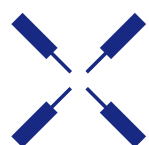# SHFLI
User Manual

8.5 GHz Lock-in Amplifier

Zurich
Instruments

SHFLI User Manual

Zurich Instruments AG

Revision 24.01

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Table of Contents

Table of Contents

CE Declaration of Conformity

CE

The manufacturer

Zurich Instruments
Technoparkstrasse 1
8005 Zurich
Switzerland

declares that the product

SHFLI 8.5 GHz Lock-in Amplifier

is in conformity with the provisions of the relevant Directives and Regulations of the Council of the European Union:

Directive / Regulation	Conformity proven by compliance with the standards
2014/30/EU (Electromagnetic compatibility [EMC])	EN 61326-1:2013, EN 55011:2016, EN 55011:2016/A1:2017, EN 55011:2016/A11:2020 (Group 1, Class A and B equipment)
2014/35/EU (Low voltage equipment [LVD])	EN 61010-1:2010, EN 61010-1:2010/A1:2019, EN 61010-1:2010/A1:2019/AC:2019-04
2011/65/EU, as amended by 2015/863 and 2017/2102 (Restriction of the use of certain hazardous substances [RoHS])	EN IEC 63000:2018
(EC) 1907/2006 (Registration, Evaluation, Authorisation, and Restrictions of Chemicals [REACH])	-

Zurich, October 20th, 2022

Flavio Heer, CTO

UKCA Declaration of Conformity

The manufacturer

Zurich Instruments
Technoparkstrasse 1
8005 Zurich
Switzerland

declares that the product

SHFLI 8.5 GHz Lock-in Amplifier

is in conformity with the provisions of the relevant UK Statutory Instruments:

Statutory Instruments	Conformity proven by compliance with the standards
S.I. 2016/1091 (Electromagnetic Compatibility Regulations)	EN 61326-1:2013, EN 55011:2016, EN 55011:2016/A1:2017, EN 55011:2016/A11:2020 (Group 1, Class A and B equipment)
S.I. 2016/1101 (Electrical Equipment (Safety) Regulations)	EN 61010-1:2010, EN 61010-1:2010/A1:2019, EN 61010-1:2010/A1:2019/AC:2019-04
S.I. 2012/3032 (Restriction of the Use of Certain Hazardous Substances Regulations)	EN IEC 63000:2018

Zurich, October 20th, 2022

Flavio Heer, CTO

1. Change Log

1.1. Release 24.01

Release date: 31-Jan-2024

- DAQ module can acquire and analyze hardware-triggered demodulator data.
- Demodulator metadata provides information on frequencies and sources.
- Demodulator frequencies are included in the LabOne UI analysis tools.
- Bypassing the demodulator LPF is available in the LabOne UI.
- Demodulator input selectors are independent from the multi-frequency (MF) option.

1.2. Release 23.10

Release date: 31-Oct-2023

- GHF-PID Quad PID/PLL Controller Option is enabled.
- External reference (ExtRef) feature allowing the user to lock an oscillator to an external signal's frequency.
- Amplitude (R) and Phase (Theta) of the demodulated signals are now available at the Auxiliary Outputs.
- Demodulator data acquisition can be triggered via Trigger Inputs.
- Connectivity: Ethernet-over-USB on the USB 2 interface.
- Sweeper: Setting the start and stop points of the sweep parameter from the x-axis cursors in the Sweeper tab.

1.3. Release 23.06

Release date: 30-Jun-2023

- Hardware triggering for demodulator data acquisition.
- New data-server kernel to improve data acquisition performance.

1.4. Release 23.02

Release date: 28-Feb-2023

- Initial release of the SHFLI user manual.

2. Getting Started

This first chapter guides you through the initial set-up of your SHFLI Instrument in order to make your first measurements.

Please refer to:

- Quick Start Guide for a Quick Start Guide for the impatient.
- Inspect the Package Contents for inspecting the package content and accessories.
- Handling and Safety Instructions for a list of essential handling and safety instructions.
- Software Installation - Software Update for help connecting to the SHFLI Instrument with the LabOne software.
- Troubleshooting for a handy list of troubleshooting guidelines.

This chapter is delivered as a hard copy with the instrument upon delivery. It is also the first chapter of the SHFLI User Manual.

2.1. Quick Start Guide

This page addresses all the people who have been impatiently awaiting their new gem to arrive and want to see it up and running quickly. Please proceed with the following steps:
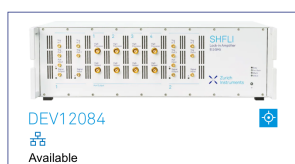
1. Inspect the package contents. Besides the Instrument there should be a country-specific power cable, a USB cable, an Ethernet cable and a hard copy of the Getting Started guide.
2. Check Handling and Safety Instructions for the Handling and Safety Instructions.
3. Download and install the latest LabOne software from the Zurich Instruments Download Center.
4. Choose the download file that suits your computer (e.g. Windows with 64-bit addressing). For more detailed information see Software Installation.
5. Connect the instrument to the power outlet and turn it on.
6. There are two options to connect to the instrument:
   - Connect the instrument to a switch in the local area network using the port labeled "LAN 1GbE" and an Ethernet cable.
   - Connect the instrument to the computer through USB using the port labeled "USB 2" and a USB cable.
7. Start the LabOne User Interface from the Windows Start Menu. The default web browser will open and display your instrument in a start screen as shown below. Use Chrome, Edge, Firefox, or Opera for best user experience.

8. The LabOne User Interface start-up screen will appear. Click the **Open** button on the lower right of the page. The default configuration will be loaded and the first signals can be generated. If the user interface does not start up successfully, please refer to Connecting to the Instrument.

If any problems occur while setting up the instrument and software, please see Troubleshooting at the end of this chapter for troubleshooting.

When connecting cables to the instrument's SMA ports, use a torque wrench specified for brass core SMA (4 in-lbs, 0.5 Nm). Using a standard SMA torque wrench (8 in-lbs) or a wrench without torque limit can damage the connectors.

After you have finished using the instrument, it is recommended to shut it down using the soft power button on the front panel of the instrument instrument or by clicking on the ⏻ button at the

bottom left of the user interface screen before turning off the power switch on the back panel of the instrument.

Once the Instrument is up and running we recommend going through some of the tutorials given in Tutorials. The functional description of the SHFLI can be found in Functional Description and provides a general introduction to the various tools and tables in each section describing every setting. In the same section, Functional Description provides an overview of the different UI tabs. For specific application know-how, the blog section of the Zurich Instruments website will serve as a valuable resource that is constantly updated and expanded.

2.2. Inspect the Package Contents

If the shipping container appears to be damaged, keep the container until you have inspected the contents of the shipment and have performed basic functional tests.

Please verify the following:

- You have received 1 Zurich Instruments SHFLI Instrument
- You have received 1 power cord with a power plug suited to your country
- You have received 1 USB 3.0 cable and/or 1 LAN cable (category 5/6 required)
- You have received a printed version of the "Getting Started" section
- The "Next Calibration" sticker on the rear panel of the instrument indicates a date approximately 2 years in the future → Zurich Instruments recommends calibration intervals of 2 years
- The MAC address of the instrument is displayed on a sticker on the back panel

Table 2.1: Package contents for the SHFLI

	SHFLI instrument
	the power cord (e.g. EU norm)
	the USB 3.0 cable
	the power inlet, with power switch
	the LAN / Ethernet cable (category 5/6 required)

Next Calibration Apr 2022	the "Next Calibration" sticker on the back panel of the instrument
S/N **SHF-DEV12028** MAC 80:2F:DE:00:07:EA	the MAC address sticker on the back panel of the instrument

The SHFLI Instrument is equipped with a multi-mains switched power supply, and therefore can be connected to most power systems in the world. The fuse holder is integrated with the power inlet and can be extracted by grabbing the holder with two small screwdrivers at the top and at the bottom at the same time. A spare fuse is contained in the fuse holder. The fuse description is found in the specifications chapter.

Carefully inspect your instrument. If there is mechanical damage or the instrument does not pass the basic tests, then you should immediately notify the Zurich Instruments support team through email.

2.3. Handling and Safety Instructions

The SHFLI Instrument is a sensitive piece of electronic equipment, and under no circumstances should its casing be opened, as there are high-voltage parts inside which may be harmful to human beings. There are no serviceable parts inside the instrument. Do not install substitute parts or perform any unauthorized modification to the product. Opening the instrument immediately voids the warranty provided by Zurich Instruments.

Do not use this product in any manner not specified by the manufacturer. The protective features of this product may be affected if it is used in a way not specified in the operating instructions.

The following general safety instructions must be observed during all phases of operation, service, and handling of the instrument. The disregard of these precautions and all specific warnings elsewhere in this manual may negatively affect the operation of the equipment and its lifetime.

Zurich Instruments assumes no liability for the user's failure to observe and comply with the instructions in this user manual.

Caution

The SMA connectors on the front panel are made for transmitting radio frequencies and can be damaged if handled inappropriately. Take care when attaching or detaching cables or when moving the instrument.

Table 2.2: Safety Instructions

|	
Ground the instrument	The instrument chassis must be correctly connected to earth ground by means of the supplied power cord. The ground pin of the power cord set plug must be firmly connected to the electrical ground (safety ground) terminal at the mains power outlet. Interruption of the protective earth conductor or disconnection of the protective earth terminal will cause a potential shock hazard that could result in personal injury and potential damage to the instrument.
Ground loops	The SMA connectors are not floating. For sensitive operations and in order to avoid ground loops, consider adding dc-blocks at the Inputs and Outputs of the device.
Measurement category	This equipment is of measurement category I (CAT I). Do not use it for CAT II, III, or IV. Do not connect the measurement terminals to mains sockets.
Maximum ratings	The specified electrical ratings for the connectors of the instrument should not be exceeded at any time during operation. Please refer to the Specifications for a comprehensive list of ratings.
Do not service or adjust anything yourself	There are no serviceable parts inside the instrument.
Software updates	Frequent software updates provide the user with many important improvements as well as new features. Only the last released software version is supported by Zurich Instruments.

Warnings	Instructions contained in any warning issued by the instrument, either by the software, the graphical user interface, the notes on the instrument or mentioned in this manual, must be followed.
Notes	Instructions contained in the notes of this user manual are of essential importance for correctly interpreting the acquired measurement data.
High voltage transients due to inductive loads	When measuring devices with high inductance, take adequate measures to protect the Signal Input connectors against the high voltages of inductive load switching transients. These voltages can exceed the maximum voltage ratings of the Signal Inputs and lead to damage.
Location and ventilation	This instrument or system is intended for indoor use in an installation category II and pollution degree 2 environment as per IEC 61010-1. Do not operate or store the instrument outside the ambient conditions specified in the Specifications section. Do not block the ventilator opening on the back or the air intake on the chassis side and front, and allow a reasonable space for the air to flow.
Cleaning	To prevent electrical shock, disconnect the instrument from AC mains power and disconnect all test leads before cleaning. Clean the outside of the instrument using a soft, lint-free cloth slightly dampened with water. Do not use detergent or solvents. Do not attempt to clean internally.
AC power connection and mains line fuse	For continued protection against fire, replace the line fuse only with a fuse of the specified type and rating. Use only the power cord specified for this product and certified for the country of use. Always position the device so that its power switch and the power cord are easily accessible during operation.
Main power disconnect	Unplug product from wall outlet and remove power cord before servicing. Only qualified, service-trained personnel should remove the cover from the instrument.
RJ45 sockets labeled ZSync	The RJ45 sockets on the back panel labeled "ZSync 1/2" are not intended for Ethernet LAN connection. Connecting an Ethernet device to these sockets may damage the instrument and/or the Ethernet device.
Operation and storage	Do not operate or store the instrument outside the ambient conditions specified in the Specifications section.
Handling	Handle with care. Do not drop the instrument. Do not store liquids on the device, as there is a chance of spillage resulting in damage.
Safety critical systems	Do not use this equipment in systems whose failure could result in loss of life, significant property damage or damage to the environment.

If you notice any of the situations listed below, immediately stop the operation of the instrument, disconnect the power cord, and contact the support team at Zurich Instruments, either through the website form or through email.

Table 2.3: Unusual Conditions

Fan is not working properly or not at all	Switch off the instrument immediately to prevent overheating of sensitive electronic components.
Power cord or power plug on instrument is damaged	Switch off the instrument immediately to prevent overheating, electric shock, or fire. Please exchange the power cord only with one for this product and certified for the country of use.
Instrument emits abnormal noise, smell, or sparks	Switch off the instrument immediately to prevent further damage.
Instrument is damaged	Switch off the instrument immediately and ensure it is not used again until it has been repaired.

Table 2.4: Symbols

⏚	Earth ground
⏛	Chassis ground
⚠	Caution. Refer to accompanying documentation
⎓	DC (direct current)

2.4. Software Installation

The SHFLI Instrument is operated from a host computer with the LabOne software. To install the LabOne software on a computer, administrator rights may be required. In order to simply run the software later, a regular user account is sufficient. Instructions for downloading the correct version of the software packages from the Zurich Instruments website are described below in the platform-dependent sections. It is recommended to regularly update to the latest software version provided by Zurich Instruments. Thanks to the Automatic Update check feature, the update can be initiated with a single click from within the user interface, as shown in Software Update.

2.4.1. Installing LabOne on Windows

The installation packages for the Zurich Instruments LabOne software are available as Windows installer .msi packages. The software is available on the Zurich Instruments Download Center. Please ensure that you have administrator rights for the PC on which the software is to be installed. See LabOne compatibility for a comprehensive list of supported Windows systems.

2.4.2. Windows LabOne Installation

1. The SHFLI Instrument should not be connected to your computer during the LabOne software installation process.
2. Start the LabOne installer program with a name of the form `LabOne64-XX.XX.XXXXX.msi` by a double click and follow the instructions. Windows Administrator rights are required for installation. The installation proceeds as follows:
   - On the welcome screen click the **Next** button.

Figure 2.1: Installation welcome screen

   - After reading through the Zurich Instruments license agreement, check the "I accept the terms in the License Agreement" check box and click the **Next** button.
   - Review the features you want to have installed. For the SHFLI Instrument the "SHFLI Series Device", "LabOne User Interface" and "LabOne APIs" features are required. Please install the features for other device classes as well, if required. To proceed click the **Next** button.

Figure 2.2: Custom setup screen

- Select whether the software should periodically check for updates. Note, the software will still not update automatically. This setting can later be changed in the user interface. If you would like to install shortcuts on your desktop area, select "Create a shortcut for this program on the desktop". To proceed click the **Next** button.

Figure 2.3: Automatic update check

- Click the **Install** button to start the installation process.
- Windows may ask up to two times to reboot the computer if you are upgrading. Make sure you have no unsaved work on your computer.

Figure 2.4: Installation reboot request

- During the first installation of LabOne, it is required to confirm the installation of some drivers from the trusted publisher Zurich Instruments. Click on **Install**.

Figure 2.5: Installation driver acceptance

- Click **OK** on the following notification dialog.

Figure 2.6: Installation completion screen

3. Click **Finish** to close the Zurich Instruments LabOne installer.
4. You can now start the LabOne User Interface as described in LabOne Software Start-up and choose an instrument to connect to via the Device Connection dialog shown in Device Connection dialog.

Warning

Do not install drivers from another source other than Zurich Instruments.

2.4.3. Start LabOne Manually on the Command Line

After installing the LabOne software, the Web Server and Data Server can be started manually using the command-line. The more common way to start LabOne under Windows is described in LabOne Software Start-up. The advantage of using the command line is being able to observe and change the behavior of the Web and Data Servers. To start the Servers manually, open a command-line

terminal (Command Prompt, PowerShell (Windows) or Bash (Linux)). For Windows, the current working directory needs to be the installation directory of the Web Server and Data Server. They are installed in the Program Files folder (usually: C:\Program Files) under \Zurich Instruments\LabOne in the WebServer and DataServer folders, respectively. The Web Server and Data Server (ziDataServer) are started by running the respective executable in each folder. Please be aware that only one instance of the Web Server can run at a time per computer. The behavior of the Servers can be changed by providing command line arguments. For a detailed list of all arguments see the command line help text:

```
$ ziWebServer --help
```

For the Data Server:

```
$ ziDataServer --help
```

One useful application of running the Webserver manually from a terminal window is to change the data directory from its default path in the user home directory. The data directory is a folder in which the LabOne Webserver saves all the measured data in the format specified by the user. Before running the Webserver from the terminal, the user needs to ensure there is no other instance of Webserver running in the background. This can be checked using the Tray Icon as shown below.

Figure 2.7: LabOne Tray Icon in Windows 10

The corresponding command line argument to specify the data path is `--data-path` and the command to start the LabOne Webserver with a non-default directory path, e.g., `C:\data` is

```
C:\Program Files\Zurich Instruments\LabOne\WebServer> ziWebServer --data-path "C:
\data"
```

Windows LabOne Uninstallation

To uninstall the LabOne software package from a Windows computer, one can open the "Apps & features" page from the Windows start menu and search for LabOne. By selecting the LabOne item in the list of apps, the user has the option to "Uninstall" or "Modify" the software package as shown in Figure 2.8.

Figure 2.8: Uninstallation of LabOne on Windows computers

Warning

Although it is possible to install a new version of LabOne on a currently-installed version, it is highly recommended to first uninstall the older version of LabOne from the computer and then, install the new version. Otherwise, if the installation process fails, the current installation is damaged and cannot be uninstalled directly. The user will need to first repair the installation and then, uninstall it.

In case a current installation of LabOne is corrupted, one can simply repair it by selecting the option "Modify" in Figure 2.8. This will open the LabOne installation wizard with the option "Repair" as shown in Figure 2.9.

Figure 2.9: Repair of LabOne on Windows computers

After finishing the repair process, the normal uninstallation process described above can be triggered to uninstall LabOne.

2.4.4. Installing LabOne on macOS

LabOne supports both Intel and ARM (M-series) architectures within a single universal disk image (DMG) file available in our Download Center.

- Download and double-click the DMG file to mount the image.

- The image contains a single LabOne application with all services needed.
- Once the application is started, a labone icon will appear in the menu bar. It allows the user to easily open a new session and shows the status of all services.

2.4.5. Uninstalling LabOne on macOS

To uninstall LabOne on macOS, simply drag the LabOne application to the trash bin.

2.4.6. Application Content

The LabOne application contains all resources available for macOS. This includes:

- The binaries for the Web Server and Data Servers.
- The binaries for the C, MATLAB, and LabVIEW APIs.
- An offline version of the user manuals.
- The latest firmware images for all instruments.

To access this content, right-click on the LabOne application and select "Show Package Contents". Then, go into Contents/Resources.

Note

Since the application name contains a space, one needs to escape it when using the command line to access the contents: `cd /Applications/LabOne\ 2X.XX.app/Contents/Resources`

2.4.7. Start LabOne Manually on the Command Line

To start the LabOne services like the data server and web server manually, one can use the command line.

The data server binary is called `ziDataServer` (`ziServer` for HF2 instruments) and is located at `Applications/LabOne\ 2X.XX.app/Contents/Resources/DataServer/`.

The web server binary is called `ziWebServer` and is located at `Applications/LabOne\ 2X.XX.app/Contents/Resources/DataServer/`.

Note

No special command line arguments are needed to start the LabOne services. Use the `--help` argument to see all available options.

2.4.8. Installing LabOne on Linux

2.4.9. Requirements

Ensure that the following requirements are fulfilled before trying to install the LabOne software package:

1. LabOne software supports typical modern GNU/Linux distributions (Ubuntu 14.04+, CentOS 7+, Debian 8+). The minimum requirements are glibc 2.17+ and kernel 3.10+.
2. You have administrator rights for the system.
3. The correct version of the LabOne installation package for your operating system and platform have been downloaded from the Zurich Instruments Download Center:

```
LabOneLinux<arch>-<release>.<revision>.tar.gz,
```

Please ensure you download the correct architecture (x86-64 or arm64) of the LabOne installer. The `uname` command can be used in order to determine which architecture you are using, by running:

```
uname -m
```

in a command line terminal. If the command outputs `x86_64` the x86-64 version of the LabOne package is required, if it displays `aarch64` the ARM64 version is required.

