plots, including saving or loading them as ASCII files.

Right-clicking a graph and choosing Copy Data will copy a bitmap image of the Graph, which can then be pasted into the Notebook (or elsewhere) for documentation.

Because of the finite resolution of such an image, it is generally recommended to save the raw data contained in each Graph (or individual plots) as ASCII files, and re-open them in a dedicated data representation software for publication quality results.

2.2 Settings Window

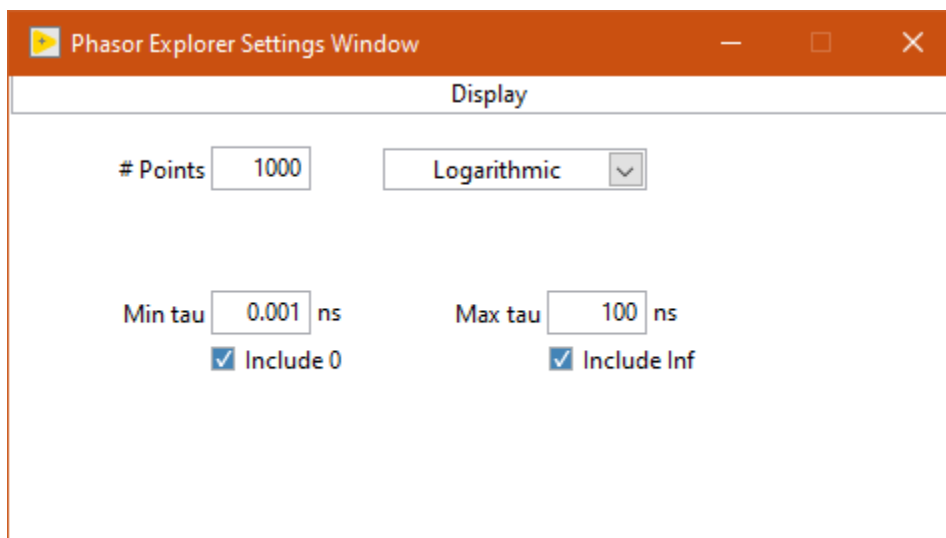
The Settings window (which can be left open at all times) gives access to all parameters/options controlling the different types of calculations:

- Display
- Phasor
- Decay
- Gates
- Detector

Once options and parameters have been set in the Settings window, calculations performed in the main window will use these parameters/options.

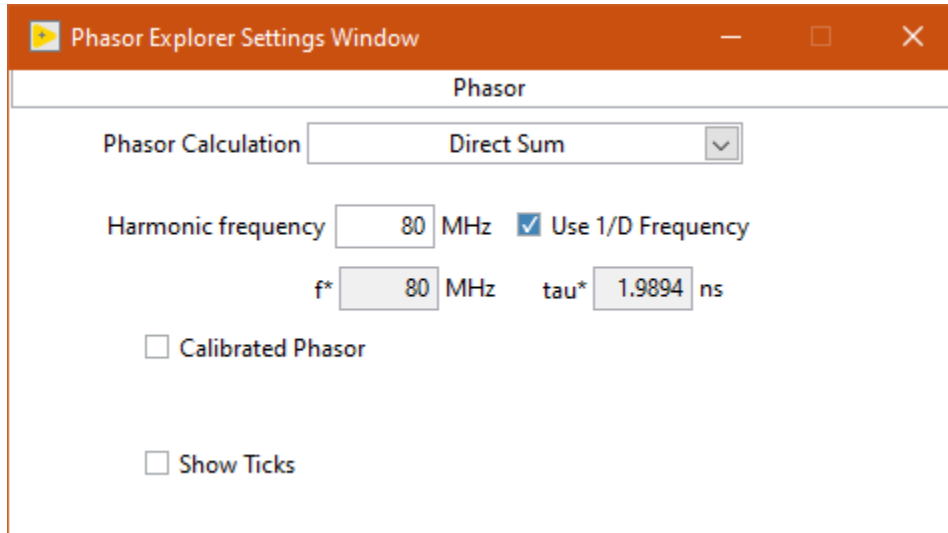
The whole set of options/parameter is also printed in the Notebook.

