Sensitive EQE Measurement Manual (last updated 28 Jan 2023)

`Codes pieces are written with this font`

Any “< >" enclosed code has to be manually adapted by the user before copying

If **“Mouse Automation”** is mentioned, it means: **Take your hands of the mouse ASAP** after giving the command for it !

Turn on:

- Switch on extension cord
- Turn the light source and slowly move the dial to 90
    - Let the lamp warm up for approx. 20-30 mins
- Turn on the monochromator, the chopper and the Lock-In
    - If the chopper controller display reads 7777, turn it off and on again
    - Once the Lock-In is turned on and connected to a PC, you will hear clicking

Preparation if you already have the sEQE program:

- Start Windows computer and check that all cables are connected.
- Log into your physics account
- Open “LabOne” software on the desktop. The Webserver opens automatically. If everything is correctly connected and installed, the Lock-in Amplifier should be found as device. Double click on the device to open the connection.
- Open “Users/Public/Documents/python_virtual_environments” as folder and type into the top header: “cmd” . Press enter. A terminal should open with the above path as current path.
- Type into the terminal: “venv\Scripts\activate” . “(venv)” should stand in front of your terminal’s cursor now.
- Type in: “cd ..” and “cd sEQE-Setup\sEQE-Control-Software" . Your path should end now with “sEQE-Control-Software"
- Type in “git checkout cryo”
- Type in “python sEQE.py” to start the sEQE GUI.
- Type in terminal (without quotation marks) if asked:
  1. Zurich instrument device ID, for AFMD: ‘hf2-dev838’
  2. Port number of second filter wheel, for AFMD: ‘4’

3. Port number of monochromator, for AFMD: ‘1’

4. Save data path, for AFMD: ‘C:\\Users\\Public\\Documents\\sEQE’

5. (for cryo version): LINK.exe path: for AFMD: 'C:\\Program Files\\Linkam Scientific\\LINK\\LINK.exe'

These data will be saved in “pathsNdevices_config.txt” and reloaded if this file is found.

- sEQE GUI should be now open.
- Go to first page and type for Lock-In amplification: “1000”. Press “Update Parameter” “ to remove potential overload.
- Leave the terminal open during measurement. Avoid marking text in the terminal later or scrolling. If you do so during a measurement process, the software will be paused.

Troubleshooting: If the “zhinst” package is not found: Remove the “zhinst” folder from the “sEQE-Control-Software" folder and try to run the sEQE.py again

Calibration:

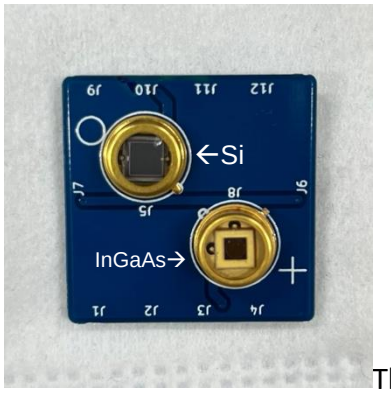
A calibration file is not needed for the measurement itself, but later on in the analysis tool. During the measurement you will see raw data that need to be converted to EQE in the analysis tool.

System is relatively stable, and calibration is not required on each day of measuring. Calibration prior to critical measurements is recommended. The calibration files will be stored in sEQE/username you set for your reference scans. On Windows, it is recommended to save the reference data in the “Public” folder within the “Reference_Scans” folder, such that anyone can check, whether a calibration was recently done.

- One can load the reference diodes measurement parameter into the GUI via the “import parameter button”. Standard parameter are found in “Reference_Scans” folder.
    - The Si photodiode connects to pins J10 and J7(J6) with an amplification of 1000. **Pay attention to the lock-in overload status! You will get EQE over 1 is**

the reference scan is taken when lock-in is overload. The calibrated wavelength range for Si diode is 360-1100 nm.

- The InGaAs photodiode connects to pins J3 and J7(J6) with an amplification of 1000. The calibrated wavelength range for InGaAs diode is 800-1500 nm.