2.4.10. Linux LabOne Installation

Proceed with the installation in a command line shell as follows:

1. Extract the LabOne tarball in a temporary directory:

```
tar xzvf LabOneLinux<arch>-<release>-<revision>.tar.gz
```

2. Navigate into the extracted directory.

```
cd LabOneLinux<arch>-<release>-<revision>
```

3. Run the install script with administrator rights and proceed through the guided installation, using the default installation path if possible:

```
sudo bash install.sh
```

The install script lets you choose between the following three modes:
   - Type "a" to install the Data Server program, the Web Server program, documentation and APIs.
   - Type "u" to install `udev` support (only necessary if HF2 Instruments will be used with this LabOne installation and not relevant for other instrument classes).
   - Type "ENTER" to install both options "a" and "u".
4. Test your installation by running the software as described in the next section.

2.4.11. Running the Software on Linux

The following steps describe how to start the LabOne software in order to access and use your instrument in the User Interface.

1. Start the Web Server program at a command prompt:

```
$ ziWebServer
```

2. Start an up-to-date web browser and enter the `127.0.0.1:8006` in the browser's address bar to access the Web Server program and start the LabOne User Interface. The LabOne Web Server installed on the PC listens by default on port number 8006 instead of 80 to minimize the probability of conflicts.
3. You can now start the LabOne User Interface as described in LabOne Software Start-up and choose an instrument to connect to via the Device Connection dialog shown in Device Connection dialog.

Important

Do not use two Data Server instances running in parallel; only one instance may run at a time.

2.4.12. Uninstalling LabOne on Linux

The LabOne software package copies an uninstall script to the base installation path (the default installation directory is `/opt/zi/`). To uninstall the LabOne package please perform the following steps in a command line shell:

1. Navigate to the path where LabOne is installed, for example, if LabOne is installed in the default installation path:

    ```
    $ cd /opt/zi/
    ```

2. Run the uninstall script with administrator rights and proceed through the guided steps:

    ```
    $ sudo bash uninstall_LabOne<arch>-<release>-<revision>.sh
    ```

2.5. Connecting to the Instrument

The Zurich Instruments SHFLI is operated using the LabOne software. After installation of LabOne, the instrument can be connected to a PC by using either the Universal Serial Bus (USB) cable or the 1 Gbit/s Ethernet (1GbE) LAN cable supplied with the instrument. The LabOne software is controlled via a web browser after suitable physical and logical connections to the instrument have been made.

Note

The following web browsers are supported (latest versions).

Chrome   Firefox   Opera   Edge   Safari

- When using 1GbE, integrate the instrument physically into an existing local area network (LAN) by connecting the instrument to a switch in the LAN using an Ethernet cable. The instrument can then be accessed from a web browser running on any computer in the same LAN with LabOne installed. The Ethernet connection can also be point-to-point. This requires some adjustment of the network card settings of the host computer. Depending on the network configuration and the installed network card, one or the other connection scheme is better suited.
- Using the USB connection to physically connect to the instrument requires the installation of a USB driver on Windows computers. This driver is included in the LabOne software installer and will be installed on the host computer as part of the LabOne installation wizard.

2.5.1. LabOne Software Architecture

The Zurich Instruments LabOne software gives quick and easy access to the instrument from a host PC. LabOne also supports advanced configurations with simultaneous access by multiple software clients (i.e., LabOne User Interface clients and/or API clients), and even simultaneous access by several users working on different computers. Here we give a brief overview of the architecture of the LabOne software. This will help to better understand the following chapters.

The software of Zurich Instruments equipment is server-based. The servers and other software components are organized in layers as shown in Figure 2.10.

- The lowest layer running on the PC is the LabOne Data Server, which is the interface to the connected instrument.
-

The middle layer contains the LabOne Web Server, which is the server for the browser-based LabOne User Interface.

- The graphical user interface, together with the programming user interfaces, are contained in the top layer.

The architecture with one central Data Server allows multiple clients to access a device with synchronized settings. The following sections explain the different layers and their functionality in more detail.

Figure 2.10: LabOne Software architecture

2.5.2. LabOne Data Server

The **LabOne Data Server** program is a dedicated server that is in charge of all communication to and from the device. The Data Server can control a single or also multiple instruments. It will distribute the measurement data from the instrument to all the clients that subscribe to it. It also ensures that settings changed by one client are communicated to other clients. The device settings are therefore synchronized on all clients. On a PC, only a single instance of a LabOne Data Server should be running.

2.5.3. LabOne Web Server

The LabOne Web Server is an application dedicated to serving up the web pages that constitute the LabOne user interface. The user interface can be opened with any device with a web browser. Since it is touch enabled, it is possible to work with the LabOne User Interface on a mobile device - like a tablet. The LabOne Web Server supports multiple clients simultaneously. This means that more than one session can be used to view data and to manipulate the instrument. A session could be running in a browser on the PC on which the LabOne software is installed. It could equally well be running in a browser on a remote machine.

With a LabOne Web Server running and accessing an instrument, a new session can be opened by typing in a network address and port number in a browser address bar. In case the Web Server runs on the **same** computer, the address is the localhost address (both are equivalent):

- `127.0.0.1:8006`
- `localhost:8006`

In case the Web Server runs on a **remote** computer, the address is the IP address or network name of the remote computer:

- `192.168.x.y:8006`
- `myPC.company.com:8006`

The most recent versions of the most popular browsers are supported: Chrome, Firefox, Edge, Safari and Opera.

2.5.4. LabOne API Layer

The instrument can also be controlled via the application program interfaces (APIs) provided by Zurich Instruments. APIs are provided in the form of DLLs for the following programming environments:

- MATLAB
- Python
- LabVIEW
- .NET
- C

APIs are provided in the form of DLLs for the following programming environments:

- MATLAB
- Python

An extensive Python API and python-based drivers are provided for the following frameworks:

- https://github.com/zhinst/zhinst-toolkit[Zurich Instruments Toolkit]
- https://github.com/zhinst/zhinst-qcodes[QCoDeS]
- https://github.com/zhinst/zhinst-labber[Labber]

The instrument can therefore be controlled by an external program, and the resulting data can be processed there. The device can be concurrently accessed via one or more of the APIs and via the user interface. This enables easy integration into larger laboratory setups. See the LabOne Programming Manual for further information. Using the APIs, the user has access to the same functionality that is available in the LabOne User Interface.

2.5.5. LabOne Software Start-up

This section describes the start-up of the LabOne User Interface which is used to control the SHFLI Instrument. If the LabOne software is not yet installed on the PC please follow the instructions in Software Installation. If the device is not yet connected please find more information in Visibility and Connection.

The LabOne User Interface start-up link can be found under the Windows 10 Start Menu (Under Windows 7 and 8, the LabOne User Interface start-up link can be found in `Start Menu → all programs / all apps → Zurich Instruments LabOne`). As shown in Figure 2.11, click on `Start Menu → Zurich Instruments LabOne`. This will open the User Interface in a new tab in your default web browser and start the LabOne Data Server and LabOne Web Server programs in the background. A detailed description of the software architecture is found in LabOne Software Architecture.

Figure 2.11: Link to the LabOne User Interface in the Windows 10 Start Menu

LabOne is an HTML5 browser-based program. This simply means that the user interface runs in a web browser and that a connection using a mobile device is also possible; simply specify the IP address (and port 8006) of the PC running the user interface.

Note

By creating a shortcut to Google Chrome on your desktop with the Target `path\to\chrome.exe -app=http://127.0.0.1:8006` set in Properties you can run the LabOne User Interface in Chrome in application mode, which improves the user experience by removing the unnecessary browser controls.

After starting LabOne, the Device Connection dialog Figure 2.12 is shown to select the device for the session. The term "session" is used for an active connection between the user interface and the device. Such a session is defined by device settings and user interface settings. Several sessions can be started in parallel. The sessions run on a shared LabOne Web Server. A detailed description of the software architecture can be found in the LabOne Software Architecture.

Figure 2.12: Device Connection dialog

The Device Connection dialog opens in the Basic view by default. In this view, all devices that are available for connection are represented by an icon with serial number and status information. If required, a button appears on the icon to perform a firmware upgrade. Otherwise, the device can be connected by a double click on the icon, or a click on the Open button at the bottom right of the dialog.

In some cases it's useful to switch to the Advanced view of the Device Connection dialog by clicking on the "Advanced" button. The Advanced view offers the possibility to select custom device and UI settings for the new session and gives further connectivity options that are particularly useful for multi-instrument setups.

Figure 2.13: Device Connection dialog (Advanced view)

The Advanced view consists of three parts:

- Data Server Connectivity
- Available Devices
- Saved Settings

The Available Devices table has a display filter, usually set to **Default Data Server**, that is accessible by a drop-down menu in the header row of the table. When changing this to **Local Data Servers**, the Available Devices table will show only connections via the Data Server on the host PC and will contain all instruments directly connected to the host PC via USB or to the local network via

1GbE. When using the **All Data Servers** filter, connections via Data Servers running on other PCs in the network also become accessible. Once your instrument appears in the Available Devices table, perform the following steps to start a new session:

1. Select an instrument in the **Available Devices** table.
2. Select a setting file in the **Saved Settings** list unless you would like to use the Default Settings.
3. Start the session by clicking on [Open]

Note

By default, opening a new session will only load the UI settings (such as plot ranges), but not the device settings (such as signal amplitude) from the saved settings file. In order to include the device settings, enable the **Include Device Settings** checkbox. Note that this can affect existing sessions since the device settings are shared between them.

Note

In case devices from other Zurich Instruments series (UHF, HF2, MF, HDAWG, PQSC, GHF, or SHF) are used in parallel, the list in **Available Devices** section can contain those as well.

The following sections describe the functionality of the **Device Connection** dialog in detail.

2.5.6. Data Server Connectivity

The Device Connection dialog represents a Web Server. However, on start-up the Web Server is not yet connected to a LabOne Data Server. With the **Connect/Disconnect** button the connection to a Data Server can be opened and closed.

This functionality can usually be ignored when working with a single SHFLI Instrument and a single host computer. Data Server Connectivity is important for users operating their instruments from a remote PC, i.e., from a PC different to the PC on which the Data Server is running or for users working with multiple instruments. The Data Server Connectivity function then gives the freedom to connect the Web Server to one of several accessible Data Servers. This includes Data Servers running on remote computers, and also Data Servers running on an MF Series instrument.

In order to work with a UHF, HF2, HDAWG, PQSC, GHF, or SHF instrument remotely, proceed as follows. On the computer directly connected to the instrument (Computer 1) open a User Interface session and change the Connectivity setting in the Config tab to "From Everywhere". On the remote computer (Computer 2), open the Device Connection dialog by starting up the LabOne User Interface and then go to the Advanced view by clicking on [Advanced] on the top left of the dialog. Change the display filter from Default Data Server to All Data Servers by opening the drop-down menu in the header row of the Available Devices table. This will make the Instrument connected to Computer 1 visible in the list. Select the device and connect to the remote Data Server by clicking on [Connect]. Then start the User Interface as described above.

Note

When using the filter "All Data Servers", take great care to connect to the right instrument, especially in larger local networks. Always identify your instrument based on its serial number in the form DEV0000, which can be found on the instrument back panel.

2.5.7. Available Devices

The Available Devices table gives an overview of the visible devices. A device is ready for use if either marked free or connected. The first column of the list holds the **Enable** button controlling the connection between the device and a Data Server. This button is greyed out until a Data Server is connected to the LabOne Web Server using the [Connect] button. If a device is connected to a Data Server, no other Data Server running on another PC can access this device.

The second column indicates the serial number and the third column shows the instrument type. The fourth column shows the host name of the LabOne Data Server controlling the device. The next column shows the interface type. For SHFLI Instruments the interfaces USB or 1GbE are available

and are listed if physically connected. The LabOne Data Server will scan for the available devices and interfaces every second. If a device has just been switched on or physically connected it may take up to 20 s before it becomes visible to the LabOne Data Server.

Table 2.5: Device Status Information

Connected	The device is connected to a LabOne Data Server, either on the same PC (indicated as local) or on a remote PC (indicated by its IP address). The user can start a session to work with that device.
Free	The device is not in use by any LabOne Data Server and can be connected by clicking the **Open** button.
In Use	The device is in use by a LabOne Data Server. As a consequence the device cannot be accessed by the specified interface. To access the device, a disconnect is needed.
Device FW upgrade required/available	The firmware of the device is out of date. Please first upgrade the firmware as described in Software Update.
Device not yet ready	The device is visible and starting up.

2.5.8. Saved Settings

Settings files can contain both UI and device settings. UI settings control the structure of the LabOne User Interface, e.g. the position and ordering of opened tabs. Device settings specify the set-up of a device. The device settings persist on the device until the next power cycle or until overwritten by loading another settings file.

The columns are described in Table 2.6. The table rows can be sorted by clicking on the column header that should be sorted. The default sorting is by time. Therefore, the most recent settings are found on top. Sorting by the favorite marker or setting file name may be useful as well.

Table 2.6: Column Descriptions

☆ ★	Allows favorite settings files to be grouped together. By activating the stars adjacent to a settings file and clicking on the column heading, the chosen files will be grouped together at the top or bottom of the list accordingly. The favorite marker is saved to the settings file. When the LabOne user interface is started next time, the row will be marked as favorite again.
Name	The name of the settings file. In the file system, the file name has the extension .md.
Date	The date and time the settings file was last written.
Comment	Allows a comment to be stored in the settings file. By clicking on the comment field a text can be typed in which is subsequently stored in the settings file. This comment is useful to describe the specific conditions of a measurement.
Device Type	The instrument type with which this settings file was saved.

Special Settings Files

Certain file names have the prefix "last_session_". Such files are created automatically by the LabOne Web Server when a session is terminated either explicitly by the user, or under critical error conditions, and save the current UI and device settings. The prefix is prepended to the name of the most recently used settings file. This allows any unsaved changes to be recovered upon starting a new session.

If a user loads such a last session settings file the "last_session_" prefix will be cut away from the file name. Otherwise, there is a risk that an auto-save will overwrite a setting which was saved explicitly by the user.

The settings file with the name "Default Settings" contains the default UI settings. See button description in Table 2.7.

Table 2.7: Button Descriptions

Open	The settings contained in the selected settings file will be loaded. The button "Include Device Settings" controls whether only UI settings are loaded, or if device settings are included.
Include Device Settings	Controls which part of the selected settings file is loaded upon clicking on Open. If enabled, both the device and the UI settings are loaded.
Auto Start	Skips the session dialog at start-up if selected device is available. The default UI settings will be loaded with unchanged device settings.

Note

The user setting files are saved to an application-specific folder in the directory structure. The best way to manage these files is using the File Manager tab.

Note

The factory default UI settings can be customized by saving a file with the name "default_ui" in the Config tab once the LabOne session has been started and the desired UI setup has been established. To use factory defaults again, the "default_ui" file must be removed from the user setting directory using the File Manager tab.

Note

Double clicking on a device row in the Available Devices table is a quick way of starting the default LabOne UI. This action is equivalent to selecting the desired device and clicking the **Open** button.

Double clicking on a row in the Saved Settings table is a quick way of loading the LabOne UI with those UI settings and, depending on the "Include Device Settings" checkbox, device settings. This action is equivalent to selecting the desired settings file and clicking the **Open** button.

2.5.9. Tray Icon

When LabOne is started, a tray icon appears by default in the bottom right corner of the screen, as shown in the figure below. By right-clicking on the icon, a new web server session can be opened quickly, or the LabOne Web and Data Servers can be stopped by clicking on Exit. Double-clicking the icon also opens a new web server session, which is useful when setting up a connection to multiple instruments, for example.

Figure 2.14: LabOne Tray Icon in Windows 10

2.5.10. Messages

The LabOne Web Server will show additional messages in case of a missing component or a failure condition. These messages display information about the failure condition. The following paragraphs list these messages and give more information on the user actions needed to resolve the problem.

Lost Connection to the LabOne Web Server

In this case the browser is no longer able to connect to the LabOne Web Server. This can happen if the Web Server and Data Server run on different PCs and a network connection is interrupted. As long as the Web Server is running and the session did not yet time out, it is possible to just attach to the existing session and continue. Thus, within about 15 seconds it is possible with **Retry** to recover

the old session connection. The **Reload** button opens the Device Connection dialog shown in Figure 2.12. The figure below shows an example of the Connection Lost dialog.

Figure 2.15: Dialog: Connection Lost

Reloading...

If a session error cannot be handled, the LabOne Web Server will restart to show a new Device Connection dialog as shown in Figure 2.12. During the restart a window is displayed indicating that the LabOne User Interface will reload. If reloading does not happen the same effect can be triggered by pressing F5 on the keyboard. The figure below shows an example of this dialog.

Figure 2.16: Dialog: Reloading

No Device Discovered

An empty "Available Devices" table means that no devices were discovered. This can mean that no LabOne Data Server is running, or that it is running but failed to detect any devices. The device may be switched off or the interface connection fails. For more information on the interface between device and PC see Visibility and Connection. The figure below shows an example of this dialog.

Figure 2.17: No Device Discovered

No Device Available

If all the devices in the "Available Devices" table are shown grayed, this indicates that they are either in use by another Data Server, or need a firmware upgrade. For firmware upgrade see Software Update. If all the devices are in use, access is not possible until a connection is relinquished by another Data Server.

2.5.11. Visibility and Connection

There are several ways to connect the instrument to a host computer. The device can either be connected by Universal Serial Bus (USB) or by 1 Gbit/s Ethernet (1GbE). The USB connection is a point-to-point connection between the device and the PC on which the Data Server runs. The 1GbE connection can be a point-to-point connection or an integration of the device into the local network (LAN). Depending on the network configuration and the installed network card, one or the other connectivity is better suited.

If an instrument is connected to a network, it can be accessed from multiple host computers. To manage the access to the instrument, there are two different connectivity states: visible and connected. It is important to distinguish if an instrument is just physically connected over 1GbE or actively controlled by the LabOne Data Server. In the first case the instrument is visible to the LabOne Data Server. In the second case the instrument is logically connected.

Connectivity Example shows some examples of possible configurations of computer-to-instrument connectivity.

- Data Server on PC 1 is connected to device 1 (USB) and device 2 (USB).
- Data Server on PC 2 is connected to device 4 (TCP/IP).
- Data Server on PC 3 is connected to device 5.
- The device 3 is free and visible to PC 1 and PC 2 over TCP/IP.
- Devices 2 and 4 are physically connected by TCP/IP and USB interface. Only one interface is logically connected to the Data Server.

Figure 2.18: Connectivity Example

Visible Instruments

An instrument is visible if the Data Server can identify it. On a TCP/IP network, several PCs running a Data Server will detect the same instrument as visible, i.e., discover it. If a device is discovered, the LabOne Data Server can initiate a connection to access the instrument. Only a single Data Server can be connected to an instrument at a time.

Connected Instrument

Once connected to an instrument, the Data Server has exclusive access to that instrument. If another Data Server from another PC already has an active connection to the instrument, the instrument is still visible but cannot be connected.

Although a Data Server has exclusive access to a connected instrument, the Data Server can have multiple clients. Because of this, multiple browser and API sessions can access the instrument simultaneously.

2.5.12. USB Connectivity

To control the device over USB, connect the instrument with the supplied USB cable to the PC on which the LabOne Software is installed. The USB driver needed for controlling the instrument is included in the LabOne Installer package. Ensure that the instrument uses the latest firmware. The software will automatically use the USB interface for controlling the device if available. If the USB connection is not available, the 1GbE connection may be selected. It is possible to enforce or exclude a specific interface connection.

Note

To use the device exclusively over the USB interface, modify the shortcut of the LabOne User Interface and LabOne Data Server in the Windows Start menu. Right-click and go to Properties, then add the following command line argument to the Target LabOne User Interface:

```
--interface-usb true --interface-ip false
```

An instrument connected over USB can be automatically connected to the Data Server because there is only a single host PC to which the device interface is physically connected. Table 2.8 provides an overview of the two settings.