2.2.1 Display



To be described.

2.2.2 Phasor

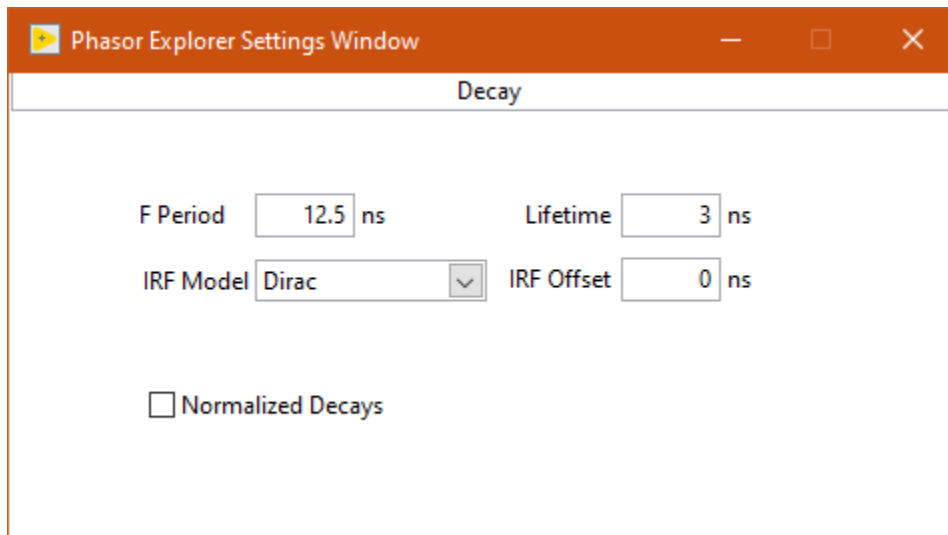


The screenshot shows the 'Phasor Explorer Settings Window' with the 'Phasor' tab selected. The window has a title bar with a play icon and standard window controls. The settings are as follows:

- Phasor Calculation:** A dropdown menu set to 'Direct Sum'.
- Harmonic frequency:** A text input field containing '80' followed by 'MHz'. To its right is a checked checkbox labeled 'Use 1/D Frequency'.
- f*:** A text input field containing '80' followed by 'MHz'.
- tau*:** A text input field containing '1.9894' followed by 'ns'.
- Calibrated Phasor:** An unchecked checkbox.
- Show Ticks:** An unchecked checkbox.

To be described.

2.2.3 Decay



The screenshot shows the 'Phasor Explorer Settings Window' with the 'Decay' tab selected. The window has a title bar with a play icon and standard window controls. The settings are as follows:

- F Period:** A text input field containing '12.5' followed by 'ns'.
- Lifetime:** A text input field containing '3' followed by 'ns'.
- IRF Model:** A dropdown menu set to 'Dirac'.
- IRF Offset:** A text input field containing '0' followed by 'ns'.
- Normalized Decays:** An unchecked checkbox.

To be described.

2.2.4 Gates

Phasor Explorer Settings Window

Gates

Gate Type

User-defined

Gate

IRF

IRF

First Gate Start

0

ns

☐ Use Gate Center

Gate Width

10

ns

☐ Use Gate Step

Gate Step

17.8571

ps

☒ Match Laser Period

Adjust

Gate Step

Gates

700

Steps

700

Integration

Fixed

Adaptive

To be described.