These are the reference diodes within the CBD (Circuit BoarD)

Cryo measurement incoming ? Please speak to Ming, now the sample mount in the stage has to happen

Alignment:

In the setup

- Place the sample in the holder. Check that holder and Circuit BoarD (CBD) are correctly connected by carefully pressing holder and CBD together
- Connect alligator clips to GND and whatever device you want to measure.

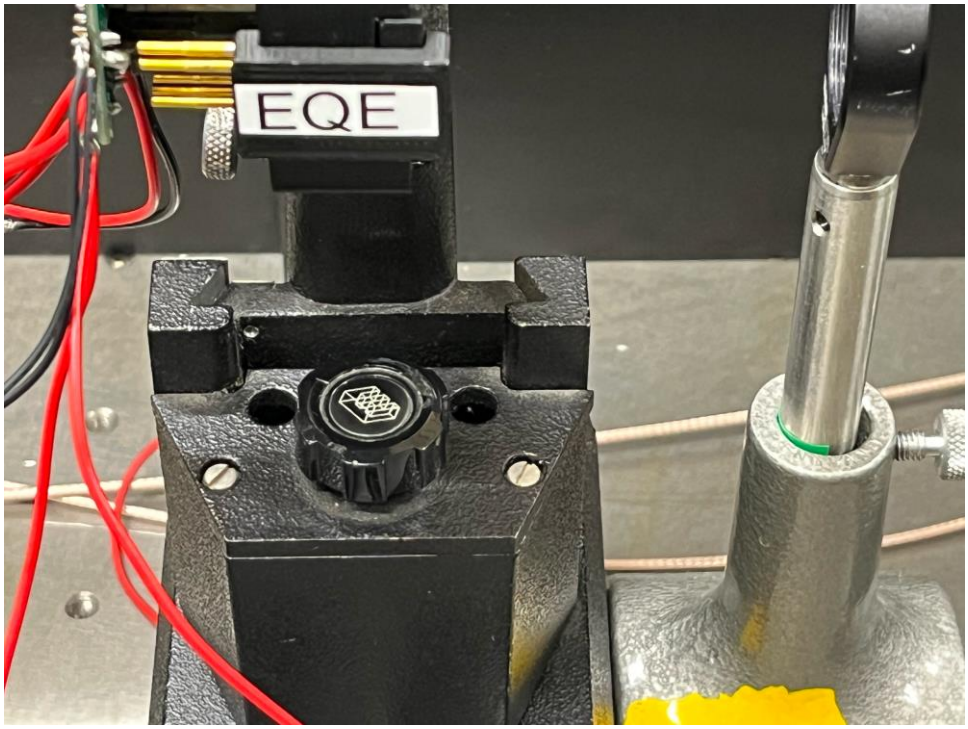
In the sEQE-Control-Software program

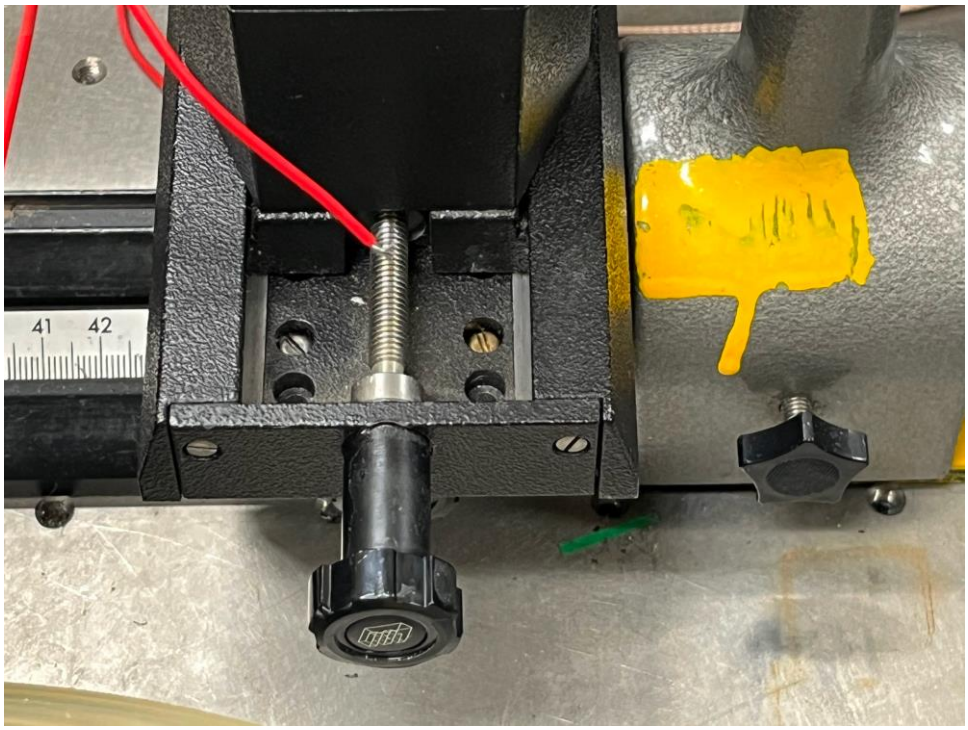
- Go to second tab. Add the username, experiment name, and file name or load it from an existing folder with the “load naming” button.
- Press the connect button and check whether the monochromator, the filter wheel, and the Lock-In connection could be established. If you want to use the cryostat, click “connect” next to “cryostat” Mouse Automation will take place, which will open the LINK software and automatically connect to USB.
    - If one or all are unsuccessful, connect to instruments individually by clicking the relevant buttons

- The Lock-In will probably be overloaded. You can tell that this is the case if either
    - the right lamp on the left-hand side of the Lock-In is on or if
    - in the LabOne web interface is a red sign on the bottom right next to “OV”

  If that is the case, go to the first tab of the program and click on the “Update parameters” button in the Lock-in section
- Look at the monochromator in the experimental setup (big black box closes to the Monitor). Check that the default position of the wheel filter is position 1, i.e. closed.
    - If that is not the case, use the filter initialization function under “Settings” and type in the current filter position. Ignore terminal output – it might display a misleading filter number. Check the filter wheel position at the setup.

      Only use manual adjustment as last resort !
- Move to filter position 2 in the software. Try to align with white light. Otherwise you can choose any other visible wavelength (500 nm works well) for alignment in the program.