Table 2.8: Settings auto-connect

Setting	Description
auto-connect = on	If a device is attached via a USB cable, a connection will be established automatically by the Data Server. This is the default behavior.
auto-connect = off	To disable automatic connection via USB, add the following command line argument when starting the Data Server:`--auto-connect=off`.

On Windows, both behaviors can be forced by right clicking the LabOne Data Server shortcut in the Start menu, selecting "Properties" and adding the text `--auto-connect=off` or `--auto-connect=on` to the Target field, see Figure 2.19.

Figure 2.19: Setting auto-connect in Windows

2.5.13. 1GbE Connectivity

There are three methods for connecting to the device via 1GbE:

- Multicast DHCP
- Multicast point-to-point (P2P)
- Static Device IP

Multicast DHCP is the simplest and preferred connection method. Other connection methods can become necessary when using network configurations that conflict with local policies.

Multicast DHCP

The most straightforward TCP/IP connection method is to rely on a network configuration to recognize the instrument. When connecting the instrument to a local area network (LAN), the DHCP server will assign an IP address to the instrument like to any PC in the network. In case of restricted networks, the network administrator may be required to register the device on the network by means of the MAC address. The MAC address is indicated on the back panel of the instrument. The LabOne Data Server will detect the device in the network by means of a multicast.

If the network configuration does not support multicast, or if the host computer has other network cards installed, it is necessary to use a static IP setup as described below. The instrument is configured to accept the IP address from the DHCP server, or to fall back to the IP address `192.168.1.10` if it does not get the address from the DHCP server.

Requirements:

-

Network supports multicast

Multicast Point-to-Point

Setting up a point-to-point (P2P) network consisting only of the host computer and the instrument avoids problems related to special network policies. Since it is nonetheless necessary to stay connected to the internet, it is recommended to install two network cards in the computer, one of which is used for internet connectivity, the other can be used for connecting to the instrument. Alternatively, internet connectivity can be established via wireless LAN.

In such a P2P network the IP address of the host computer needs to be set to a static value, whereas the IP address of the device can be left dynamic.

1. Connect the 1GbE port of the network card that is dedicated for instrument connectivity directly to the 1GbE port of the instrument
2. Set this network card to static IP in TCP/IPv4 using the address `192.168.1.n`, where n=[2..9] and the mask `255.255.255.0`. (On Windows go to `Control Panel → Internet Options → Network and Internet → Network and Sharing Center → Local Area Connection → Properties`).

Figure 2.20: Static IP configuration for the host computer

3. Start up the LabOne User Interface normally. If your instrument does not show in the list of Available Devices, the reason may be that your network card does not support multicast. In that case, see Static Device IP.

Requirements:

- Two network cards needed for additional connection to internet
- Network card of PC supports multicast
- Network card connected to the device must be in static IP4 configuration

Note

A power cycle of the instrument is required if it was previously connected to a network that provided an IP address to the instrument.

Note

Only IP v4 is currently supported. There is no support for IP v6.

Note

If the instrument is detected by LabOne but the connection can not be established, the reason can be the firewall blocking the connection. It is then recommended to change the P2P connection from Public to Private. On Windows this is achieved by turning on network discovery in the Private tab of the network's advanced sharing settings as shown in the figure below.

Figure 2.21: Turn on network discovery for Private P2P connection

Warning

Changing the IP settings of your network adapters manually can interfere with its later use, as it cannot be used anymore for network connectivity until it is configured again for dynamic IP.

Figure 2.22: Dynamic IP configuration for the host computer

Static Device IP

Although it is highly recommended to use dynamic IP assignment method in the host network of the instrument, there may be cases where the user wants to assign a static IP to the instrument. For instance, when the host network only contains Ethernet switches and hubs but no Ethernet routers are included, there is no DHCP server to dynamically assign an IP to the instrument. It is still advised to add an Ethernet router to the network and benefit from dynamic IP assignment; however, if a router is not available, the instrument can be configured to work with a static IP.

Note that the static IP assigned to the instrument must be within the same range of the IP assigned to the host computer. Whether the host computer's IP is assigned statically or by a fallback mechanism, one can find this IP by running the command `ipconfig` or `ipconfig/all` in the operating system's terminal. As an example, Figure 2.23 shows the outcome of running `ipconfig` in the terminal.

Figure 2.23: IP and subnet mask of host computer

It shows the network adapter of the host computer can be reached via the IP `169.254.16.57` and it uses a subnet mask of `255.255.0.0`. To make sure that the instrument is visible to this computer, one needs to assign a static IP of the form `169.254.x.x` and the same subnet mask to the instrument. To do so, the user should follow the instructions below.

1. Attach the instrument using an Ethernet cable to the network where the user's computer is hosted.
2. Attach the instrument via a USB cable to the host computer and switch it on.
3. Open the LabOne user interface (UI) and connect to the instrument via USB.
4. Open the "Device" tab of the LabOne UI and locate the "Communication" section as shown in Configuration of static IP in LabOne UI.
5. Write down the desired static IP, e.g. `169.254.16.20`, into the numeric field "IPv4 Address".
6. Add the same subnet mask as the host computer, e.g. `255.255.0.0` to the numeric field "IPv4 Mask".
7. You can leave the field "Gateway" as `0.0.0.0` or change to be similar to the IP address but ending with `1`, e.g. `169.254.16.1`.
8. Enable the radio button for "Static IP".
9. Press the button "Program" to save the new settings to the instruments.
10. Power cycle the instrument and remove the USB cable. The instrument should be visible to LabOne via Ethernet connection.

Figure 2.24: Configuration of static IP in LabOne UI

To make sure the IP assignment is done properly, one can use the command `ping` to check if the instrument can be reached through the network using its IP address. Figure 2.25 shows the outcome of `ping` when the instrument is visible via the IP `169.254.16.20`.

Figure 2.25: Instrument visible through pinging

If set properly according to the instructions above, the instrument will use the same static IP configurations after each power cycle.

Fallback Device IP

When configured to a dynamic address, but no DHCP server is present in the network, e.g., device connected directly to a PC, the instrument falls back on an IP address in the local link IP range that is `169.254.x.x`. If the host computer has also an IP address within the same range, the instrument becomes visible to the LabOne data server running on the host computer. This way, there is no need to go through the process described above to assign a static IP to the instrument.

2.6. Software Update

2.6.1. Overview

It is recommended to regularly update the LabOne software on the SHFLI Instrument to the latest version. In case the Instrument has access to the internet, this is a very simple task and can be done with a single click in the software itself, as shown in Updating LabOne using Automatic Update Check. If you use one of the LabOne APIs with a separate installer, don't forget to update this part of the software, too.

2.6.2. Updating LabOne using Automatic Update Check

Updating the software is done in two steps. First, LabOne is updated on the PC by downloading and installing the LabOne software from the Zurich Instruments downloads page, as shown in Software Installation. Second, the instrument firmware needs to be updated from the Device Connection dialog after starting up LabOne. This is shown in Updating the Instrument Firmware . In case "Periodically check for updates" has been enabled during the LabOne installation and LabOne has access to the internet, a notification will appear on the Device Connection dialog whenever a new version of the software is available for download. This setting can later be changed in the Config tab of the LabOne user interface. In case automatic update check is disabled, the user can manually check for updates at any time by clicking on the button Check For Update in the Device Connection dialog. In case an update is found, clicking on the button "Update Available" shown in Figure 2.26 will start a download the latest LabOne installer for Windows or Linux, see Figure 2.27. After download, proceed as explained in Software Installation to update LabOne.

Figure 2.26: Device Connection dialog: LabOne update available

Figure 2.27: Download LabOne MSI using Automatic Update Check feature

2.6.3. Updating the Instrument Firmware

The LabOne software consists of both software that runs on your PC and software that runs on the instrument. In order to distinguish between the two, the latter will be called firmware for the rest of this document. When upgrading to a new software release, it's also necessary to update the instrument firmware.

If the firmware needs an update, this is indicated in the Device Connection dialog of the LabOne user interface under Windows.

In the Basic view of the dialog, there will be a button "Upgrade FW" appearing together with the instrument icon as shown in Figure 2.28. In the Advanced view, there will be a link "Upgrade FW" in the Update column of the Available Devices table. Click on **Upgrade FW** to open the firmware update start-up dialog shown in Figure 2.29. The firmware upgrade takes approximately 2 minutes.

Figure 2.28: Device Connection dialog with available firmware update

Figure 2.29: Device Firmware Update start-up dialog

Important

Do not disconnect the USB or 1GbE cable to the Instrument or power-cycle the Instrument during a firmware update.

If you encounter any issues while upgrading the instrument firmware, please contact Zurich Instruments at support@zhinst.com.

2.7. Troubleshooting

This section aims to help the user solve and avoid problems while using the software and operating the instrument.

2.7.1. Common Problems

Your SHFLI Instrument is an advanced piece of laboratory equipment which has many more features and capabilities than a traditional lock-in amplifier. In order to benefit from these, the user needs access to a large number of settings in the LabOne User Interface. The complexity of the settings might overwhelm a first-time user, and even expert users can get surprised by certain combinations of settings. To avoid problems, it's good to use the possibility to save and load settings in the Config Tab. This allows one to keep an overview by operating the instrument based on known configurations. This section provides an easy-to-follow checklist to solve the most common mishaps.

Table 2.9: Common Problems

Problem	Check item
The software cannot be installed or uninstalled	Please verify you have administrator/root rights.
The software cannot be updated	Please use the Modify option in Windows Apps & Features functionality. In the software installer select Repair, then uninstall the old software version, and install the new version.
The Instrument does not turn on	Please verify the power supply connection and inspect the fuse. The fuse holder is integrated in the power connector on the back panel of the instrument.
The Instrument can't be connected over USB	Please verify that the instrument is connected through the "USB 1" port. The port labeled "USB 2" is not currently supported and will be enabled with a future LabOne release.
The Instrument has a high input noise floor (when connected to host computer by USB)	the USB cable connects the Instrument ground to computer ground, which might inject some unwanted noise to the measurements results. In this case it is recommended to use the Ethernet connection which is galvanically isolated using a UTP Cat 5 or 6 cable (UTP stands for "unshielded twisted pair").
The Instrument performs poorly at low frequencies (below 100 kHz)	the signal inputs of the instrument might be set to AC operation. Please verify to turn off the AC switch in the Lock-in Tab or In / Out Tab.
The Instrument performs poorly during operation	the demodulator filters might be set too wide (too much noise) or too narrow (slow response) for your application. Please verify if the demodulator filter settings match your frequency versus noise plan.
The Instrument performs poorly during operation	clipping of the input signal may be occurring. This is detectable by monitoring the red LEDs on the front panel of the instrument or the Input Overflow (OVI) flags on the STATUS_TAB of the user interface. It can be avoided by adding enough margin on the input range setting (for instance 50% to 70% of the maximum signal peak).
The Instrument performs strangely when working with the SHFLI-MF Multi-frequency Option	it is easily possible to turn on more signal generators than intended. Check the generated Signal Output with the integrated oscilloscope and check the number of simultaneously activated oscillator voltages.
The Instrument performs close to specification, but higher performance is expected	After 2 years since the last calibration, a few analog parameters are subject to drift. This may cause inaccurate measurements. Zurich Instruments recommends re-calibration of the Instrument every 2 years.
The Instrument measurements are unpredictable	Please check the Status Tab to see if there is any active warning (red flag), or if one has occurred in the past (yellow flag).
The Instrument does not generate any output signal	verify that signal output switch has been activated in the Lock-in Tab or in the In / Out Tab.
The sample stream from the Instrument to the host computer is not continuous	Check the communication (COM) flags in the status bar. The three flags indicate occasional sample loss, packet loss, or stall. Sample loss occurs when a sampling rate is set too high (the instrument sends more samples than the interface and the host computer can absorb). The packet loss indicates an important failure of the communications to the host computer and compromises the behavior of the instrument. Both problems are prevented by reducing the sample rate settings. The stall flag indicates that a setting was actively changed by the system to prevent UI crash.
The LabOne User Interface does not start	Verify that the LabOne Data Server (`ziDataServer.exe`) and the LabOne Web Server (`ziWebServer.exe`) are running via the Windows Task Manager. The Data Server should be started automatically by `ziService.exe` and the Web Server should be started upon clicking "Zurich Instruments LabOne" in the Windows Start Menu. If both are running, but clicking the Start Menu does not open a new User Interface session in a new tab of your default browser then try to create a new session manually by entering `127.0.0.1:8006` in the address bar of your browser.

Problem	Check item
The user interface does not start or starts but remains idle	Verify that the Data Server has been started and is running on your host computer.
The user interface is slow and the web browser process consumes a lot of CPU power	Make sure that the hardware acceleration is enabled for the web browser that is used for LabOne. For the Windows operating system, the hardware acceleration can be enabled in `Control Panel → Display → Screen Resolution`. Go to Advanced Settings and then Trouble Shoot. In case you use a NVIDIA graphics card, you have to use the NVIDIA control panel. Go to Manage 3D Settings, then Program Settings and select the program that you want to customize.

2.7.2. Location of the Log Files

The most recent log files of the LabOne Web and Data Server programs are most easily accessed by clicking on Logs in the LabOne Device Connection dialog of the user interface. The Device Connection dialog opens on software start-up or upon clicking on Session Manager in the Config tab of the user interface.

The location of the Web and Data Server log files on disk are given in the sections below.

Windows

The Web and Data Server log files on Windows can be found in the following directories.

- LabOne Data Server (`ziDataServer.exe`):
  C:\Windows\ServiceProfiles\LocalService\AppData\Local\Temp\Zurich Instruments\LabOne\ziDataServerLog
- LabOne Web Server (`ziWebServer.exe`):
  C:\Users[USER]\AppData\Local\Temp\Zurich Instruments\LabOne\ziWebServerLog

Note

The `C:\Users\[USER]\AppData` folder is hidden by default under Windows. A quick way of accessing it is to enter `%AppData%\..` in the address bar of the Windows File Explorer.

Figure 2.30: Using the

Linux and macOS

The Web and Data Server log files on Linux or macOS can be found in the following directories.

- LabOne Data Server (`ziDataServer`):
  /tmp/ziDataServerLog_[USER]
- LabOne Web Server (`ziWebServer`):
  /tmp/ziWebServerLog_[USER]

2.7.3. Prevent web browsers from sleep mode

It often occurs that an experiment requires a long-time signal acquisition; therefore, the setup including the measurement instrument and LabOne software are left unattended. By default, many web browsers go to a sleep mode after a certain idle time which results in the loss of acquired data when using the web-based user interface of LabOne for measurement. Although it is recommended to take advantage of LabOne APIs in these situations to automate the measurement process and avoid using web browsers for data recording, it is still possible to adjust the browser settings to prevent it from entering the sleep mode. Below, you will find how to modify the settings of your preferred browser to ensure a long-run data acquisition can be implemented properly.

Edge

1. Open **Settings** by typing `edge://settings` in the address bar
2. Select **System** from the icon bar.
3. Find the **Never put these sites to sleep** section of the **Optimized Performance** tab.
4. Add the IP address and the port of LabOne Webserver, e.g., `127.0.0.1:8006` or `192.168.73.98:80` to the list.

Chrome

1. While LabOne is running, open a tab in Chrome and type `chrome://discards` in the address bar.
2. In the shown table listing all the open tabs, find LabOne and disable its **Auto Discardable** feature.
3. This option avoids discarding and refreshing the LabOne tab as long as it is open. To disable this feature permanently, you can use an extension from the Chrome Webstore.

Firefox

1. Open **Advanced Preferences** by typing `about:config` in the address bar.
2. Look for `browser.tabs.unloadOnLowMemory` in the search bar.
3. Change it to **false** if it is **true**.

Opera

1. Open **Settings** by typing `opera://settings` in the address bar.
2. Locate the **User Interface** section in the **Advanced** view.
3. Disable the **Snooze inactive tabs to save memory** option and restart Opera.

Safari

1. Open **Debug** menu.
2. Go to **Miscellaneous Flags**.
3. Disable **Hidden Page Timer Throttling**.

3. Functional Overview

This chapter provides the overview of the features offered by the SHFLI Lock-in Amplifier. The first section contains the description of the functional diagram, and the hardware and software feature list. The following section details the front panel and the back panel of the measurement instrument. The last section provides product selection and ordering support.

3.1. Features

The SHFLI Lock-in Amplifier consists of several internal units that process digital data (light blue color) and several interface units processing analog signals (dark blue color). The front panel is depicted on the left-hand side and the back panel is depicted on the right-hand side. The arrows between the panels and the interface units indicate selected physical connections and the data flow.

The orange blocks are optional units that can be either ordered at purchase or upgraded later. The SHFLI Lock-in Amplifier has 2 physical channels each with its own signal input and output, auxiliary input and digital inputs and outputs. The ordering guide details the currently available upgrade options.

Figure 3.1: SHFLI instrument functional diagram

The signal to be measured is usually connected to one of the two SHFLI signal inputs where it is amplified to a defined range and mixed down to an intermediate frequency (IF) through a double-superheterodyne scheme and digitized at very high speed if above 800 MHz, or directly digitized if below this frequency threshold. The resulting samples are fed into the digital signal processor that contains 8 dual-phase demodulators. The results of the demodulation are fed into a digital interface to be transferred to the host computer through the LAN or USB interface, and can also be routed to the auxiliary outputs on the front panel of the SHFLI. Two low-distortion signal outputs provide the signal generator functionality.

The numerical oscillators generate sine and cosine pairs that are used for the demodulation of the input signal and also for the generation of the SHFLI output signals. For this purpose, when the SHFLI-MF Multi-Frequency option is present, the Output Adder can generate a linear combination of the oscillator outputs to generate a multi-frequency output signal. After the digital-to-analog conversion, the output signal is either routed directly to the output connectors, if its final frequency is below 800 MHz, or through the double-superheterodyne upconversion path if its final frequency needs to be above this frequency.

Hardware trigger and reference signals are used for various purposes inside the instrument, such as triggering demodulation and oscilloscope data acquisition, to acquire or generate an external reference signal, or triggering other equipment.

3.1.1. Lock-in Operating Modes

- Internal reference mode
- External reference mode (coming later in 2023)
- Dual-lock-in operation (two independent lock-in amplifiers in the same box)
- Triple-harmonic mode (simultaneous measurement at three frequencies within the measurement window that are harmonic of the Numerical Oscillator frequency)
- Arbitrary frequency mode (with SHFLI-MF option, simultaneous measurement at up to eight arbitrary frequencies within the measurement window)

3.1.2. Super-high-frequency Signal Inputs

- 2 low-noise SHF Inputs, DC - 8.5 GHz frequency range, 1 GHz bandwidth
- Variable input range, selectable from 1 mV to 1 V peak (10 mV to 1 V in Baseband)
- Selectable AC/DC coupling in Baseband

3.1.3. Super-high-frequency Signal Outputs

- Low-noise SHF Outputs, DC - 8.5 GHz frequency range, 1 GHz bandwidth
- Variable output range, selectable from 10 mV to 1 V peak (10 mV to 0.5 V in Baseband)

3.1.4. Demodulators & Reference

- Up to 8 dual-phase demodulators
- Up to 8 programmable numerical oscillators
- Up to 2 external reference signals (coming later in 2023)
- Up to 4 input and up to 4 output trigger signals
- Individually programmable demodulator filters
- 128-bit internal processing
- 64-bit resolution demodulator sample
- 48-bit internal reference resolution

3.1.5. Auxiliary Input and Outputs

- 4 high-speed auxiliary outputs for user-defined signals, 25 MHz bandwidth, 14 bit
- 4 high-precision auxiliary outputs for user-defined signals, 200 kHz bandwidth, 18 bit
- 2 auxiliary inputs, general purpose

3.1.6. High-speed Connectivity

- SMA connectors on front and back panel for triggers, signals and external clock
- USB 3.0 high-speed host interface
- LAN/Ethernet 1 Gbit/s controller interface
- DIO: 32-bit digital input-output port
- Clock input/output connectors (10/100 MHz)

3.1.7. Extensive Time and Frequency Domain Analysis Tools

- Numeric tool
- Plotter
- Oscilloscope
- Sweeper and Frequency response analyzer
- FFT spectrum analyzer

3.1.8. Software Features

- Web-based, high-speed LabOne® user interface with multi-instrument control
- Data server with multi-client support
- API for Python and MATLAB®

3.2. Front Panel Tour

The front panel SMA and BNC connectors and control LEDs are arranged as shown in Figure 3.2 and listed in .