2.2.5 Detector

Phasor Explorer Settings Window

Detector

Incident Signal

0

☐ Poisson Signal

Frames/Image

0

Gates/Frame

1

Bits/Frame

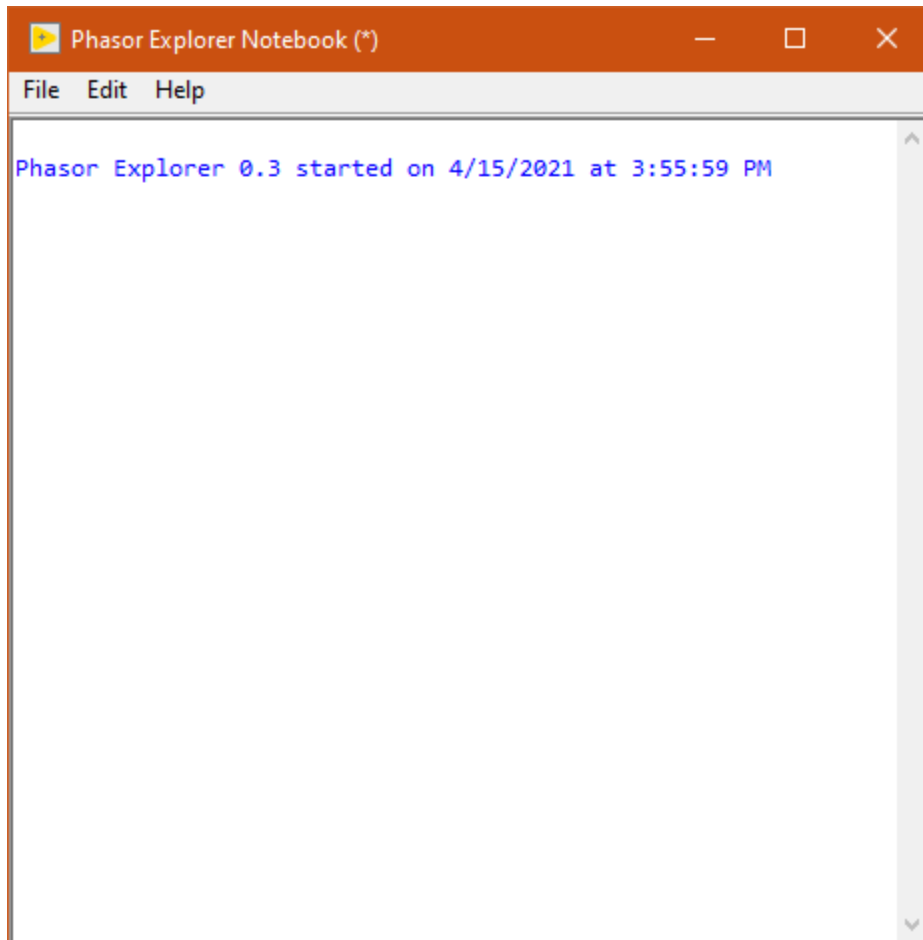
1

Multiplicity

0

To be described.

2.3 Notebook

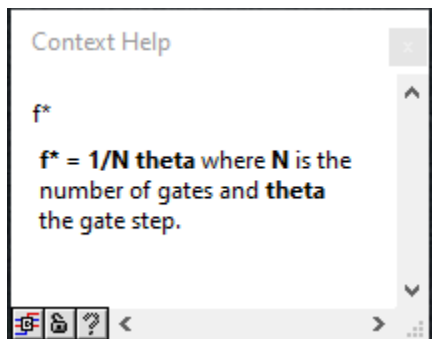


The Notebook is a Rich Text Box object in which most actions performed by the software are recorded. It is accessed via the **Windows >> Notebook** menu item (shortcut: **Ctrl+N**).

It can also be used to type in user comments, copy/paste text or graphics, etc. and in general is intended as a log of an experimental session.