    - Click “connect to monochromator” to have white light for re-alignment again.
- Align by eye and use the Lock-In control (LabOne) interface for fine alignment. To do this, navigate to the “Plotter” tab in LabOne interface
    - Use the knobs on the sample stage to adjust the position of the substrate





sEQE Measurement

- Once aligned, you are ok to start measuring:
- Select suitable filters on page 2 to increase sensitivity in weak absorption regime
    - for ZnPc:C60 the following filter set works well: noFilter, 665nm, 715nm, 780nm; for lower band gap systems consider adding 850nm

- Adjust the step size (default 5 nm) , amplification etc. as needed
    - typically default amplification of 10^5 gives good results; consider higher amplification in the very weak absorption regime
- You can load in previously saved measurement parameter via the “import parameter” button.
- If you use the cryostat:
    - Type in the cryostat parameter in the order shown in the bottom right text box.
    - Convert to .csv. Add the .csv ending to the filename !
    - Convert this .csv file into .lpf files into LINK: **Mouse Automation after entering filename!**
        - The Automation will type in the parameter into the LINK software. Check after automation that the correct parameter were typed in via navigating with the arrows in the top left quarter of the screen.
    - The cryostat will start as soon as you click ‘Start Scan’, and it will then measure the sample with the same sEQE parameter at the different Temperatures. Mouse Automation in between sEQE measurements ! As long as you see the data being plotted, you are free to use the mouse.
- Data files will automatically be saved
- The graph should update during measurement
- The time constant, data transfer rate and low pass filter order are set on page 1
    - The software averages X * time constant per value, where X can be set in page 2
    - In general, you do not need to change the data transfer rate and the low pass filter order.