Figure 3.2: SHFLI Lock-in Amplifier front panel

Table 3.1: SHFLI Lock-in Amplifier front panel description

Position	Label / Name	Description
A	Aux In	analog Auxiliary Input, max. 10 V
B	Signal Output	single-ended analog Signal Output, DC-8.5 GHz, max. 1 V peak
C	Trig Out	TTL Trigger Outputs 1 to 4
D	Trig In	TTL Trigger Inputs 1 to 4
E	Signal Input	single-ended analog Signal Input, DC-8.5 GHz, max. 1 V peak
F	High Precision	high-precision auxiliary outputs 1 to 4
G	High Speed	high-speed auxiliary outputs 1 to 4

H	multicolor LEDs	off
		    Instrument off or uninitialized
		blink
		    all LEDs blink for 5 seconds → indicator used by the Identify Device functionality

	Busy	unused

	Ext. Clock	off
		    10/100 MHz External Clock Signal not present/detected
		blue
		    10/100 MHz External Clock Signal is present and locked on to
		yellow
		    10/100 MHz External Clock Signal present, but not locked on to
		red
		    10/100 MHz External Clock Signal present, but lock failed

	ZSync	unused

	Status	off
		    Instrument off or uninitialized
		blue
		    Instrument is initialized and has no warnings or errors
		yellow
		    Instrument has warnings
		red
		    Instrument has errors

Position	Label / Name	Description
J	⏻ Soft power button	Power button with incorporated status LED off Instrument off and disconnected from mains power blue - flashing rapidly (>1/sec): Firmware is starting - flashing slowly (<1/sec): Firmware ready, waiting for connection - constant: Instrument ready and active connection over USB or Ethernet red - breathing: Instrument off but connected to mains power → safe to power off using the rear panel switch, or restart using the soft power button - flashing: Instrument booting up - constant: Fatal error occurred

3.3. Back Panel Tour

The back panel is the main interface for power, control, service and connectivity to other ZI instruments. Please refer to Figure 3.3 and for the detailed description of the items.

Figure 3.3: SHFLI Lock-in Amplifier back panel

Table 3.2: SHFLI Lock-in Amplifier back panel description

Position	Label / Name	Description
A	⏚ Earth ground	4 mm banana jack connector for earth ground, electrically connected to the chassis and the earth pin of the power inlet
B	AC 100 - 240 V	Power inlet, fuse holder, and power switch
C	MDS 1	SMA: bidirectional TTL ports for multi-device synchronization
D	MDS 2	SMA: bidirectional TTL ports for multi-device synchronization
E	USB 1	Universal Serial Bus (USB) 3.0 port **Attention:** This port offers limited data throughput and the USB 2 port (see position H) is recommended for normal operation
F	LAN 1GbE	1 Gbit LAN connector for instrument control and data acquisition
G	DIO 32bit	32-bit digital input/output (DIO) connector
H	USB 2	Universal Serial Bus (USB) 3.0 port for instrument control and data acquisition
I	ZSync Secondary	unused **Attention:** This is not an Ethernet plug, connection to an Ethernet network might damage the instrument
J	ZSync Primary	unused **Attention:** This is not an Ethernet plug, connection to an Ethernet network might damage the instrument

Position	Label / Name	Description
K	External Clk In	external clock Input (10 MHz/100 MHz) for synchronization with other instruments
L	External Clk Out	external clock Output (10 MHz/100 MHz) for synchronization with other instruments

3.4. Ordering Guide

Table 3.3 provides an overview of the available SHFLI products. Upgradeable features are options that can be purchased anytime without the need to send the Instrument back to Zurich Instruments.

Table 3.3: SHFLI Instrument product codes for ordering

Product code	Product name	Description	Field upgrade possible
SHFLI	SHFLI Lock-in Amplifier	base lock-in amplifier	-
SHFLI-MF	SHFLI-MF Multi-frequency	option	yes
SHFLI-MOD	SHFLI-MOD AM/FM Modulation	option	yes[1]
SHFLI-PID	SHFLI-PID Quad PID/PLL Controller	option	yes

[1] Requires SHFLI-MF Multi-frequency option

Table 3.4: Product selector SHFLI

Feature	SHFLI	SHFLI + SHFLI-MF	SHFLI + SHFLI-PID	SHFLI + SHFLI-MF + SHFLI-PID
Internal reference mode	yes	yes	yes	yes
External reference mode	yes	yes	yes	yes
Dual-channel operation (2 independent measurement units)	yes	yes	yes	yes
Signal generators	2	2	2	2
Superposed output sinusoidals per generator	1	up to 8	1	up to 8
Triple-harmonic mode	yes	yes	yes	yes
Multi-frequency mode	-	yes	-	yes
Arbitrary frequency mode	-	yes	-	yes
Number of demodulators	8	8	8	8
Simultaneous frequencies	2	8	2	8
Simultaneous numerical oscillator harmonics	4+4	-	4+4	-
External references	2	2	2	2
PID controllers	-	-	4	4
Dynamic reserve	100 dB	100 dB	100 dB	100 dB
Lock-in range	8.5 GHz	8.5 GHz	8.5 GHz	8.5 GHz
USB 3.0	yes	yes	yes	yes
LAN 1 Gbit/s	yes	yes	yes	yes

4. Tutorials

The tutorials in this chapter have been created to allow users to become more familiar with the basic technique of lock-in amplification, with the features and operations of the SHFLI Lock-in Amplifier, with the LabOne user interface, as well as with some more advanced lock-in measurement techniques. To successfully carry out the tutorials, users are required to have certain laboratory equipment and basic equipment handling knowledge. The equipment list is given below.

Note

For all tutorials, you must have LabOne installed as described in the Getting Started.

- 1 USB 3.0 cable or 1 LAN cable (supplied with your SHFLI Lock-in Amplifier)
- 3 SMA cables
- 1 SMA shorting cap (optional)
- 1 oscilloscope with a bandwidth ≥ 2 GHz (optional)
- 1 SMA T-piece (optional)

4.1. Simple Loop

Note

This lock-in amplifier tutorial is applicable to all SHFLI instruments as no option is required. Some settings depend on whether or not the SHFLI-MF Multi-frequency option is installed, and the differences are pointed out where necessary.

4.1.1. Goals and Requirements

This tutorial is for people with no or little prior experience with the Zurich Instruments SHFLI Lock-in Amplifier. By using a very basic measurement setup, it shows the most fundamental working principles of the SHFLI and the LabOne UI using a hands-on approach.

There are no special requirements to complete the tutorial.

4.1.2. Preparation

In this exercise, you are asked to generate a signal with the SHFLI and measure that signal with the same instrument. This is done by first connecting Signal Output 1 to Signal Input 1 with a short SMA cable (ideally 10 to 20 cm). Optionally, it is possible to connect the generated signal at Signal Output 1 to an oscilloscope by using a T-piece and an additional cable. Figure 4.1 displays a sketch of the hardware setup.

Figure 4.1: Tutorial simple loop setup (LAN connection shown)

Make sure that the SHFLI unit is powered and connected by USB to your host computer or by Ethernet to your local area network (LAN) where the host computer resides. Start the LabOne User

Interface as explained in Connecting to the Instrument. The LabOne Data Server and the LabOne Web Server are automatically started and run in the background.

4.1.3. Generate the Test Signal

Perform the following steps in order to generate a 1.6 GHz signal of 0.25 V peak amplitude on Signal Output 1.

1. In the Signal Inputs section of the Lock-in tab, make sure that the Frequency Range of Input 1 is set (dark blue) to RF and then set its Center frequency (labeled c_1) to 1.5 GHz: enter 1.5G or 1500000000 in the field and press <TAB> or <ENTER> on the keyboard, or click somewhere else in the GUI to activate the setting.
2. Change the frequency value of oscillator 1 (Lock-in tab, Oscillators section) to 100 MHz: click on the field, enter 100000000 or 100M in short.
3. (Without SHFLI-MF option) In the Signal Outputs section of the Lock-in tab, set the Range pull-down to 0.5 V and the amplitude to 250 mV for Output 1. The Read-only Frequency field of Output 1 should show 1.6 GHz.
   (With SHFLI-MF option) In the Output 1 section of the Lock-in tab, set Amplitude to 250 mV for demodulator 4 (4th row) and enable the button next to this field, if it's not enabled yet (dark blue). The read-only Frequency field of this component should show 1.6 GHz. At the bottom of the Output 1 section, set the Range selector to 0.5 V.
4. By default all physical outputs of the SHFLI are inactive to prevent damage to connected circuits. Turn on the main output switch by clicking on the On/Off button at the top right of the Output 1 section. The switch turns to dark blue when enabled.
5. If you have an oscilloscope connected to the setup, you should now be able to see the generated signal.

Table 4.1 and Table 4.2 summarize the instrument settings to be made without and with SHFLI-MF Multi-frequency option.

Table 4.1: Settings: generate the test input signal (without SHFLI-MF Multi-frequency option)

Tab	Section	#	Label	Setting / Value / State
Lock-in	Signal Inputs	1	Freq Range	RF
Lock-in	Signal Inputs	1	Center Freq (Hz)	1.5 GHz
Lock-in	Oscillators	1	Frequency	100 MHz
Lock-in	Signal Outputs	1	Range	0.5 V
Lock-in	Signal Outputs	1	Amplitude	0.25 V
Lock-in	Signal Outputs	1	On	ON

Table 4.2: Settings: generate the test input signal (with SHFLI-MF Multi-frequency option)

Tab	Section	#	Label	Setting / Value / State
Lock-in	Signal Inputs	1	Freq Range	RF
Lock-in	Signal Inputs	1	Center Freq (Hz)	1.5 GHz
Lock-in	Oscillators	1	Frequency	100 MHz
Lock-in	Output 1	4	Amp (V)	0.25 V
Lock-in	Output 1	4	Amp Enable	ON
Lock-in	Output 1		Range	0.5 V
Lock-in	Output 1		On	ON

Oscillators and Demodulators are both represented as rows in the Lock-in tab, but need to be distinguished for a good understanding of the user interface. This is particularly important for users of the SHFLI-MF Multi-frequency option. By default, oscillator 1 is assigned to demodulators 1-4, and oscillator 2 is assigned to demodulators 5-8. This means, for example that when generating a signal using row 2 of the Output 1 section, the frequency of this signal depends on row 1 of the Oscillators section (and not row 2) by default. The final frequency of the output sine wave also depends on the center frequency of the channel being used, if this is in RF mode. In the example above, since we considered the Output 1 section, the frequency of Oscillator 1 needs to be added to the center frequency of channel 1, because this is set to RF mode. In base-band (BB) mode, instead, the output signal's frequency is equal to the one of its corresponding demodulator.

Hovering over the read-only frequency field of each output component shows a tool-tip that describes what elements compose that frequency.

4.1.4. Check the Test Input Signal

Next, set the input range to 500 mV as shown in the following table.

Table 4.3: Settings: configure the Signal Input

Tab	Section	#	Label	Setting / Value / State
Lock-in	Signal Inputs	1	Range	500 mV

The range setting ensures that the analog amplification on Signal Input 1 is set such that the dynamic range of the input high-speed analog-digital converter is used optimally without clipping the signal.

The incoming signal can now be observed in the Scope tab. The Scope can be opened by clicking on its icon in the left sidebar or by dragging it to one of the open tab rows. Choose the following settings on the Scope tab to display the signal entering Signal Input 1:

Table 4.4: Settings: configure the Scope

Tab	Sub-tab	Section	#	Label	Setting / Value / State
Scope	Control	Horizontal		Sampling Rate	2 GSa
Scope	Control	Horizontal		Length	4992
Scope	Control	Vertical		Channel 1	Signal Input 1
Scope				Run / Stop	ON

The Scope now displays single shots of Signal Input 1 after the analog frequency down-mixing. The scale on top of the graphs indicates the time-axis zoom level for orientation. The icons on the left and below the figure give access to the main scaling properties and allow one to store the measurement data as a SVG image file or plain data text file. Moreover, the view can be panned by clicking and holding the left mouse button inside the graph while moving the mouse.

Note

The mouse wheel can be used to zoom in and out horizontally. To zoom vertically, the shift key needs to be pressed while using the mouse wheel.

Having set the Input Range to 500 mV ensures that no signal clipping occurs. If you set the Input Range to 100 mV, clipping can be seen immediately on the scope window accompanied by a red error flag on the status bar in the lower right corner of the LabOne User Interface. At the same time, the LED next to the Signal Input 1 SMA connector on the instrument's front panel will turn red. The error flag can be cleared by pressing the clear button marked with the letter C on the right side of the status bar after setting the Input Range back to 500 mV.

The Scope is a useful tool for checking quickly the properties of the input signal in the time and frequency domain. For the full description of the Scope tool please refer to the functional description in Scope Tab.

4.1.5. Measure the Test Input Signal

Now, you are ready to use the SHFLI Lock-in Amplifier to demodulate the input signal and measure its amplitude and phase. You will use two tools of the LabOne User Interface: the Numerical and the Plotter.

First, adjust the following parameters on the Lock-in tab for demodulator 1 (or choose another demodulator if desired):

Table 4.5: Settings: measure the test input signal

Tab	Section	#	Label	Setting / Value / State
Lock-in	Frequencies	1	n	1

Tab	Section	#	Label	Setting / Value / State
Lock-in	Frequencies	1	Phase	0
Lock-in	Input	1	Signal	Sig In 1
Lock-in	Low-Pass Filters	1	Order	3 (18 dB/Oct)
Lock-in	Low-Pass Filters	1	TC / BW 3dB	9.3 ms / 8.7 Hz
Lock-in	Data Transfer	1	Rate	100 Sample/s
Lock-in	Data Transfer	1	Enable	ON

These settings configure the demodulation filter to the third-order low-pass operation with a 9 ms integration time constant. Alternatively, the corresponding 3 dB bandwidth can be displayed and entered. The output of the demodulator filter is read out at a rate of 100 Hz: 100 data samples are sent to the host PC each second with equidistant spacing. These samples can be viewed in the Numerical and the Plotter tools which we will examine next.

The Numerical tool provides the space for 16 or more measurement panels. Each of the panels has the option to display the demodulation samples in Cartesian (X,Y) or in polar (R, Θ) representation, plus other quantities such as the Demodulation Frequencies. The unit of the (X,Y,R) values are by default given in V_{RMS}. The numerical values are accompanied by graphical bar scale indicators that provide better readability, e.g. for alignment procedures. Display zoom is also available by holding the control key pressed while scrolling with the mouse wheel. You may observe rapidly changing digits in the Numerical panels. This is due to the fact that you are measuring thermal noise that may be in the µV or even nV range depending on the filter settings.

To better familiarize yourself with the settings, you can now change some of the values entered before, such as the amplitude of the generated signal, and observe the effect on the demodulator output.

Next, we will have a look at the Plotter tool, which allows users to observe the demodulator signals as a function of time. It is possible to adjust the scaling of the graph in both axes, or make detailed measurements with 2 cursors for each axis. Signals with same properties, e.g. amplitude from different demodulators, are automatically added to the same default y-axis group. This ensures that the axis scaling is identical. Signals can be moved between groups. More information on y-axis groups can be found in the section called "Plot Area Elements".

Try zooming in along the time dimension using the mouse wheel or the icons below the graph to display about one second of the data stream.

Figure 4.2: LabOne User Interface Plotter displaying demodulator results continuously over time (roll mode)

Data displayed in the Plotter can also be saved continuously to the computer memory. Please have a look at User Interface Overview for a detailed description of the data saving and recording functionality. Instrument and user interface settings can be saved and loaded in the Settings section (Config Tab).

4.1.6. Different Filter Settings

Next you will learn to change the filter settings and see their effect on the measurement results. For this exercise, configure the second demodulator with the same settings as the first one, except for the time constant that you set to 1 ms, corresponding to a 3 dB bandwidth of 83 Hz.

Table 4.6: Settings: change the demodulator filter settings

Tab	Section	#	Label	Setting / Value / State
Lock-in	Low-Pass Filters	2	Order	3 (18 dB/Oct)
Lock-in	Low-Pass Filters	2	TC / BW 3dB	1 ms / 77.38 Hz

A higher time constant increases the filter integration time of the demodulators. This, in turn, "smooths out" the demodulator outputs and hence decreases available time resolution. It is recommended to keep the sample rate 7 to 10 times the filter 3 dB bandwidth. The sample rate will be rounded off to the next available sampling frequency. In this example, type 1k in the Rate field, which is sufficient to not only properly resolve the signal, but also to avoid aliasing effects. Figure 4.3 shows data samples displayed for the two demodulators with different filter settings described above.

Figure 4.3: LabOne User Interface Plotter: Demodulator 1 (TC = 9.3 ms, blue), Demodulator 2 (TC = 1 ms, green)

Moreover, you may for instance "disturb" the demodulator with a change of test signal amplitude, for example from 0.25 V to 0.4 V and vice-versa. The green plot may go out of the display range which can be re-adjusted by clicking the Auto Scale button, cf. Plot Functionality. With a large time constant, the demodulated data changes more slowly in reaction to the change in the input signal compared to a small time constant. In addition, the number of stable significant digits in the Numerical tab will also be higher with a high time constant.

4.2. Up and Down frequency conversion

Note

This lock-in amplifier tutorial is applicable to all SHFLI instruments as no option is required. Some settings depend on whether or not the SHFLI-MF Multi-frequency option is installed, and the differences are pointed out where necessary.

4.2.1. Goals and Requirements

This tutorial aims at familiarizing you with the frequency conversions performed by the SHFLI front-ends and their consequences. The practical examples and exercises are meant to provide better understanding of the technical aspects and introduce the tools that will help you avoid possible pitfalls.

In particular, it will show how the channel center frequency values make the 2 channels independent and, depending on how they are chosen, may prevent one channel from being able to measure the signals generated by the other.

There are no prerequisites for this tutorial, but completing the Simple Loop will make it easier to follow along.

4.2.2. Preparation

In this tutorial we need to connect Signal Output 2 to Signal Input 1 with a short (10 to 20 cm) SMA coaxial cable. Channel 2 will be used to generate a signal that is then measured with Channel 1. This will highlight the role of the Center Frequency setting. As in the Simple Loop, it is possible to also

visualize the signal using a stand-alone oscilloscope by splitting the signal from the output using a T connector. Figure 4.4 displays a sketch of the hardware setup.

Figure 4.4: Tutorial single tone, two channels setup

Make sure that the SHFLI is powered and connected to the computer, and start the LabOne user interface. Please refer to the Preparation section in the Simple Loop tutorial for more details on this.

4.2.3. Generate the Test Signal

Perform the following steps in order to generate a 1.6 GHz signal of 0.25 V peak amplitude on Signal Output 2. Please note that these are very similar to the ones in the Simple Loop, but performed on Channel 2

1. In the Signal Inputs section of the Lock-in tab, make sure that the Frequency Range of Input 2 is set (dark blue) to RF and then set its Center frequency (labeled c_2) to 1.5 GHz: enter 1.5G or 1500000000 in the field and press <TAB> or <ENTER> on the keyboard, or click somewhere else in the GUI to activate the setting.
2. Change the frequency value of oscillator 2 (Lock-in tab, Oscillators section, labeled f_2) to 100 MHz: click on the field, enter 100000000 or 100M in short.
3. (Without SHFLI-MF option) In the Signal Outputs section of the Lock-in tab, set the Range pull-down to 0.5 V and the amplitude to 250 mV for Output 2. The Read-only Frequency field of Output 2 should show 1.6 GHz.
   (With SHFLI-MF option) In the Output 2 section of the Lock-in tab, set Amp to 250 mV for demodulator 8 (8th row) and enable the button next to this field, if it's not enabled yet (dark blue). The read-only Frequency field of this component should show 1.6 GHz. At the bottom of the Output 2 section, set the Range selector to 0.5 V.
4. By default all physical outputs of the SHFLI are inactive to prevent damage to connected circuits. Turn on the main output switch by clicking on the On/Off button at the top right of the Output 2 section. The switch turns dark blue when enabled.
5. If you have an oscilloscope connected to the setup, you should now be able to see the generated signal.