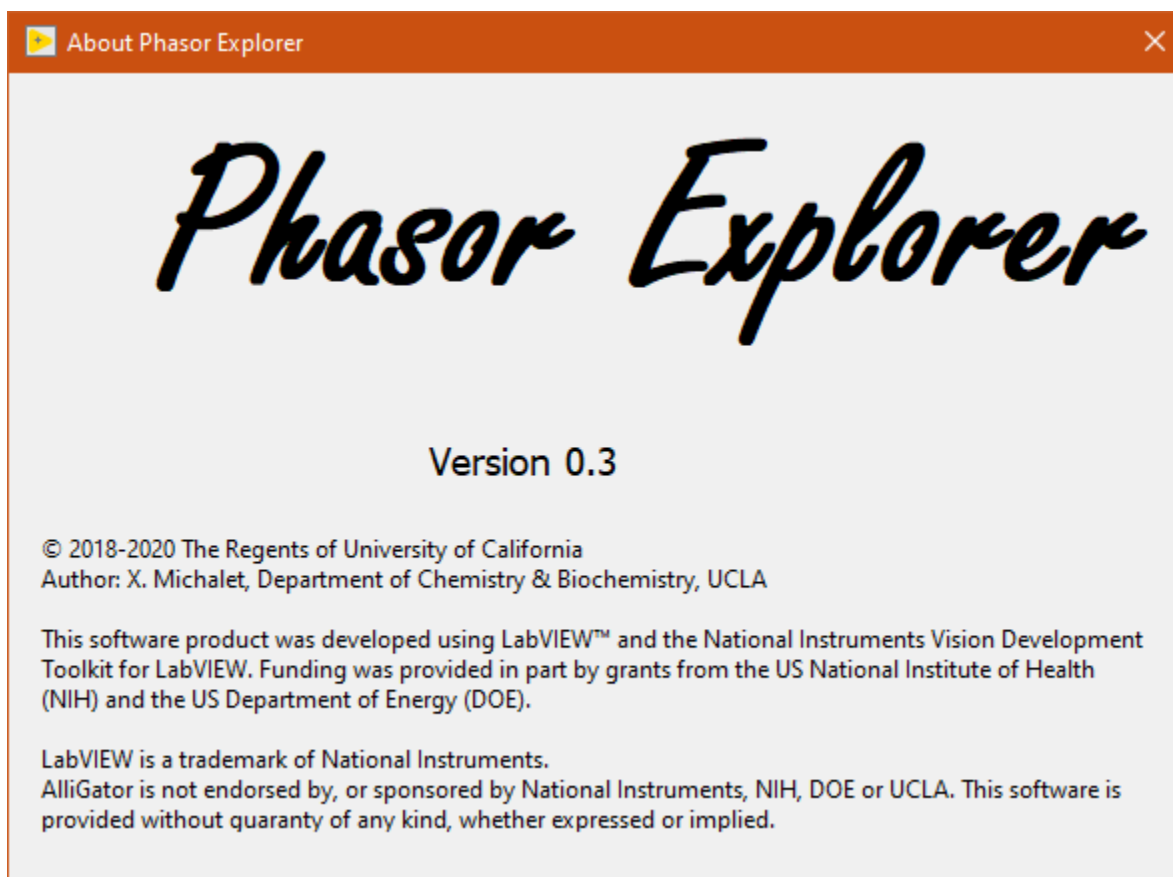
The content of the Notebook can be saved (and re-opened within the Notebook) as a rich text format (.rtf) file.

2.4 Context Help Window



The Context Help window is a floating window and shows information (when available) about the object the mouse is over. It is shown or hidden using the Help >> Show Context Help menu item (shortcut: Ctrl+H).

2.5 About Window



The About Window is a dialog window (it prevents other windows from being interacted with). Click anywhere in it to close it.

3.1 Phasor Plot

The different “Single-Exponential Phasor Loci” (SEPL) curves discussed in ref. [1] of the bibliography can be reproduced by setting the gate parameters, laser period, phasor frequency and calibration lifetime in the respective panels of the Settings window, and then selecting Analysis>> Phasor Plot from the menu bar. This adds the corresponding plot to the graph.