End of measurements

- Once you are done with your measurements you need to switch off the monochromator, the chopper, and the lock in amplifier. If you used the cryostat, remove you sample and dispose of the remaining liquid nitrogen according to the rules.
    - Turn down the light power source dial to zero and wait ~20 min for the lamp to cool down before switching it off.

    - Remember to also turn off the extension switch.
- Close all the terminals before leaving.
- Happily analyze your data!

Monochromator filters

Filter 1: closed

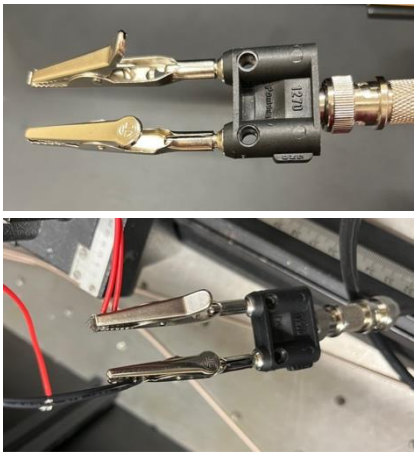
Filter 2: open

Filters 3 - 5: Optical filters that the program automatically moves to

Thorlabs filter wheel filters

Filter 1: open

Filters 2 - 5: Optical filters that the program automatically moves to



Double aligator clip

Troubleshooting

- Low signal even in strong absorption regime. May occur after a heavy overload (e.g. from setting a high amplification). Further diagnostics: recorded currents (see measurement files) are below 10^-6 to 10^-9.

  → restart terminal server (close window, check status to make sure it has stopped, start again)
- No light beam

    - Set monochromator to e.g. 500nm
    - Set monochromator filter to 2 (=open, potentially manually)
    - Set Thorlabs filter wheel to 1 (=open, buttons at filter wheel)
- At low signals, Dip in the signal before saturating to slightly higher value → best guess: exchange cables OR exchange BNC to banana adapter

First time setting up:

Git:

- Watch this video, to get started with git: https://www.youtube.com/watch?v=RGOj5yH7evk
- You do not have the sEQE software yet ? Follow the "How to clone a directory" Github guide and clone the sEQE code: https://docs.github.com/en/repositories/creating-and-managing-repositories/cloning-a-repository

Ubuntu Desktop:

- Install Python3 newest version
- Start a terminal window on your desktop and Install the python package "virtualenv" with typing into the terminal:

  ```
  python3 -m pip install virtualenv
  ```
- Install second python version:

  ```
  sudo apt-get install software-properties-common
  # adding python repository
  sudo add-apt-repository ppa:deadsnakes/ppasudo apt update
  # install python 3.9
  sudo apt install python3.9
  ```

  (source: https://towardsdatascience.com/installing-multiple-alternative-versions-of-python-on-ubuntu-20-04-237be5177474)
- Create a virtual environment by typing into the terminal (specifying the virtual environments path and name):

  ```
  python3.9 -m virtualenv <path/to/env/envname>
  ```
- Go to the parent folder the virtual environment and activate it by typing

`source envname/bin/activate`

- Navigate to the sEQE code folder and install the sEQE code dependencies:

  `python3 -m pip install –r requirements_linux.txt`

Windows Desktop:

If you dont find LabOne:

- Install “LabOne” and the “MF device finder” from the Zurich instrument download center (https://www.zhinst.com/europe/en/support/ download-center) with admin rights (ask IT)

How to set up Python and virtualenv:

- Install Python3 newest version from the “self service” tool from Physics IT.
- Start a terminal window on your desktop by opening the windows file browser, navigating to “Desktop” and then typing into the text box where the path to “Desktop” is shown: `cmd`
- Install the python package “virtualenv” with typing into the terminal:

  `python -m pip install virtualenv`
- Install Python 3.9.13 via this link: https://www.python.org/ftp/python/3.9.13/python-3.9.13-amd64.exe (when the installer asks: do not add Python 3.9.13 to Windows PATH environment variable)
- Find the location of your Python 3.9.13 .exe file and copy the full absolute path of the .exe file.
- Create a virtual environment by typing into the terminal (specifying the Python version’s path and choosing a name):

  “`python -m virtualenv –python <path\to\pythonVersion\python.exe> <path\to\env\envname>`”
- Go in to parent folder of your virtual environment with the “`cd`” command
- Type in:

  `envname\Scripts\activate`

  -> you should then see a “(envname)” in front of your terminal cursor.

  If not: you did not enter the virtual environment, read error message and try to enter virtual environment again
- Check Python version by typing:

`python –version`

-> output should be: “3.9.13”

If not: virtual environment has the wrong python version, package incompatibilities might arise and the control code might be unusable. Try to create a new virtual env with the correct Python version.

- Install the needed python packages for the sEQE by navigating your terminal (via “cd” command) to the sEQE-Control-Folder and typing in:

  `pip install –r requirements_windows.txt`

Preparation:

Windows:

- If you have the github repository cloned: Update your current version of sEQE.py to the latest stable release via either:

1. Go in to folder of sEQE code with “cd” command in terminal and type

   `git pull master`

   (only works with ssh connection set up: https://docs.github.com/en/authentication/connecting-to-github-with-ssh)
2. or cloning the repository again: https://docs.github.com/en/repositories/creating-and-managing-repositories/cloning-a-repository

- Start a terminal window in the public folder “python_virtual_environments” by opening the windows file browser, navigating to “python_virtual_environments” and then typing into the text box where the path to “python_virtual_environments” is shown: `cmd`
- Type in:

  `<envname>\Scripts\activate`

  -> you should then see a “(<envname>)” in front of your terminal cursor
- To run the sEQE script in the terminal:
- Navigate again with “`cd`” commands into the folder where you placed the "sEQE.py" file. On Windows use “`dir`” command to see folder structure
- Start the sEQE Control Program by typing:

  `python sEQE.py`

Ubuntu Desktop:

- Verify that monochromator is connected via the USB cable, not the serial cable.
- **Check that the "zhinst" folder is within the folder of the sEQE control code**
- Go in to parent folder of your virtual environment with the "cd" command. On Linux use "`ls`" command to see folder structure
- Type in:
  `source <envname>/bin/activate`
  -> you should then see a "(envname)" in front of your terminal cursor.
- Type "`ziService status`" into the terminal connected to the virtual environment. If this gives an error message, try the same without the virtual environment
- If the answer is "ziServer has stopped", then type "`ziServer`" into the terminal
  - *The ziServer often crashes after a couple of minutes after the sEQE is turned on. If the sEQE control program crashes, then check the ziServer status again*
  - **Do not close this terminal while using the instrument**
- Type "`startWebServer`" into a separate terminal, but also connected to the virtual environment, command should autocomplete. If this gives an error message, try the same without the virtual environment
  - You can now access the Lock-In control interface on http://127.0.0.1:8006/
    → click 'open'
  - **Do not close this terminal while using the instrument**
- Open another terminal, activate the virtual environment, navigate back to the sEQE folder and start the sEQE control code with:
  `python3 sEQE.py` into the terminal, press enter.
- Type in terminal (without quotation marks):
  1. Zurich instrument device ID, for AFMD: 'hf2-dev838'
  2. Port number of second filter wheel, for AFMD: '0'
  3. Port number of monochromator, for AFMD: '1'
  4. Save data path, for AFMD: '/home/jungbluthl/Desktop/sEQE Data'

  These data will be saved in "pathsNdevices_config.txt" and reloaded if this file is found.

- Leave the terminal open during measurement. Avoid marking text in the terminal later or scrolling. If you do so during a measurement process, the software will be paused.

- **Troubleshooting:** If there are any bugs due to the AFMD older ubuntu system, please refer to Max's reported bug list.