Table 4.7 and Table 4.8 summarize the instrument settings to be made without and with SHFLI-MF Multi-frequency option.

Table 4.7: Settings: generate the test input signal (without SHFLI-MF Multi-frequency option)

Tab	Section	#	Label	Setting / Value / State
Lock-in	Signal Inputs	2	Freq Range	RF
Lock-in	Signal Inputs	2	Center Freq (Hz)	1.5 GHz
Lock-in	Oscillators	2	Frequency	100 MHz
Lock-in	Signal Outputs	2	Range	0.5 V
Lock-in	Signal Outputs	2	Amplitude	0.25 V

Tab	Section	#	Label	Setting / Value / State
Lock-in	Signal Outputs	2	On	ON

Table 4.8: Settings: generate the test input signal (with SHFLI-MF Multi-frequency option)

Tab	Section	#	Label	Setting / Value / State
Lock-in	Signal Inputs	2	Freq Range	RF
Lock-in	Signal Inputs	2	Center Freq (Hz)	1.5 GHz
Lock-in	Oscillators	2	Frequency	100 MHz
Lock-in	Output 2	8	Amp (V)	0.25 V
Lock-in	Output 2	8	Amp Enable	ON
Lock-in	Output 2		Range	0.5 V
Lock-in	Output 2		On	ON

One important aspect to note is that the center frequency is channel-based, i.e., it is the same for both input and output of that channel. Its input field in the LabOne graphical user interface is located in the Signal Inputs section.

Visualize the Signal with the Scope

Next, adjust the parameters of Signal Input 1 (please note that we are now setting up the other channel) as shown in the following table, so that they match the ones of Channel 2.

Table 4.9: Settings: configure the Signal Input

Tab	Section	#	Label	Setting / Value / State
Lock-in	Signal Inputs	1	Range	500 mV
Lock-in	Signal Inputs	1	Freq Range	RF
Lock-in	Signal Inputs	1	Center Freq (Hz)	1.5 GHz

The range setting ensures that the analog amplification on Signal Input 1 is set such that the dynamic range of the input high-speed analog-digital converter is used optimally without clipping the signal, and matching the center frequency to the one of Channel 2 ensures that the 2 measurement windows overlap completely.

The incoming signal can now be observed in the Scope tab. The Scope can be opened by clicking on its icon in the left sidebar or by dragging it to one of the open tab rows. Choose the following settings on the Scope tab to display the signal entering Signal Input 1:

Table 4.10: Settings: configure the Scope

Tab	Sub-tab	Section	#	Label	Setting / Value / State
Scope	Control	Horizontal		Sampling Rate	2 GSa
Scope	Control	Horizontal		Length	4992
Scope	Control	Vertical		Channel 1	Signal Input 1
Scope	Control	Vertical		Channel 1	On
Scope				Run / Stop	ON

The Scope now displays single shots of Signal Input 1 after the analog frequency down-mixing. The scale on top of the graphs indicates the time-axis zoom level for orientation. The icons on the left and below the figure give access to the main scaling properties and allow one to store the measurement data as a SVG image file or plain data text file. Moreover, the view can be panned by clicking and holding the left mouse button inside the graph while moving the mouse.

Click on "Freq FFT" in the Scope's Control panel, Horizontal section, to display the spectrum of the signal. You should see a peak at 100 MHz on the plot. The Scope, in RF mode, shows the complex signal coming from the analog front-end's mixer, so the spectrum is centered around 0 Hz with

positive and negative frequencies, from -1 GHz to +1 GHz. To visualize the signal's real frequency, go to the "Advanced" panel in the Scope tab and click on the "Absolute Freq" button.

If you now change the center frequency of channel 1, the signal will move on the screen relatively to the window's center. For example, try to change channel 1's center frequency to 1.7 GHz. The signal is now displayed to the left of the window's center, as this is now located at 1.7 GHz, but its frequency has not changed because you haven't modified any of channel 2's parameters. Turning off "Absolute Freq" will show the signal's relative frequency to be -100 MHz now. If you set channel 1's center frequency higher than 2.6 GHz, the signal will no longer be visible because its measurement window no longer contains the 1.6 GHz frequency.

Measure the Signal with a Demodulator

Let's now set up a lock-in measurement of the signal coming from Output 2. The following table shows the settings that need to be made in the Lock-in tab, starting with resetting the center frequency of channel 1.

Table 4.11: Settings: configure the Signal Input

Tab	Section	#	Label	Setting / Value / State
Lock-in	Signal Inputs	1	Freq Range	RF
Lock-in	Signal Inputs	1	Center Freq (Hz)	1.5 GHz
Lock-in	Oscillators	1	Frequency	100 MHz
Lock-in	Demodulators	1	Input Signal	Sig In 1
Lock-in	Demodulators	1	Osc	f_1
Lock-in	Demodulators	1	n	1
Lock-in	Demodulators	1	BW 3 dB	100
Lock-in	Demodulators	1	Rate (Sa/s)	1000
Lock-in	Demodulators	1	En	ON

With these settings, demodulator 1 demodulates at a frequency of 1.6 GHz, equal to the one of the signal at the output. This can be verified in the read-only frequency fields next to demodulator 1 and next to the active frequency component in Output 2.

You can now check the demodulator output in the numerical tab: you should see both amplitude and phase panels showing rather stable readings.

Now let's play with the frequencies of channel 1 similarly to what we did earlier with the Scope: if we increase the center frequency by 200 MHz, to 1.7 GHz and change the frequency of oscillator 1 (f_1) to -100 MHz, we end up at the same demodulator frequency, so we should see a similar readout in the numerical tab. The two readings are likely different: the amplitude may be slightly different because of slight variations in the analog path response with frequency, while the phase measurement, although stable, is likely very different because, differently from the Simple Loop tutorial, we are using 2 independent numerical oscillators and changing the frequency of one modifies the relative phase offset between them.

Finally, if we changed the center frequency of channel 1 to 2.5 GHz, the measurement windows of channel 2, generating the signal, and of channel 1, measuring it, would overlap only at 2 GHz, so in order to be able to measure the signal generated by channel 2 using channel 1, we need to change the frequency of oscillator 2 (f_2) to +500 MHz and that of oscillator 1 (f_1) to -500 MHz. Increasing the gap between the center frequencies further will completely separate the windows and signals generated in one would no longer be measurable by the other.

5. Functional Description LabOne User Interface

This chapter gives a detailed description of the functionality available in the LabOne User Interface (UI) for the Zurich Instruments SHFLI Lock-in Amplifier. LabOne provides a data server and a web server to control the Instrument with any of the most common web browsers (e.g. Firefox, Chrome, Edge, etc.). This platform-independent architecture supports interaction with the Instrument using various devices (PCs, tablets, smartphones, etc.) even at the same time if needed.

On top of standard functionality like acquiring and saving data points, this UI provides a wide variety of measurement tools for time and frequency domain analysis of measurement data as well as for convenient servo loop implementation.

5.1. User Interface Overview

5.2. UI Nomenclature

This section provides an overview of the LabOne User Interface, its main elements and naming conventions. The LabOne User Interface is a browser-based UI provided as the primary interface to the SHFLI instrument. Multiple browser sessions can access the instrument simultaneously and the user can have displays on multiple computer screens. Parallel to the UI, the instrument can be controlled and read out by custom programs written in any of the supported languages (e.g. LabVIEW, MATLAB, Python, C) connecting through the LabOne APIs.

Figure 5.1: LabOne User Interface (default view)

The LabOne User Interface automatically opens some tabs by default after a new UI session has been started. At start-up, the UI is divided into two tab rows, each containing a tab structure that gives access to the different LabOne tools. Depending on display size and application, tab rows can be freely added and deleted with the control elements on the right-hand side of each tab bar. Similarly, the individual tabs can be deleted or added by selecting app icons from the side bar on the left. A click on an icon adds the corresponding tab to the display, alternatively the icon can be dragged and dropped into one of the tab rows. Moreover, tabs can be moved by drag-and-drop within a row or across rows.

Table 5.1 gives a brief descriptions and naming conventions for the most important UI items.

Table 5.1: LabOne User Interface features

Item name	Position	Description	Contains
side bar	left-hand side of the UI	contains app icons for each of the available tabs - a click on an icon adds or activates the corresponding tab in the active tab row	app icons
status bar	bottom of the UI	contains important status and warning indicators, device and session information, and access to the command log	status indicators
main area	center of the UI	accommodates all active tabs – new rows can be added and removed by using the control elements in the top right corner of each tab row	tab rows, each consisting of tab bar and the active tab area
tab area	inside of each tab	provides the active part of each tab consisting of settings, controls and measurement tools	sections, plots, sub-tabs, unit selections

Further items are highlighted in Figure 5.2.

Figure 5.2: LabOne User Interface (more items)

5.2.1. Unique Set of Analysis Tools

All instruments feature a comprehensive tool set for time and frequency domain analysis for both raw and demodulated signals.

The app icons on the left side of the UI can be roughly divided into two categories: settings and tools.

Settings-related tabs are in direct connection to the instrument hardware, allowing the user to control all the settings and instrument states.

Tools-related tabs place a focus on the display and analysis of gathered measurement data.

There is no strict distinction between settings and tools, e.g. the Sweeper will change certain demodulator settings while performing a frequency sweep. Within the tools one can often further discriminate between time domain and frequency domain analysis. Moreover, a distinction can be made between the analysis of fast input signals - typical sampling rate of 2 GSa/s - and the measurement of orders of magnitude slower data - typical sampling rate of ≤50 MSa/s - derived for instance from demodulator outputs and auxiliary inputs. Table 5.2 provides a brief classification of the tools.

Table 5.2: Tools for time domain and frequency domain analysis

	Time Domain	Frequency Domain
Fast signals (2 GSa/s)	Oscilloscope (Scope tab)	FFT Analyzer (Scope tab)
Slow signals (≤50 MSa/s)	Numeric	Spectrum Analyzer (Spectrum tab)
	Plotter	Sweeper
	Data Acquisition	-

The following table gives the overview of all app icons. Note that the selection of app icons may depend on the upgrade options installed on a given instrument.

Table 5.3: Overview of app icons and short description

Control/Tool	Option/Range	Description
Config		Provides access to software configuration.
Device		Provides instrument specific settings.
Files		Access settings and measurement data files on the host computer.
In/Out		Gives access to all controls relevant for the Signal Inputs and Signal Outputs of each channel.
Mod		Access to all the settings of the digital modulation.
DIO		Gives access to all controls relevant for the digital inputs and outputs including DIO, Trigger Inputs, Trigger Outputs, and Marker Outputs.
AWG		Generate arbitrary signals using sequencing and sample-by-sample definition of waveforms.
ZI Labs		Experimental settings and controls.

Table 5.4 provides a quick overview over the different status bar elements along with a short description.

Table 5.4: Status bar description

Control/Tool	Option/Range	Description
Command log	last command	Shows the last command. A different formatting (MATLAB, Python, ..) can be set in the config tab. The log is also saved in [User]\Documents\Zurich Instruments\LabOne\WebServer\Log
Show Log		Show the command log history in a separate browser window.
Errors	Errors	Display system errors in separate browser tab.
Device	devXXX	Indicates the device serial number.
Identify Device		When active, device LED blinks
MDS	grey/green/red/yellow	Multiple device synchronization indicator. Grey: Nothing to synchronize - single device on the UI. Green: All devices on the UI are correctly synchronized. Yellow: MDS sync in progress or only a subset of the connected devices is synchronized. Red: Devices not synchronized or error during MDS sync.
REC	grey/red	A blinking red indicator shows ongoing data recording (related to global recording settings in the Config tab).
RCO	grey/yellow/red	Router Channel Overflow - Red: present overflow condition on the channel. Yellow: indicates an overflow occurred in the past.
CF	grey/yellow/red	Clock Failure - Red: present malfunction of the external 10 MHz reference oscillator. Yellow: indicates a malfunction occurred in the past.
OVI	grey/yellow/red	Signal Input Overload - Red: present overload condition on the signal input also shown by the red front panel LED. Yellow: indicates an overload occurred in the past.
OVO	grey/yellow/red	Overload Signal Output - Red: present overload condition on the signal output. Yellow: indicates an overload occurred in the past.

Control/ Tool	Option/ Range	Description
COM	grey/ yellow/red	Packet Loss - Red: present loss of data between the device and the host PC. Yellow: indicates a loss occurred in the past.
COM	grey/ yellow/red	Sample Loss - Red: present loss of sample data between the device and the host PC. Yellow: indicates a loss occurred in the past.
C	c	Reset status flags: Clear the current state of the status flags
Full Screen		Toggles the browser between full screen and normal mode.

5.2.2. Plot Functionality

Several tools provide a graphical display of measurement data in the form of plots. These are multi-functional tools with zooming, panning and cursor capability. This section introduces some of the highlights.

Plot Area Elements

Plots consist of the plot area, the X range and the range controls. The X range (above the plot area) indicates which section of the wave is displayed by means of the blue zoom region indicators. The two ranges show the full scale of the plot which does not change when the plot area displays a zoomed view. The two axes of the plot area instead do change when zoom is applied.

The mouse functionality inside of a plot greatly simplifies and speeds up data viewing and navigation.

Table 5.5: Mouse functionality inside plots

Name	Action	Description	Performed inside
Panning	left click on any location and move around	moves the waveforms	plot area
Zoom X axis	mouse wheel	zooms in and out the X axis	plot area
Zoom Y axis	shift + mouse wheel	zooms in and out the Y axis	plot area
Window zoom	shift and left mouse area select	selects the area of the waveform to be zoomed in	plot area
Absolute jump of zoom area	left mouse click	moves the blue zoom range indicators	X and Y range, but outside of the blue zoom range indicators
Absolute move of zoom area	left mouse drag-and-drop	moves the blue zoom range indicators	X and Y range, inside of the blue range indicators
Full Scale	double click	set X and Y axis to full scale	plot area

Each plot area contains a legend that lists all the shown signals in the respective color. The legend can be moved to any desired position by means of drag-and-drop.

The X range and Y range plot controls are described in Table 5.6.

Note

Plot data can be conveniently exported to other applications such as Excel or Matlab by using LabOne's Net Link functionality, see LabOne Net Link for more information.

Table 5.6: Plot control description

Control/Tool	Option/Range	Description
Axis scaling mode	Auto FS Man Auto	Selects between automatic, full scale and manual axis scaling.
Axis mapping mode	Lin Lin Log dB	Select between linear, logarithmic and decibel axis mapping.
Axis zoom in	⊕	Zooms the respective axis in by a factor of 2.
Axis zoom out	⊖	Zooms the respective axis out by a factor of 2.
Rescale axis to data	⊕	Rescale the foreground Y axis in the selected zoom area.
Save figure		Generates PNG, JPG or SVG of the plot area or areas for dual plots to the local download folder.
Save data		Generates a CSV file consisting of the displayed wave or histogram data (when histogram math operation is enabled). Select full scale to save the complete wave. The save data function only saves one shot at a time (the last displayed wave).
Cursor control	Off Off	Cursors can be switch On/Off and set to be moved both independently or one bound to the other one.
Net Link	☁	Provides a LabOne Net Link to use displayed wave data in tools like Excel, MATLAB, etc.

Cursors and Math

The plot area provides two X and two Y cursors which appear as dashed lines inside of the plot area. The four cursors are selected and moved by means of the blue handles individually by means of drag-and-drop. For each axis, there is a primary cursor indicating its absolute position and a secondary cursor indicating both absolute and relative position to the primary cursor.

Cursors have an absolute position which does not change upon pan or zoom events. In case a cursor position moves out of the plot area, the corresponding handle is displayed at the edge of the plot area. Unless the handle is moved, the cursor keeps the current position. This functionality is very effective to measure large deltas with high precision (as the absolute position of the other cursors does not move).

The cursor data can also be used to define the input data for the mathematical operations performed on plotted data. This functionality is available in the Math sub-tab of each tool. The Table 5.7 gives an overview of all the elements and their functionality. The chosen Signals and Operations are applied to the currently active trace only.

Note

Cursor data can be conveniently exported to other applications such as Excel or MATLAB by using LabOne's Net Link functionality, see LabOne Net Link for more information.

Table 5.7: Plot math description

Control/Tool	Option/Range	Description
Source Select		Select from a list of input sources for math operations.
	Cursor Loc	Cursor coordinates as input data.
	Cursor Area	Consider all data of the active trace inside the rectangle defined by the cursor positions as input for statistical functions (Min, Max, Avg, Std).
	Tracking	Display the value of the active trace at the position of the horizontal axis cursor X1 or X2.

Control/ Tool	Option/Range	Description
	Plot Area	Consider all data of the active trace currently displayed in the plot as input for statistical functions (Min, Max, Avg, Std).
	Peak	Find positions and levels of up to 5 highest peaks in the data.
	Trough	Find positions and levels of up to 5 lowest troughs in the data.
	Histogram	Display a histogram of the active trace data within the x-axis range. The histogram is used as input to statistical functions (Avg, Std). Because of binning, the statistical functions typically yield different results than those under the selection Plot Area.
	Resonance	Display a curve fitted to a resonance.
	Linear Fit	Display a linear regression curve.
Operation Select		Select from a list of mathematical operations to be performed on the selected source. Choice offered depends on the selected source.
	Cursor Loc: X1, X2, X2-X1, Y1, Y2, Y2-Y1, Y2 / Y1	Cursors positions, their difference and ratio.
	Cursor Area: Min, Max, Avg, Std	Minimum, maximum value, average, and bias-corrected sample standard deviation for all samples between cursor X1 and X2. All values are shown in the plot as well.
	Tracking: Y(X1), Y(X2), ratioY, deltaY	Trace value at cursor positions X1 and X2, the ratio between these two Y values and their difference.
	Plot Area: Min, Max, Pk Pk, Avg, Std	Minimum, maximum value, difference between min and max, average, and bias-corrected sample standard deviation for all samples in the x axis range.
	Peak: Pos, Level	Position and level of the peak, starting with the highest one. The values are also shown in the plot to identify the peak.
	Histogram: Avg, Std, Bin Size, (Plotter tab only: SNR, Norm Fit, Rice Fit)	A histogram is generated from all samples within the x-axis range. The bin size is given by the resolution of the screen: 1 pixel = 1 bin. From this histogram, the average and bias-corrected sample standard deviation is calculated, essentially assuming all data points in a bin lie in the center of their respective bin. When used in the plotter tab with demodulator or boxcar signals, there additionally are the options of SNR estimation and fitting statistical distributions to the histogram (normal and rice distribution).
	Resonance: Q, BW, Center, Amp, Phase, Fit Error	A curve is fitted to a resonator. The fit boundaries are determined by the two cursors X1 and X2. Depending on the type of trace (Demod R or Demod Phase) either a Lorentzian or an inverse tangent function is fitted to the trace. The Q is the quality factor of the fitted curve. BW is the 3dB bandwidth (FWHM) of the fitted curve. Center is the center frequency. Amp gives the amplitude (Demod R only), whereas Phase returns the phase at the center frequency of the resonance (demod Phase only). The fit error is given by the normalized root-mean-square deviation. It is normalized by the range of the measured data.
	Linear Fit: Intercept, Slope, R^2	A simple linear least squares regression is performed using a QR decomposition routine. The fit boundaries are determined by the two cursors X1 and X2. The parameter outputs are the Y-axis intercept, slope and the R^2-value, which is the coefficient of determination to determine the goodness-of-fit.
Add	Add	Add the selected math function to the result table below.
Add All	Add All	Add all operations for the selected signal to the result table below.
Clear Selected	Clear	Clear selected lines from the result table above.
Clear All	Clear All	Clear all lines from the result table above.
Copy	Copy	Copy selected row(s) to Clipboard as CSV

Control/ Tool	Option/Range	Description
Unit Prefix		Adds a suitable prefix to the SI units to allow for better readability and increase of significant digits displayed.
CSV	CSV	Values of the current result table are saved as a text file into the download folder.
Net Link	Link	Provides a LabOne Net Link to use the data in tools like Excel, MATLAB, etc.
Help	Help	Opens the LabOne User Interface help.