Using a cursor linked to that plot, and moving it along the plotted SEPL, the indicators labelled `tau_i`, `original tau_ph` or `current tau_ph` and `original tau_m` or `current tau_m` will be updated according to the cursor location.

`tau_i` represents the actual lifetime used to compute the phasor at that location, while `original tau_ph` and `original tau_m` represent the calculated pseudo phase and modulus lifetimes corresponding to that phasor, using the calibration settings chosen when the Phasor Plot command was issued. `current tau_ph` and `current tau_m` represent the calculated pseudo phase and modulus lifetimes corresponding to the phasor, using the current calibration settings.

For instance, if the SEPL was calculated with the options “Calibrated Phasor” and a Reference Phasor selected as UC and a Calibration Lifetime = 0, the `original tau_ph` and `original tau_m` would correspond to the phase and modulus lifetimes computed as if the UC was the actual SEPL. If the current settings are different (say Reference Phasor = L_N and Calibration Lifetime = 0), `current tau_ph` and `current tau_m` will be the phase and modulus lifetimes computed as if L_N was the actual SEPL.

Note that these values are computed only for the finite number of lifetime values used to build the SEPL (defined in the Display panel of the Settings window).

3.2 Pseudo Phase Lifetime

The dependence of the pseudo phase lifetime τ_φ of PSED as defined in this article can be studied using Analysis >> Pseudo Phase Lifetime Plot in the menu bar.

The gate parameters, laser period, phasor frequency and calibration lifetime used in this calculation are those defined in the respective panels of the Settings window.

A checkbox on the front panel (Compute Delta Tau) allows calculating the difference $\tau_\varphi - \tau$ instead.

3.3 Decay, Gate & Gated Decay

This panel allows previewing the effect of gating on periodic single-exponential decays (PSEDs). Select which curve to compute and display using one of the 3 checkboxes on the bottom right side of the graph. Parameters used to compute these curves are set in the Settings >> Decay and Settings >> Gate panels of the Settings window.

The decay is compute with 1,000 points, but the Gated Decay is computed for the number of gates (# Gates) defined in the Settings>>Gate panel.

DOWNLOAD & INSTALLATION

4.1 System Requirements

The executable version of this software will only run on 64 bit versions of Microsoft Windows 7 and up. The source code will run on Windows only due to the use of some .NET functions.

Some of the functions used by the software support parallelism, therefore a multiprocessor and/or multicore computer is recommended (this statement is not as dated as it sounds, as virtual machines offer the choice of core number).

4.2 Software Requirements

2 pieces of software need to be present on your computer for Phasor Explorer to run properly. They depend on whether you want to use the source code (say, if you want to look under the hood and understand what is being calculated) or simply run an executable.

4.2.1 Using the source code

- Phasor Explorer source code
- LabVIEW Full Development System (FDS)

4.2.2 Using the executable

- Phasor Explorer Installer
- LabVIEW Run-time Engine (RTE)

Follow the corresponding instructions below for each part, in order to make sure you install the correct versions of only the part you need. Do not hesitate to post a support request on the Support Google Group to ask for help or advice.

4.3 Source code installation

The source files can be found in the Phasor Explorer Distribution repository on Github at: <https://github.com/smXplorer/Phasor-Explorer>

You can either clone the repository on your computer using git, or simply download a zipped archive of the full repository from the Code dropdown menu visible on the topright corner of the window (Download ZIP).

4.4 Executable installation

1. Download the zipped installer file, which can be found in the installer directory of the Phasor Explorer Distribution repository on Github at: <https://github.com/smXplorer/Phasor-Explorer>

Note: The installer only installs the software and its dependent files, but won't result in a functional executable unless you have the LabVIEW 64 bit Run-Time Engine (RTE) installed on your machine (*). If you have a LabVIEW 64 bit RTE version more recent than the one recommended below, Phasor Explorer should run fine with it, and thus there is no need to install an older RTE version than the one you are already using.