Note

The standard deviation is calculated using the formula $\sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(x_i - \bar{x})^2}$ for the unbiased estimator of the sample standard deviation with a total of N samples x_i and an arithmetic average $\bar{x}$. The formula above is used as-is to calculate the standard deviation for the Histogram Plot Math tool. For large number of points (Cursor Area and Plot Area tools), the more accurate pairwise algorithm is used (Chan et al., "Algorithms for Computing the Sample Variance: Analysis and Recommendations", The American Statistician 37 (1983), 242-247).

Note

The fitting functions used in the Resonance Plot Math tool depend on the selected signal source. The demodulator R signal is fitted with the following function:

$$R(f) = C + A\frac{f}{\sqrt{f^2 + \left(\frac{Q}{f_0}\right)^2 (f^2 - f_0^2)^2}} \tag{1}$$

where C accounts for a possible offset in the output, A is the amplitude, Q is the quality factor and f_0 is the center frequency. The demodulator ϕ signal s fitted with the following function:

$$\phi(f) = \tan^{-1}\left(Q\frac{1 - \left(\frac{f}{f_0}\right)^2}{\frac{f}{f_0}}\right) \tag{2}$$

using the same parameters as above.

Tree Selector

The Tree selector allows one to access streamed measurement data in a hierarchical structure by checking the boxes of the signals that should be displayed. The tree selector also supports data selection from multiple instruments, where available. Depending on the tool, the Tree selector is either displayed in a separate Tree sub-tab, or it is accessible by a click on the button.

Figure 5.3: Tree selector with Display drop-down menu

Vertical Axis Groups

Vertical Axis groups are available as part of the plot functionality in many of the LabOne tools. Their purpose is to handle signals with different axis properties within the same plot. Signals with different units naturally have independent vertical scales even if they are displayed in the same plot. However, signals with the same unit should preferably share one scaling to enable quantitative comparison. To this end, the signals are assigned to specific axis group. Each axis group has its own axis system. This default behavior can be changed by moving one or more signals into a new group.

Figure 5.4: Vertical Axis Group in Plotter tool

The tick labels of only one axis group can be shown at once. This is the foreground axis group. To define the foreground group click on one of the group names in the Vertical Axis Groups box. The current foreground group gets a high contrast color.

Select foreground group

Click on a signal name or group name inside the Vertical Axis Groups. If a group is empty the selection is not performed.

Split the default vertical axis group

Use drag-and-drop to move one signal on the field **[Drop signal here to add a new group]**. This signal will now have its own axis system.

Change vertical axis group of a signal

Use drag-and-drop to move a signal from one group into another group that has the same unit.

Group separation

In case a group hosts multiple signals and the unit of some of these signals changes, the group will be split in several groups according to the different new units.

Remove a signal from the group

In order to remove a signal from a group drag-and-drop the signal to a place outside of the Vertical Axis Groups box.

Remove a vertical axis group

A group is removed as soon as the last signal of a custom group is removed. Default groups will remain active until they are explicitly removed by drag-and-drop. If a new signal is added that match the group properties it will be added again to this default group. This ensures that settings of default groups are not lost, unless explicitly removed.

Rename a vertical axis group

New groups get a default name "Group of ...". This name can be changed by double-clicking on the group name.

Hide/show a signal

Uncheck/check the check box of the signal. This is faster than fetching a signal from a tree again.

Figure 5.5: Vertical Axis Group typical drag and drop moves.

Table 5.8: Vertical Axis Groups description

Control/Tool	Option/Range	Description
Vertical Axis Group		Manages signal groups sharing a common vertical axis. Show or hide signals by changing the check box state. Split a group by dropping signals to the field [Drop signal here to add new group]. Remove signals by dragging them on a free area. Rename group names by editing the group label. Axis tick labels of the selected group are shown in the plot. Cursor elements of the active wave (selected) are added in the cursor math tab.
Signal Type		Select signal types for the Vertical Axis Group.
Channel	integer value	Selects a channel to be added.
Signal	integer value	Selects signal to be added.
Add Signal	Add Signal	Adds a signal to the plot. The signal will be added to its default group. It may be moved by drag and drop to its own group. All signals within a group share a common y-axis. Select a group to bring its axis to the foreground and display its labels.
Window Length	2 s to 12 h	Window memory depth. Values larger than 10 s may cause excessive memory consumption for signals with high sampling rates. Auto scale or pan causes a refresh of the display for which only data within the defined window length are considered.

Trends

The Trends tool lets the user monitor the temporal evolution of signal features such as minimum and maximum values, or mean and standard deviation. This feature is available for the Scope , Spectrum, Plotter, and DAQ tab. Using the Trends feature, one can monitor all the parameters obtained in the Math sub-tab of the corresponding tab.

The Trends tool allows the user to analyze recorded data on a different and adjustable time scale much longer than the fast acquisition of measured signals. It saves time by avoiding post-processing of recorded signals and it facilitates fine-tuning of experimental parameters as it extracts and shows the measurement outcome in real time.

To activate the Trends plot, enable the Trends button in the Control sub-tab of the corresponding main tab. Various signal features can be added to the plot from the Trends sub-tab in the Vertical Axis Groups . The vertical axis group of Trends has its own Run/Stop button and Length setting independent from the main plot of the tab. Since the Math quantities are derived from the raw signals in the main plot, the Trends plot is only shown together with the main plot. The Trends feature is only available in the LabOne user interface and not at the API level.

Figure 5.6: Top: main plot of the Scope tab showing the signal trace. Bottom: corresponding Trends plot tracking an average, standard deviation, and difference signal derived from the cursor positions in the main plot. The example shown is part of the HF2LI user interface. The controls of the Trends feature and their layout are very similar in all tabs and product platforms where this feature is available.

5.3. Saving and Loading Data

5.4. Overview

In this section we discuss how to save and record measurement data with the SHFLI Instrument using the LabOne user interface. In the LabOne user interface, there are 3 ways to save data:

- Saving the data that is currently displayed in a plot
- Continuously recording data in the background
- Saving trace data in the History sub-tab

Furthermore, the History sub-tab supports loading data. In the following, we will explain these methods.

5.4.1. Saving Data from Plots

A quick way to save data from any plot is to click on the Save CSV icon ⊞▷▫ at the bottom of the plot to store the currently displayed curves as a comma-separated value (CSV) file to the download folder of your web browser. Clicking on ⊞▷▫ will save a graphics file instead.

5.4.2. Recording Data

The recording functionality allows you to store measurement data continuously, as well as to track instrument settings over time. The Config Tab gives you access to the main settings for this function. The Format selector defines which format is used: HDF5, CSV, or MATLAB. The CSV delimiter character can be changed in the User Preferences section. The default option is Semicolon.

The node tree display of the Record Data section allows you to browse through the different measurement data and instrument settings, and to select the ones you would like to record. For instance, the demodulator 1 measurement data is accessible under the path of the form `Device 0000/Demodulators/Demod 1/Sample`. An example for an instrument setting would be the filter time constant, accessible under the path `Device 0000/Demodulators/Demod 1/Filter Time Constant`.

The default storage location is the LabOne Data folder which can, for instance, be accessed by the Open Folder button ⬀. The exact path is displayed in the Folder field whenever a file has been written.

Clicking on the Record checkbox will initiate the recording to the hard drive. In case of demodulator and boxcar data, ensure that the corresponding data stream is enabled, as otherwise no data will be saved.

Figure 5.7: Browsing and inspecting files in the LabOne File Manager tab

In case HDF5 or MATLAB is selected as the file format, LabOne creates a single file containing the data for all selected nodes. For the CSV format, at least one file for each of the selected nodes is created from the start. At a configurable time interval, new data files are created, but the maximum size is capped at about 1 GB for easier data handling. The storage location is indicated in the Folder field of the Record Data section.

The File Manager Tab is a good place to inspect CSV data files. The file browser on the left of the tab allows you to navigate to the location of the data files and offers functionalities for managing files in the LabOne Data folder structure. In addition, you can conveniently transfer files between the folder structure and your preferred location using the Upload/Download buttons. The file viewer on the right side of the tab displays the contents of text files up to a certain size limit. Figure 5.7 shows the Files tab after recording Demodulator Sample and Filter Time Constant for a few seconds. The file viewer shows the contents of the demodulator data file.

Note

The structure of files containing instrument settings and of those containing streamed data is the same. Streaming data files contain one line per sampling period, whereas in the case of instrument settings, the file usually only contains a few lines, one for each change in the settings. More information on the file structure can be found in the LabOne Programming Manual.

5.4.3. History List

Tabs with a history list such as Sweeper Tab, Data Acquisition Tab , Scope Tab, Spectrum Analyzer Tab support feature saving, autosaving, and loading functionality. By default, the plot area in those tools displays the last 100 measurements (depending on the tool, these can be sweep traces, scope shots, DAQ data sets, or spectra), and each measurement is represented as an entry in the History sub-tab. The button to the left of each list entry controls the visibility of the corresponding trace in the plot; the button to the right controls the color of the trace.[1] Double-clicking on a list entry allows you to rename it. All measurements in the history list can be saved with Save All . Clicking on the Save Sel button (note the dropdown button ▼) saves only those traces that were selected by a mouse click. Use the Control or Shift button together with a mouse click to select multiple traces. The file location can be accessed by the Open Folder button ⬀. Figure 5.10.8 illustrates some of these features. Figure 5.8 illustrates the data loading feature.

Figure 5.8: History sub-tab features. The entries "My measurement 1" etc. were renamed by the user. Measurement 1, 2, 3, 4 are currently displayed in the plot because their left-hand-side button is enabled. Clicking on Save Sel would save "My measurement 3" and "My measurement 4" to a file, because these entries were selected (gray overlay) by a Control key + mouse click action.

Which quantities are saved depends on which signals have been added to the Vertical Axis Groups section in the **Control** sub-tab. Only data from demodulators with enabled Data Transfer in the Lock-in tab can be included in the files.

The history sub-tab supports an **autosave** functionality to store measurement results continuously while the tool is running. Autosave directories are differentiated from normal saved directories by the text "autosave" in the name, e.g. sweep_autosave_000. When running a tool continuously (Run/Stop button) with Autosave activated, after the current measurement (history entry) is complete, all measurements in the history are saved. The same file is overwritten each time, which means that old measurements will be lost once the limit defined by the history Length setting has been reached. When performing single measurements (Single button) with Autosave activated, after each measurement, the elements in the history list are saved in a new directory with an incrementing count, e.g. `sweep_autosave_001`, `sweep_autosave_002`.

Data which was saved in HDF5 file format can be loaded back into the history list. Loaded traces are marked by a prefix "loaded " that is added to the history entry name in the user interface. The `createdtimestamp` information in the header data marks the time at which the data were measured.

- Only files created by the Save button in the History sub-tab can be loaded.
- Loading a file will add all history items saved in the file to the history list. Previous entries are kept in the list.
- Data from the file is only displayed in the plot if it matches the current settings in the Vertical Axis Group section the tool. Loading e.g. PID data in the Sweeper will not be shown, unless it is selected in the Control sub-tab.
- Files can only be loaded if the devices saving and loading data are of the same product family. The data path will be set according to the device ID loading the data.

Figure 5.9 illustrates the data loading feature.

Figure 5.9: History data loading feature. Here, the file sweep_00000.h5 is loaded by drag-and-drop. The loaded data are added to the measurements in the history list.

5.4.4. Supported File Formats

HDF5

Hierarchical Data File 5 (HDF5) is a widespread memory-efficient, structured, binary, open file format. Data in this format can be inspected using the dedicated viewer HDFview. HDF5 libraries or import tools are available for Python, MATLAB, LabVIEW, C, R, Octave, Origin, Igor Pro, and others. The following example illustrates how to access demodulator data from a sweep using the h5py library in Python:

```python
import h5py
filename = 'sweep_00000.h5'
f = h5py.File(filename, 'r')
x = f['000/dev3025/demods/0/sample/frequency']
```

The data loading feature of LabOne supports HDF5 files, while it is unavailable for other formats.

MATLAB

The MATLAB File Format (.mat) is a proprietary file format from MathWorks based on the open HDF5 file format. It has thus similar properties as the HDF5 format, but the support for importing .mat files into third-party software other than MATLAB is usually less good than that for importing HDF5 files.

SXM

SXM is a proprietary file format by Nanonis used for SPM measurements.

5.4.5. LabOne Net Link

Measurement and cursor data can be downloaded from the browser as CSV data. This allows for further processing in any application that supports CSV file formats. As the data is stored internally on the web server it can be read by direct server access from other applications. Most up-to-date

software supports data import from web pages or CSV files over the internet. This allows for automatic import and refresh of data sets in many applications. To perform the import the application needs to know the address from where to load the data. This link is supplied by the LabOne User Interface. The following chapter lists examples of how to import data into some commonly used applications.

The CSV data sent to the application is a snap-shot of the data set on the web server at the time of the request. Many applications support either manual or periodic refresh functionality.

Since tabs can be instantiated several times within the same user interface, the link is specific to the tab that it is taken from. Changing the session on the LabOne User Interface or removing tabs may invalidate the link.

Supported applications:

- Excel
- MATLAB
- Python
- C#.NET
- Igor Pro
- Origin

Excel

These instructions are for Excel 2010 (English). The procedure for other versions may differ.

1. In Excel, click on the cell where the data is to be placed. From the Data ribbon, click the "From Text" icon. The "Import Text File" dialog will appear.

2. In LabOne, click the "Link" button of the appropriate Math tab. Copy the selected text from the "LabOne Net Link" dialog to the clipboard (either with Ctrl-C or by right clicking and selecting "Copy").

3. In Excel, paste the link into the "File name" entry field of the "Import Text File" dialog and click the "Open" button. This will start the text import wizard. Ensure that the "Delimited" button is checked before clicking the "Next" button.

4. In the next dialog, select the delimiter character corresponding to that selected in LabOne (this can be found in the "Sessions" section of the Config tab). The default is semicolon. Click the "Next" button.

5. In the next dialog, click on "Finish" and then "OK" in the "Import Data" dialog. The data from the Math tab will now appear in the Excel sheet.

6. The data in the sheet can be updated by clicking the "Refresh All" icon. To make updating the data easier, the "Import text file" dialog can be suppressed by clicking on "Properties".

7. Deactivate the check box "Prompt for file name on refresh".

MATLAB

By copying the link text from the "LabOne Net Link" dialog to the clipboard, the following code snippet can be used in MATLAB to read the data.

```
textscan(urlread(clipboard('paste')),'%s%s%f%s%d%s%s','Headerlines',
4,'Delimiter', ';')
```

Python

The following code snippet can be used in Python 2 to read the LabOne Net Link data, where "url" is assigned to the text copied from the "LabOne Net Link" dialog.

```python
import csv
import urllib2
url = "http://127.0.0.1:8006/netlink?id=c0p5t6p1cfplotmath&ziSessionId=0"
webpage = urllib2.urlopen(url)
datareader = csv.reader(webpage)
data = []
for row in datareader:
    data.append(row)
```

C#.NET

The .NET Framework offers a WebClient object which can be used to send web requests to the LabOne WebServer and download LabOne Net Link data. The string with comma separated content can be parsed by splitting the data at comma borders.

```csharp
using System;
using System.Text;
using System.Net;

namespace ExampleCSV
{
  class Program
  {
    static void Main(string[] args)
    {
      try
      {
        WebClient wc = new WebClient();
        byte[] buffer = wc.DownloadData("http://127.0.0.1:8006/netlink?
id=c0p1t6p1cfplotmath&ziSessionId=0");
        String doc = Encoding.ASCII.GetString(buffer);
        // Parse here CSV lines and extract data
        // ...
        Console.WriteLine(doc);
      } catch (Exception e) {
        Console.WriteLine("Caught exception: " + e.Message);
      }
    }
  }
 }
```

Igor Pro

These instructions are for Igor Pro 6.34A English. The procedure for other versions may differ.

1. For Igor Pro, the CSV separator has to be the comma. Set this in the LabOne Config tab as follows:

2. In Igor Pro, select the menu "Data→Load Waves→Load Waves...".

3. In the "Load Waves" dialog, click the "File..." button and paste the link text from the "LabOne Net Link" dialog into the entry field. Then click the "Tweaks..." button to open the "Load Data Tweaks" dialog.

4. Adjust values as highlighted below and click "Return". The "Loading Delimited Data" dialog will appear.

5. Click the "Load" button to read the data.

6. The data will appear in the Igor Pro main window.

Origin

These instructions are for Origin 9.1 English. The procedure for other versions may differ.

1. Open the import wizard by clicking on the icon highlighted below.

2. Ensure that the ASCII button is selected. Click the "..." button. See screenshot below. The "Import Multiple ASCII" dialog will appear.

3. Paste the link text from the "LabOne Net Link" dialog into the entry field highlighted below. Then click "Add File(s)" followed by "OK".

4. Back in the "Import Wizard - Source" dialog click "Finish".

5. The data will appear in the Origin main window.

1. Among the mentioned tools, the Scope is exceptional: it displays the most recent acquisition, and its display color is fixed. However, the Persistence feature represents a more specialized functionality for multi-trace display. ↩

5.5. Lock-in Tab

This tab is the main lock-in amplifier control panel. Users with instruments with SHFLI-MF Multi-frequency option installed are kindly referred to Lock-in Tab (SHF-MF option)

5.5.1. Features

- Parameter table with main input, output and demodulator controls
- Control elements for 8 configurable demodulators
- Control for 2 oscillators
- Settings for main signal inputs and signal outputs

5.5.2. Description

The Lock-in tab is the main control center of the instrument and open by default after start up.

Whenever the tab is closed or an additional one of the same type is needed, clicking the following icon will open a new instance of the tab.

Table 5.9: App icon and short description

Control/ Tool	Option/ Range	Description
Lock-in	⊗⊟	Quick overview and access to all the settings and properties for signal generation and demodulation.

The Lock-in tab provides controls for all demodulators in the instrument.

The Lock-in tab (see Figure 5.10) consists of 4 vertical sections: Signal Inputs, Oscillators, Demodulators and Signal Outputs. The **Demodulator section** is divided horizontally into two identical groups. The upper group is tied to oscillator 1 (f_1) and channel 1 (c_1), while the lower group is

tied to oscillator 2 (f_2) and channel 2 (c_2). That means demodulators 1 to 4 (5 to 8) demodulate the signals from input 1 (2) at the center frequency of channel 1 (2), plus the frequency of oscillator 1 (2) times a multiplier n. Signal Input 1 and 2 are identical in all aspects, the same holds for the Signal Outputs 1 and 2, but each channel has its own independent center frequency.

Figure 5.10: LabOne User Interface Lock-in tab

The **Signal Inputs section** allows the user to define all settings relevant to the signal at the input such as input coupling, amplitude range, etc. On the right-hand side of the Lock-in tab the Signal Outputs section allows defining signal amplitudes and range values for the generated sinusoidal signal.

The "Freq Range" button toggles the input between baseband, in which no analog mixing occurs and the signal is digitized directly, and RF, in which the analog up- and down-mixing path is selected. The AC/DC button sets the coupling type: AC coupling has a high-pass cutoff frequency that can be used to block large DC signal components to prevent input signal saturation during amplification. This button is only active when in baseband (BB) mode, because RF mode is AC coupled by design.

The **Oscillator section** controls the frequencies of both internal oscillators. When the Mode indicator shows Manual, the user can define the oscillator frequency manually by typing a frequency value in the field.

We now discuss the Demodulators settings in more detail. The block diagram displayed in Figure 5.11 shows the main demodulator components and their interconnection. The understanding of the wiring is essential for successfully operating the instrument.

Figure 5.11: Demodulator block diagram without SHFLI-MF Multi-frequency option.

Every line in the Demodulators section represents one demodulator and all 4 demodulators in each group can be used to demodulate simultaneously the signal from their signal input, using different filter settings or at different harmonic frequencies of their oscillator within the channel's measurement window. Demodulation of frequencies that are at integer multiples of any of the oscillator frequencies is achieved by entering the desired factor in the "n" column; the demodulation frequency is then the oscillator frequency times the factor n plus the channel center frequency. The result of the demodulation, the amplitude and phase can be read, for instance, using the Numeric tab which is described in Numeric Tab.