2. Unzip the file. This requires right-clicking on the zip file and selecting "Extract All..." to expand the archive into a new, temporary folder.
3. Run the setup.exe file found in that folder.
4. Follow the instructions on the installation screen (the default values are fine).

The installer will create a "Phasor Analysis" folder under the "Program Files" directory on your computer (unless it already exists, in which case it will not be modified) and install the corresponding version of Phasor Explorer in it.

4.5 LabVIEW FDS or RTE Installation

- The LabVIEW FDS installer is available from NI for registered users, or can be downloaded for a limited trial period, at: <https://www.ni.com/en-us/support/downloads/software-products/download.labview.html>

Registered users can select whatever version they want, while trial users will only have access to the latest version. Make sure you select the 64 bit LabVIEW 2019 SP1 Windows version.

- The LabVIEW RTE installer is available for free from NI (link below).

(*) The required version of the RTEs depends on the Phasor Explorer software version:

LabVIEW 2019 SP1 64 bit RTE for version 0.2 and above: RTE: <https://www.ni.com/en-us/support/downloads/software-products/download.labview.html#329457>

Uninstalling Phasor Explorer does not uninstall the corresponding RTE version, therefore it is only necessary to install the required RTE once.

Note that if you have the correct LabVIEW development environment installed on your machine, there is no need to install the RTE again, as it will already be available.

VERSION HISTORY

5.1 0.4.1 (released 2021-11-08)

- New Features:
 - if the IRF/gate is user-defined, enforce using numerical calculation
 - Improved SEPL Plot Names
 - Fixed confusing combination of options when computing Phasor Plot
- Bug Fixes:
 - Corrected round-off error when computing $z_N[W](\tau = 0)$
 - Minor improvements and fixes

5.2 0.3.1 (released 2021-04-30)

- Bug Fixes
 - fixed an erroneous error message when computing non square gates

5.3 0.3 (released 2021-04-15)

- Bug Fixes
 - Minor UI issues fixed
 - Minor bug fixes
- New Features
 - Added Poisson Noise option in Decay
 - Added “Use Gate Step” option to set the gate width (Gates tab)
 - Apply normalization option to Gate/IRF
 - Renamed IRF parameter to “IRF Period” (instead of “Laser Period”)

5.4 0.2 (released 2020-06-04)

initial release

BIBLIOGRAPHY

- [1] Continuous and discrete phasor analysis of binned or time-gated periodic single-exponential decays, X. Michalet, AIP Advances 11 (2021) 035331. <https://doi.org/10.1063/5.0027834>
- [2] An overview of continuous and discrete phasor analysis of binned or time-gated periodic decays, X. Michalet, Proceedings of SPIE 11648 (2021) 116480E. <https://doi.org/10.1117/12.2577747>
- [3] Wide-field time-gated SPAD imager for phasor-based FLIM applications, Arin Ulku, Andrei Ardelean, Michel Antolovic, Shimon Weiss, Edoardo Charbon, Claudio Bruschini and Xavier Michalet, Methods & Applications in Fluorescence 8 (2020) 024002. <https://doi.org/10.1088/2050-6120/ab6ed7>

ACKNOWLEDGMENTS

This work, carried out in the Weiss lab (Chemistry & Biochemistry Department at UCLA) was supported by a variety of projects as follows:

- UCLA JCCC Seed Grant 2020
- Human Frontier Science Program Grant No. RGP0061/2015
- US National Institutes of Health Grant Nos. R01 GM095904 and R01 CA250636
- University of California CRCC Grant No. CRR-18-523872
- US Department of Energy Grant No. DE-SC0020338
- European Research Council Horizon 2020 research and innovation program Grant Agreement No. 669941
- Partner University Fund, a program of the French American Culture Exchange

SUPPORT

If you find issues with the software (persistent error, bug, etc.) or want to suggest features for future releases, please join the Alligator and other Phasor Analysis Software Support Google Group at <https://groups.google.com/g/alligator-software-support>.

- search