In the center of the Lock-in tab is the Low-Pass Filters section where the filter order for each demodulator can be selected in the drop-down list and the filter bandwidth (BW 3dB) can be chosen by typing a numerical value. Alternatively, the time constant of the filter (TC) or the noise equivalent power filter bandwidth (BW NEP) can be chosen from the drop-down menu in the column's header. Each unit of the filter order correspond to a 6 dB/oct increase in the filter steepness; for example, setting the filter order to 4 corresponds to a roll off of 24 dB/oct or 80 dB/dec i.e. an attenuation of 10^4 for a tenfold frequency increase. If the Low-Pass Filter bandwidth is comparable to, or larger than the oscillator frequency (not the full demodulator frequency), the demodulator output may contain frequency components at the frequency of demodulation and its higher harmonics, when operating in baseband, or the component at the center of the measurement window (i.e. oscillator frequency =0). In this case, a smaller low-pass filter bandwidth is recommended, and the additional Sinc Filter should be enabled. The Sinc Filter is useful when measuring at low oscillator frequencies,

since it allows one to apply a Low-Pass Filter bandwidth closer to the oscillator frequency, thus speeding up the measurement time.

The transfer of demodulator output data is activated with the Enable button in the Data Transfer section where also the sampling rate (Rate) for each demodulator can be defined.

In the **Signal Outputs section** the On buttons are used to activate the Signal Outputs and remain available even when the Signal Outputs panel is collapsed. This is also the place where the output amplitudes for each of the Signal Outputs can be set in adjustable units (Vpk or Vrms). The Range drop-down list is used to select the proper output range setting.

5.5.3. Functional Elements

Note

Please note that some elements will be implemented in a future LabOne release. This is reflected in the description of these elements in the table below and also in the LabOne tooltips.

Table 5.10: Lock-in tab

Control/Tool	Option/ Range	Description
Frequency Range		Switch between RF and Baseband frequency range.
Center Frequency		Center frequency of the detection band at the input/output of the instrument.
Range		Defines the gain of the analog input amplifier. The range should exceed the incoming signal by roughly a factor two including a potential DC offset. The instrument selects the next higher available range relative to a value inserted by the user. A suitable choice of this setting optimizes the accuracy and signal-to-noise ratio by ensuring that the full dynamic range of the input ADC is used.
Auto	⧨	Automatic adjustment of the Range to about two times the maximum signal input amplitude measured over about 100 ms. It will be implemented in a future release.
Coupling	OFF: DC coupling	Defines the input coupling for the Signal Inputs. AC coupling inserts a high-pass filter.
	ON: AC coupling	
Mode		Indicates how the frequency of the corresponding oscillator is controlled (manual, external reference, PLL, PID). Read only flag.
	Manual	The user setting defines the oscillator frequency.
	ExtRef	An external reference is mapped onto the oscillator frequency.
Frequency (Hz)		Frequency control for each oscillator.
Locked	ON / OFF	Oscillator locked to external reference when turned on.
Mode		Select the reference mode (manual or external reference) or indicate the unit that uses the demodulator (e.g. PLL).
	Manual	Default lock-in operating mode with manually set reference frequency.
	ExtRef	The demodulator is used for external reference mode and tracks the frequency of the selected reference input. The demodulator bandwidth is set automatically to adapt to the signal properties.
Osc	oscillator index	Connects the selected oscillator with the demodulator corresponding to this line. Number of available oscillators depends on the installed options.
n	1 to 1023	Multiplies the demodulator's reference frequency with the integer factor defined by this field.

Control/Tool	Option/ Range	Description
Demod Freq (Hz)		Indicates the frequency used for demodulation and for output generation.
Phase (deg)	-180° to 180°	Phase shift applied to the reference input of the demodulator.
Zero	⊳◁	Adjust the phase of the demodulator reference automatically in order to read zero degrees at the demodulator output. This action maximizes the X output, zeros the Y output, zeros the Θ output, and leaves the R output unchanged.
Signal		Selects the signal source to be associated to the demodulator.
	Sig In 2	Signal Input 2 is connected to the corresponding demodulator.
	Sig In 1	Signal Input 1 is connected to the corresponding demodulator.
Order		Selects the filter roll off between 6 dB/oct and 48 dB/oct.
	1	1st order filter 6 dB/oct
	2	2nd order filter 12 dB/oct
	3	3rd order filter 18 dB/oct
	4	4th order filter 24 dB/oct
TC/BW Select		Defines the display unit of the low-pass filters: time constant (TC) in seconds, noise equivalent power bandwidth (BW NEP) in Hz, 3 dB bandwidth (BW 3 dB) in Hz.
	TC	Defines the low-pass filter characteristic using time constant (s) of the filter.
	BW NEP	Defines the low-pass filter characteristic using the noise equivalent power bandwidth (Hz) of the filter.
	BW 3 dB	Defines the low-pass filter characteristic using the 3 dB cut-off frequency (Hz) of the filter.
TC/BW Value	numeric value	Defines the low-pass filter characteristic in the unit defined above.
Sinc	ON / OFF	Enables the sinc filter. When the filter bandwidth is comparable to or larger than the demodulation frequency, the demodulator output may contain frequency components at the frequency of demodulation and its higher harmonics. The sinc is an additional filter that attenuates these unwanted components in the demodulator output.
Filter Lock	⟳	Makes all demodulator filter settings equal (order, time constant, bandwidth). Enabling the lock copies the settings from demodulator 1 to all other demodulators. With locked filters, any modification to a filter setting is applied to all other filters, too. Releasing the lock does not change any setting.
Enable Streaming	ON / OFF	Enables the data acquisition and streaming of demodulated samples to the host computer for the corresponding demodulator. The streaming rate is defined in the field on the right hand side. Enabling a stream activates a corresponding element in the numeric tab and allows for demodulated samples to be visualized and analyzed in any of the LabOne measurement tools. Note: increasing number of active demodulators increases load on physical connection to the host computer.

Control/Tool	Option/ Range	Description
Rate (Sa/s)		Defines the demodulator sampling rate, the number of samples that are sent to the host computer per second. A rate of about 7-10 higher as compared to the filter bandwidth usually provides sufficient aliasing suppression. This is also the rate of data received by LabOne Data Server and saved to the computer hard disk. This setting has no impact on the sample rate on the auxiliary outputs connectors. Note: the value inserted by the user may be approximated to the nearest value supported by the instrument.
Demodulator Sampling Rate Lock	⟳	Makes all demodulator sampling rates equal. Enabling the lock copies the settings from demodulator 1 to all other demodulators. With locked sampling rates, any modification to a sampling rate is applied to all other sampling rate fields, too. Releasing the lock does not change any setting.
Amplitude Unit	Vpk, Vrms	Select the unit of the displayed amplitude value.
Amplitude Enable	ON / OFF	Enables individual output signal amplitude.
Auto Range	⊠	Selects the most suited output range automatically. It will be implemented in a future release.
Output Clipping	grey/red	Indicates that the specified output amplitude(s) exceeds the range setting. Signal clipping occurs and the output signal quality is degraded. Adjustment of the range or the output amplitudes is required.
Offset	-range to range	Defines the DC voltage that is added to the dynamic part of the output signal.
On	ON / OFF	Main switch for the Signal Output corresponding to the blue LED indicator on the instrument front panel.
Range		Defines the maximum output voltage that is generated by the corresponding Signal Output. This includes the potential multiple Signal Amplitudes and Offsets summed up. Select the smallest range possible to optimize signal quality. This setting ensures that no levels or peaks above the setting are generated, and therefore it limits the values that can be entered as output amplitudes. Therefore selected output amplitudes are clipped to the defined range and the clipping indicator turns on. If 50 Ω target source or differential output is enabled the possible maximal output range will be half.
Amp 1/2	-range to range	Defines the output amplitude for each demodulator frequency as rms or peak-to-peak value. A negative amplitude value is equivalent to a phase change of 180 degree. Demodulator 4 is the signal source for Signal Output 1, demodulator 8 is the source for Signal Output 2.

5.6. Lock-in Tab (SHF-MF option)

This tab is the main lock-in amplifier control panel for SHFLI Instruments with the SHF-MF Multi-frequency option installed. Users with instruments without this option installed are kindly referred to Lock-in Tab.

5.6.1. Features

- Parameter table with main input, output and demodulator controls
- Controls for 8 individually configurable demodulators
- Control for 8 oscillators
- Settings for main signal inputs and signal outputs

5.6.2. Description

The Lock-in tab is the main control center of the instrument and open after start up by default. Whenever the tab is closed or an additional one of the same type is needed, clicking the following icon will open a new instance of the tab.

Table 5.11: App icon and short description

Control/ Tool	Option/ Range	Description
Lock-in MF	⊗⊟	Quick overview and access to all the settings and properties for signal generation and demodulation.

The lock-in tab provides controls for all demodulators in the instrument.

The lock-in tab for Multi-frequency SHFLI instruments`` (see Figure 5.12) consists of 5 vertical sections: Signal Inputs, Oscillators, Demodulators, Output 1 and Output 2. The **Demodulator section** contains 8 rows, each of them providing access to the settings of one dual phase demodulator. Every demodulator can be connected to any of the possible inputs, outputs and oscillators. Signal Input 1 and 2 are identical in all aspects, but each can be set to a different center frequency; the same holds for Signal Outputs 1 and 2. Each input and output pair constitutes a signal channel with a specific center frequency.

Figure 5.12: LabOne User Interface Lock-in tab with SHFLI-MF Multi-frequency option.

The **Signal Inputs section** allows the user to define all relevant settings specific to the signal at the input such as input coupling, amplitude range, etc. On the right-hand side of the Lock-in tab the two Output sections allow to define the individual tones amplitudes and the output range value.

The "Freq Range" button toggles the input between baseband, in which no analog mixing occurs and the signal is digitized directly, and RF, in which the analog up- and down-mixing path is selected. The AC/DC button sets the coupling type: AC coupling has a high-pass cutoff frequency that can be used to block large DC signal components to prevent input signal saturation during amplification. This button is only active when in baseband (BB) mode, because RF mode is AC coupled by design.

The **Oscillator section** controls the frequencies of all 8 internal oscillators. Where the Mode indicator shows Manual the user can define the oscillator frequency manually defined by typing a frequency value in the field.

The next section contains the Demodulators settings. The block diagram displayed in Figure 5.13 indicates the main demodulator components and their interconnection. The understanding of the wiring is essential for successfully operating the instrument.
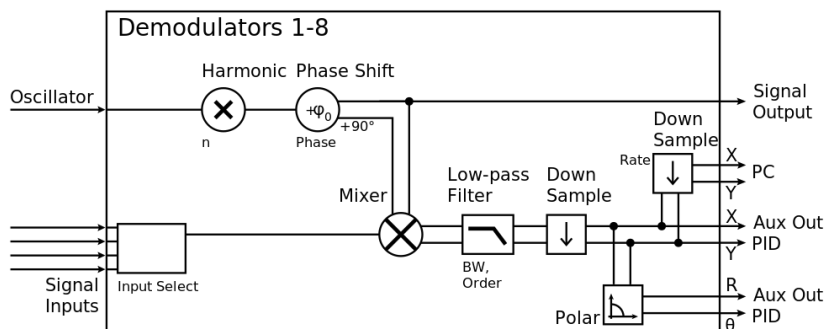

Figure 5.13: Demodulator block diagram with SHFLI-MF Multi-frequency option.

Every line in the Demodulators section represents one demodulator. It is possible to demodulate the input signals with up to 8 demodulators simultaneously at up to 8 independent frequencies and using different filter settings.

In the Input Signal column one defines the signal that is taken as input for the demodulator. Currently Input 1 and Input 2 can be selected, but in the future more sources will be made available, such as Auxiliary Inputs and Outputs.

Demodulation of frequencies that are at integer multiples of any of the oscillator frequencies is achieved by entering the desired factor in the "n" column; the demodulation frequency is then the oscillator frequency times the factor n plus the channel center frequency. The result of the demodulation, the amplitude and phase can be read, for instance, using the Numeric tab which is described in Numeric Tab.

In the center of the Lock-in tab is the Low-Pass Filters section where the filter order for each demodulator can be selected in the drop-down list and the filter bandwidth (BW 3dB) can be chosen by typing a numerical value. Alternatively the time constant of the filter (TC) or the noise equivalent power filter bandwidth (BW NEP) can be chosen from the drop-down menu in the column's header. Each unit of the filter order correspond to a 6 dB/oct increase in the filter steepness; for example, setting the filter order to 4 corresponds to a roll off of 24 dB/oct or 80 dB/dec i.e. an attenuation of 10^4 for a tenfold frequency increase. If the Low-Pass Filter bandwidth is comparable to or larger than the oscillator frequency (not the full demodulator frequency), the demodulator output may contain frequency components at the frequency of demodulation and its higher harmonics, when operating in baseband, or the component at the center of the measurement window (i.e. oscillator frequency =0). In this case, a smaller low-pass filter bandwidth is recommended, and the additional Sinc Filter should be enabled. The Sinc Filter is useful when measuring at low oscillator frequencies, since it allows one to apply a Low-Pass Filter bandwidth closer to the oscillator frequency, thus speeding up the measurement time

The data transfer of demodulator outputs is activated by the Enable button in the Data Transfer section where also the sampling rate (Rate) for each demodulator can be defined.

The 2 **Output sections** are only available on Instruments with the SHFLI-MF option installed. They allow for the flexible adjustment of output amplitudes of different demodulators and their summation on either Signal Output 1 or Signal Output 2. In order to avoid signal clipping the sum of the amplitudes of each signal output needs to be smaller than the range defined in the the corresponding Output section. At the top of each Output section one can select the format in which amplitudes are displayed in that section between root mean square values or peak-to-peak values.

In the top right-hand-side corner of each **Output section** the On button turns on or off the corresponding physical output. Even when the Output panel is collapsed, the On button remains available. The Range drop down list is used to select the proper output range setting for each channel.

5.6.3. Functional Elements

Note

Please note that some elements will be implemented in a future LabOne release. This is reflected in the description of these elements in the table below and also in the LabOne tooltips.

Table 5.12: Lock-in MF tab

Control/Tool	Option/ Range	Description
Frequency Range		Switch between RF and Baseband frequency range.
Center Frequency		Center frequency of the detection band at the input/output of the instrument.
Range		Defines the gain of the analog input amplifier. The range should exceed the incoming signal by roughly a factor two including a potential DC offset. The instrument selects the next higher available range relative to a value inserted by the user. A suitable choice of this setting optimizes the accuracy and signal-to-noise ratio by ensuring that the full dynamic range of the input ADC is used.
Auto	⧖	Automatic adjustment of the Range to about two times the maximum signal input amplitude measured over about 100 ms. It will be implemented in a future release.

Control/Tool	Option/ Range	Description
Coupling	OFF: DC coupling	Defines the input coupling for the Signal Inputs. AC coupling inserts a high-pass filter.
	ON: AC coupling	
Mode		Indicates how the frequency of the corresponding oscillator is controlled (manual, external reference, PLL, PID). Read only flag.
	Manual	The user setting defines the oscillator frequency.
	ExtRef	An external reference is mapped onto the oscillator frequency.
Frequency (Hz)		Frequency control for each oscillator.
Locked	ON / OFF	Oscillator locked to external reference when turned on.
Mode		Select the reference mode (manual or external reference) or indicate the unit that uses the demodulator (e.g. PLL).
	Manual	Default lock-in operating mode with manually set reference frequency.
	ExtRef	The demodulator is used for external reference mode and tracks the frequency of the selected reference input. The demodulator bandwidth is set automatically to adapt to the signal properties.
Osc	oscillator index	Connects the selected oscillator with the demodulator corresponding to this line. Number of available oscillators depends on the installed options.
Harm	1 to 1023	Multiplies the demodulator's reference frequency with the integer factor defined by this field.
Demod Freq (Hz)		Indicates the frequency used for demodulation and for output generation.
Phase (deg)	-180° to 180°	Phase shift applied to the reference input of the demodulator.
Zero	▷◁	Adjust the phase of the demodulator reference automatically in order to read zero degrees at the demodulator output. This action maximizes the X output, zeros the Y output, zeros the Θ output, and leaves the R output unchanged.
Signal		Selects the signal source to be associated to the demodulator.
	Sig In 2	Signal Input 2 is connected to the corresponding demodulator.
	Sig In 1	Signal Input 1 is connected to the corresponding demodulator.
Order		Selects the filter roll off between 6 dB/oct and 48 dB/oct.
	1	1st order filter 6 dB/oct
	2	2nd order filter 12 dB/oct
	3	3rd order filter 18 dB/oct
	4	4th order filter 24 dB/oct
TC/BW Select		Defines the display unit of the low-pass filters: time constant (TC) in seconds, noise equivalent power bandwidth (BW NEP) in Hz, 3 dB bandwidth (BW 3 dB) in Hz.
	TC	Defines the low-pass filter characteristic using time constant (s) of the filter.
	BW NEP	Defines the low-pass filter characteristic using the noise equivalent power bandwidth (Hz) of the filter.
	BW 3 dB	Defines the low-pass filter characteristic using the 3 dB cut-off frequency (Hz) of the filter.
TC/BW Value	numeric value	Defines the low-pass filter characteristic in the unit defined above.

Control/Tool	Option/Range	Description
Sinc	ON / OFF	Enables the sinc filter. When the filter bandwidth is comparable to or larger than the demodulation frequency, the demodulator output may contain frequency components at the frequency of demodulation and its higher harmonics. The sinc is an additional filter that attenuates these unwanted components in the demodulator output.
Filter Lock	⟳	Makes all demodulator filter settings equal (order, time constant, bandwidth). Enabling the lock copies the settings from demodulator 1 to all other demodulators. With locked filters, any modification to a filter setting is applied to all other filters, too. Releasing the lock does not change any setting.
Enable Streaming	ON / OFF	Enables the data acquisition and streaming of demodulated samples to the host computer for the corresponding demodulator. The streaming rate is defined in the field on the right hand side. Enabling a stream activates a corresponding element in the numeric tab and allows for demodulated samples to be visualized and analyzed in any of the LabOne measurement tools. Note: increasing number of active demodulators increases load on physical connection to the host computer.
Rate (Sa/s)		Defines the demodulator sampling rate, the number of samples that are sent to the host computer per second. A rate of about 7-10 higher as compared to the filter bandwidth usually provides sufficient aliasing suppression. This is also the rate of data received by LabOne Data Server and saved to the computer hard disk. This setting has no impact on the sample rate on the auxiliary outputs connectors. Note: the value inserted by the user may be approximated to the nearest value supported by the instrument.
Demodulator Sampling Rate Lock	⟳	Makes all demodulator sampling rates equal. Enabling the lock copies the settings from demodulator 1 to all other demodulators. With locked sampling rates, any modification to a sampling rate is applied to all other sampling rate fields, too. Releasing the lock does not change any setting.
Amplitude Unit	Vpk, Vrms	Select the unit of the displayed amplitude value.
Amplitude Enable	ON / OFF	Enables individual output signal amplitude.
Amplitude (V)	-range to range	Defines the output amplitude for each demodulator frequency as rms or peak-to-peak value. A negative amplitude value is equivalent to a phase change of 180 degree. Linear combination of multiple amplitude settings on the same output are clipped to the range setting. Note: the value inserted by the user may be approximated to the nearest value supported by the Instrument.
Auto Range	⧖	Selects the most suited output range automatically. It will be implemented in a future release.
Output Clipping	grey/red	Indicates that the specified output amplitude(s) exceeds the range setting. Signal clipping occurs and the output signal quality is degraded. Adjustment of the range or the output amplitudes is required.
Offset	-range to range	Defines the DC voltage that is added to the dynamic part of the output signal.
On	ON / OFF	Main switch for the Signal Output corresponding to the blue LED indicator on the instrument front panel.

Control/Tool	Option/ Range	Description
Range		Defines the maximum output voltage that is generated by the corresponding Signal Output. This includes the potential multiple Signal Amplitudes and Offsets summed up. Select the smallest range possible to optimize signal quality. This setting ensures that no levels or peaks above the setting are generated, and therefore it limits the values that can be entered as output amplitudes. Therefore selected output amplitudes are clipped to the defined range and the clipping indicator turns on. If 50 Ω target source or differential output is enabled the possible maximal output range will be half.

5.7. PID / PLL Tab

The PID / PLL tab is only available if the SHFLI-PID Quad PID/PLL Controller option is installed on the SHFLI Lock-in Amplifier (the installed options are displayed in the Device tab).

Note

The feedback controllers provide general-purpose PID functionality, phase-locked loop (PLL) functionality, and External Reference functionality. When the user sets one of the demodulators to ExtRef mode (see Lock-in tab, Demodulators section, Mode column), one of the PID controllers will be reserved for that purpose.

Note

Some settings in the PID / PLL tab are interdependent with settings that are accessible from other tabs. If the PID output controls a certain variable, e.g. Signal Output Offset, this variable will be shown as read-only where it appears in other tabs (i.e. in the Lock-in tab for this case).

5.7.1. Features

- Four fully programmable proportional, integral, derivative (PID) controllers
- Two fully programmable 1.8 GHz phased-locked loops
- Input parameters: demodulated phase, amplitude, X & Y
- Output parameters: output amplitudes, oscillator frequencies, demodulator phase
- Phase unwrap for demodulator Θ data (± 1024 π), e.g. for optical phase-locked loops
- Bandwidth limit for the derivative (D) feedback component
- Programmable PLL center frequency and phase setpoint
- Programmable PLL phase detector filter settings
- Generation of sub-multiple frequencies by use of harmonic multiplication factor

5.7.2. Description

The PID / PLL tab is the main control center for the feedback loop controllers in the instrument. Whenever the tab is closed or an additional one of the same type is needed, clicking the following icon will open a new instance of the tab.

Table 5.13: App icon and short description

Control/ Tool	Option/ Range	Description
PID		Features all control, analysis, and simulation capabilities of the PID controllers.

The PID / PLL tab (see LabOne UI: PID / PLL tab) consists of four identical side-tabs, each of them providing access to the functionality of one of the four PID / PLL controllers and the associated PID Advisor.

Note

Please note that the PID Advisor will be enabled in a future LabOne release.

Figure 5.14: LabOne UI: PID / PLL tab

With their variety of different input and output connections, the LabOne PID controllers are extremely versatile and can be used in a wide range of different applications including microwave resonator characterization and control, laser locking or high-speed SPM. Figure 5.15 shows a block diagram of all PID controller components, their interconnections and the variables to be specified by the user.

Figure 5.15: PID controller block diagram

Setting up a Control Loop

Depending on the application there are a number of ways to set up a control loop. To learn the core principles of Proportional-Integral-Derivative (PID) Controllers you can visit Zurich Instruments YouTube channel and watch the following video:

Principles of PID Controllers

Manual Setup

In cases where the transfer function of the device under test (DUT) is unknown and only little noise couples into the system from the environment, a manual approach is often the quickest way to get going. For manual configuration of a new control loop it is recommended to start with a small value for P and set the other parameters (I, D, D Limit) to zero. By enabling the controller one will then immediately see if the sign of P is correct and if the feedback is acting on the correct output parameter. For instance, by checking the numbers (Error, Shift, Out) displayed in the PID / PLL tab. A stepwise increase of the integral gain, I, will then help to zero the PID error signal completely. Enabling the derivative gain, D, can increase the speed of the feedback loop, but it can also cause an instable feedback loop behavior which sometimes can be mitigated by activating the associated low-pass filter.

5.7.3. Functional Elements

Table 5.14: PID tab: PID section

Control/ Tool	Option/ Range	Description
Enable	ON / OFF	Enable the PID controller
Mode		Operation mode of the PID module.
	PID	The PID is used for a general application.
	PLL	The PID is used to control an internal oscillator.
	ExtRef	The PID is used by the external reference to control an internal oscillator.
Auto Mode		This defines the type of automatic adaptation of parameters in the PID.
	Off	No automatic adaptation.
	PID Coeff	The coefficients of the PID controller are automatically set.
	Coeff + BW (low)	The PID coefficients, the filter bandwidth and the output limits are automatically set using a low bandwidth.
	Coeff + BW (high)	The PID coefficients, the filter bandwidth and the output limits are automatically set using a high bandwidth.
	Adaptive	All parameters of the PID including the center frequency are adapted.
Input		Select input source of PID controller
	Demodulator X	Demodulator cartesian X component
	Demodulator Y	Demodulator cartesian Y component
	Demodulator R	Demodulator magnitude component
	Demodulator Theta	Demodulator phase
Input Channel	index	Select input channel of PID controller.
Setpoint	numeric value	PID controller setpoint
Phase Unwrap	ON / OFF	Enables the phase unwrapping to track phase errors past the +/-180 degree boundary and increase PLL bandwidth.
Filter BW	numeric value	Bandwidth of the demodulator filter used as an input.
Filter Order		Selects the filter roll off between 6 dB/oct and 48 dB/oct of the current demodulator.
	1	1st order filter 6 dB/oct
	2	2nd order filter 12 dB/oct
	3	3rd order filter 18 dB/oct
	4	4th order filter 24 dB/oct
Harmonic	1 to 1023	Multiplier of the for the reference frequency of the current demodulator.
Output		Select output of the PID controller
	Sig Out 1 Amplitude	Feedback to the main signal output amplitude 1
	Sig Out 2 Amplitude	Feedback to the main signal output amplitude 2
	Oscillator Frequency	Feedback to any of the internal oscillator frequencies

Control/ Tool	Option/ Range	Description
Output Channel	index	Select output channel of PID controller.
Center	numeric value	After adding the Center value to the PID output, the signal is clamped to Center + Lower Limit and Center + Upper Limit.
Lower Limit	numeric value	After adding the Center value to the PID output, the signal is clamped between Center - Lower Limit, and Center + Upper Limit.
Upper Limit	numeric value	After adding the Center value to the PID output, the signal is clamped between Center - Lower Limit, and Center + Upper Limit.
P (Hz/deg)	numeric value	PID proportional gain P
I (Hz/deg/s)	numeric value	PID integral gain I
D (Hz/ deg*s)	numeric value	PID derivative gain D
D Limit TC/ BW 3 dB		The cutoff of the low-pass filter for the D limitation, shown as either the filter time constant or the 3 dB cutoff frequency, depending on the selected TC mode. When set to 0, the low-pass filter is disabled.
Rate		PID sampling rate and update rate of PID outputs. Needs to be set substantially higher than the targeted loop filter bandwidth. The numerical precision of the controller is influenced by the loop filter sampling rate. If the target bandwidth is below 1 kHz is starts to make sense to adjust this rate to a value of about 100 to 500 times the target bandwidth. If the rate is set too high for low bandwidth applications, integration inaccuracies can lead to non linear behavior.
Error	numeric value	Error = Set point - PID Input
Lock LED	grey/green	Indicates when the PID (configured as PLL) is locked. The PLL error is sampled at 5 Sa/s and its absolute value is calculated. If the result is smaller than 5 degrees the loop is considered locked. Only works if mode is PLL or ExtRef.
Shift	numeric value	Difference between the current output value Out and the Center. Shift = P*Error + I*Int(Error, dt) + D*dError/dt
Value	numeric value	Current output value
To Advisor	To Advisor	Copy the current PID settings to the PID Advisor.

5.8. Numeric Tab

The Numeric tab provides a powerful time domain based measurement display as introduced in Unique Set of Analysis Tools. It is available on all SHFLI instruments.

5.8.1. Features

- Display of demodulator output data
- Graphical and numerical range indicators
- Polar and Cartesian formats
- Support for Input Scaling and Input Units

5.8.2. Description

The Numeric tab serves as the main numeric overview display of multiple measurement data. The display can be configured by both choosing the values displayed and also rearrange the display tiles by drag-and-drop. Whenever the tab is closed or an additional one of the same type is needed, clicking the following icon will open a new instance of the tab.

Table 5.15: App icon and short description

Control/ Tool	Option/ Range	Description
Numeric	0.058	Access to all continuously streamed measurement data as numerical values.

The numeric tab (see Figure 5.16) is divided into a display section on the left and a configuration section on the right. The configuration section is further divided into a number of sub-tabs.

Figure 5.16: LabOne UI: Numeric tab

The numeric tab can be deployed to display the demodulated signal, phase, frequency as well as the signal levels at the auxiliary inputs. By default, the user can display the demodulated data either in polar coordinates (R, Θ) or in Cartesian coordinates (X, Y) which can be toggled using the presets. To display other measurement quantities as available from any of the presets simply click on the tree tab next to the preset tab. The desired display fields can be selected under each demodulator's directory tree structure.

5.8.3. Functional Elements

Table 5.16: Numeric tab: Presets sub-tab

Control/ Tool	Option/Range	Description
Select a Preset		Select numerical view based on a preset. Alternatively, the displayed value may also selected based on tree elements.
	Demods Polar	Shows R and Phase of all demodulators.
	Enabled Demods Polar	Shows R and Phase of enabled demodulators.
	Demods Cartesian	Shows X and Y of all demodulators.
	Enabled Demods Cartesian	Shows X and Y of enabled demodulators.
	Demods R	Shows R of all demodulators.
	Unpopulated	Shows no signals.
	Manual	If additional signals are added or removed the active preset gets manual.

For the Tree sub-tab please see the section called "Tree Selector".

Table 5.17: Numeric tab: Settings sub-tab

Control/ Tool	Option/ Range	Description
Name	text label	Name of the selected plot(s). The default name can be changed to reflect the measured signal.
Mapping		Mapping of the selected plot(s)
	Lin	Enable linear mapping.
	Log	Enable logarithmic mapping.
	dB	Enable logarithmic mapping in dB.

Control/ Tool	Option/ Range	Description
Scaling	Manual/Full Scale	Scaling of the selected plot(s)
Zoom To Limits	▷◁	Adjust the zoom to the current limits of the displayed histogram data.
Start Value	numeric value	Start value of the selected plot(s). Only visible for manual scaling.
Stop Value	numeric value	Stop value of the selected plot(s). Only visible for manual scaling.

5.9. Plotter Tab

The Plotter is one of the powerful time-domain measurement tools as introduced in Unique Set of Analysis Tools and is available on all SHFLI instruments.

5.9.1. Features

- Plotting of all streamed data, e.g. demodulator data, auxiliary inputs, auxiliary outputs, etc.
- Vertical axis grouping for flexible axis scaling
- Polar and Cartesian data format
- Histogram and Math functionality for data analysis
- 4 cursors for data analysis
- Support for Input Scaling and Input Units

5.9.2. Description

The Plotter serves as graphical display for time domain data in a roll mode, i.e. continuously without triggering. Whenever the tab is closed or an additional one of the same type is needed, clicking the following icon will open a new instance of the tab.

Table 5.18: App icon and short description

Control/ Tool	Option/ Range	Description
Plotter		Displays various continuously streamed measurement data as traces over time (roll mode).

The Plotter tab (see Figure 5.17) is divided into a display section on the left and a configuration section on the right.

Figure 5.17: LabOne UI: Plotter tab

The Plotter can be used to monitor the evolution of demodulated data and other streamed data continuously over time. Just as in the numeric tab any continuously streamed quantity can be displayed, for instance R, Θ, X, Y, frequency, and others. New signals can be added by either using the presets in the Control sub-tab or by going through the tree and selecting the signals of interest in the tree structure. The vertical and horizontal axis can be displayed in Lin, Log or dB scale. The Plotter display can be zoomed in and out with the magnifier symbols, or through Man (Manual), Auto (Automatic) and FS (Full Scale) button settings (see also Plot Functionality. The maximum duration data is kept in the memory can be defined through the window length parameter in the Settings sub-tab. The window length also determines the file size for the Record Data functionality.

Note

Setting the window length to large values when operating at high sampling rates can lead to memory problems at the computer hosting the data server.

The sampling rate of the demodulator data is determined by the Rate value in Sa/s set in the Lock-in tab . The Plotter data can be continuously saved to disk by clicking the record button in the Config tab which will be indicated by a green Recording (REC) LED in the status bar. See Saving and Loading Data for more information on data saving.

5.9.3. Functional Elements

Table 5.19: Plotter tab: Control sub-tab

Control/ Tool	Option/Range	Description
Run/Stop	Run/Stop	Start and stop continuous data plotting (roll mode)
Select a Preset		Select a pre-defined group signals. A signal group is defined by a common unit and signal type. They should have the same scaling behavior as they share a y-axis. Split a group if the signals have different scaling properties.
	Enabled Demods R	Selects the amplitude of all enabled demodulators.
	Enabled Demods Cartesian	Selects X and Y of all enabled demodulators.
	Enabled Demods Polar	Selects amplitude and phase of all enabled demodulators.
	Unpopulated	Shows no signals.
	Manual	Selects the signals as defined in the tree sub-tab.

For the Vertical Axis Groups, please see the table "Vertical Axis Groups description" in the section called "Vertical Axis Groups".

For the Math sub-tab please see the table "Plot math description" in the section called "Cursors and Math".

5.10. Scope Tab

The Scope is a powerful time domain and frequency domain measurement tool as introduced in Unique Set of Analysis Tools and is available on all SHFLI instruments.

5.10.1. Features

- Two input channels
- 14 bit nominal resolution
- Fast Fourier Transform (FFT): up to 2 GHz span (800 MHz in baseband), spectral density and power conversion, choice of window functions

5.10.2. Description

The Scope tab serves as the graphical display for time domain data. Whenever the tab is closed or an additional one of the same type is needed, clicking the following icon will open a new instance of the tab.

Table 5.20: App icon and short description

Control/ Tool	Option/ Range	Description
Scope		Displays shots of data samples in time and frequency domain (FFT) representation.

Figure 5.18: LabOne UI: Scope tab - Time domain

The Scope tab consists of a plot section on the left and a configuration section on the right. The configuration section is further divided into a number of sub-tabs. It gives access to a single-channel oscilloscope that can be used to monitor a choice of signals in the time or frequency domain. Hence the X axis of the plot area is time (for time domain display, Figure 5.18) or frequency (for frequency domain display, Figure 5.20). It is possible to display the time trace and the associated FFT simultaneously by opening a second instance of the Scope tab.

The Scope records data from a single channel at up to 2 GSa/s. The channel can be selected among the two Signal Inputs. The Scope records data sets of up to 64'000 samples.

The product of the inverse sampling rate and the number of acquired points (Length) determines the total recording time for each shot. Hence, longer time intervals can be captured by reducing the sampling rate. The Scope can perform sampling rate reduction either using decimation or BW Limitation as illustrated in Figure 5.19. BW Limitation is activated by default, but it can be deactivated in the Advanced sub-tab. The figure shows an example of an input signal at the top, followed by the Scope output when the highest sample rate of 2 GSa/s is used. The next signal shows the Scope output when a rate reduction by a factor of 4 (i.e. 500 MSa/s) is configured and the rate reduction method of decimation is used. For decimation, a rate reduction by a factor of N is performed by only keeping every N^{th} sample and discarding the rest. The advantage of this method is its simplicity, but the disadvantage is that the signal is undersampled because the input filter bandwidth of the SHFLI instrument is fixed at 1 GHz. As a consequence, the Nyquist sampling criterion is no longer satisfied and aliasing effects may be observed. The default rate reduction mechanism of BW Limitation is illustrated by the lowermost signal in the figure. BW Limitation means that for a rate reduction by a factor of N, each sample produced by the Scope is computed as the average of N samples acquired at the maximum sampling rate. The effective signal bandwidth is thereby reduced and aliasing effects are largely suppressed. As can be seen from the figure, with a rate reduction by a factor of 4, every output sample is simply computed as the average of 4 consecutive samples acquired at 2 GSa/s.

Figure 5.19: Illustration of how the Scope output is generated in BW Limitation and decimation mode when the sampling rate is reduced from the default of 2 GSa/s to 500 MSa/s

Important

When operating in RF mode, the SHFLI's Scope shows two traces per channel in the time domain, labeled I and Q. This is because it visualizes the data coming from the frequency mixing stage, which is composed of an in-phase and a quadrature component, similar to the data from the demodulators. In the frequency domain, this corresponds to a spectrum with symmetrical positive and negative frequencies centered around the channel's center frequency.

The frequency domain representation is activated in the Control sub-tab by selecting Freq Domain FFT as the Horizontal Mode. It allows the user to observe the spectrum of the acquired shots of samples. All controls and settings are shared between the time domain and frequency domain representations.

The Scope supports averaging over multiple shots. The functionality is implemented by means of an exponential moving average filter with configurable filter depth. Averaging helps to suppress noise components that are uncorrelated with the main signal. It is particularly useful in combination with the Frequency Domain FFT mode where it can help to reveal harmonic signals and disturbances that might otherwise be hidden below the noise floor.

Figure 5.20: LabOne UI: Scope tab - Frequency domain

The Trigger sub-tab offers all the controls necessary for triggering on different signal sources. When the trigger is enabled, then oscilloscope shots are acquired whenever the trigger conditions are met. Trigger and Hysteresis levels can be indicated graphically in the plot. A disabled trigger is equivalent to continuous oscilloscope shot acquisition.

5.10.3. Functional Elements

Table 5.21: Scope tab: Control sub-tab

Control/ Tool	Option/ Range	Description
Single	**Single**	Acquires a single shot of samples.
Channel 1/2	[icon]	Selects the signal source for the corresponding scope channel. Navigate through the tree view that appears and click on the required signal. Note: Channel 2 requires the DIG option.
Enable	ON / OFF	Activates the display of the corresponding scope channel. Note: Channel 2 requires the DIG option.
Run/Stop	**Run/Stop**	Runs the scope/FFT continuously.
Mode	Freq Domain (FFT)	Switches between time and frequency domain display.
	Time Domain	
Sampling Rate	916 Sa/s to 60 MSa/s	Defines the sampling rate of the scope. The numeric values are rounded for display purposes. The exact values are equal to the base sampling rate divided by 2^n, where n is an integer.
Sampling Rate		Defines the sampling rate of the scope. The numeric values are rounded for display purposes. The exact values are equal to the base sampling rate divided by 2^n, where n is an integer. Warning: Due to the lack of sample averaging feature, reduced sampling rates can cause aliasing and thus artifacts in the signal spectrum. Currently, the Scope tool only supports sample decimation, but in the future it will also offer sample averaging.
Average Filter		Enable Exponential Moving Average (EMA) filter that is applied when the average of several scope shots is computed and displayed. Depending on the mode, the source data for averaging is either the Time or the Freq FFT trace.
	Off	Averaging is turned off.
	On	Consecutive scope shots are averaged with an exponential weight.
Averages	integer value	The number of shots required to reach 63% settling. Twice the number of shots yields 86% settling.
Reset	**R**	Resets the averaging filter.

For the Vertical Axis Groups, please see the table "Vertical Axis Groups description" in the section called "Vertical Axis Groups".

Table 5.22: Scope tab: Trigger sub-tab

Control/ Tool	Option/ Range	Description
Enable	ON / OFF	When triggering is enabled scope data are acquired every time the defined trigger condition is met. If disabled, scope shots are acquired continuously.
Segments	1 to 32768	Specifies the number of segments to be recorded in device memory. The maximum scope shot size is given by the available memory divided by the number of segments. This functionality requires the DIG option.
Shown Trigger	integer value	Displays the number of triggered events since last start.

Table 5.23: Scope tab: Advanced sub-tab

Control/ Tool	Option/ Range	Description
FFT Window	Cosine squared (ring-down)	Several different FFT windows to choose from. Each window function results in a different trade-off between amplitude accuracy and spectral leakage. Please check the literature to find the window function that best suits your needs.
	Rectangular	
	Hann	
	Hamming	

Control/ Tool	Option/ Range	Description
	Blackman Harris	
	Flat Top	
	Exponential (ring-down)	
	Cosine (ring-down)	
Resolution (Hz)	mHz to Hz	Spectral resolution defined by the reciprocal acquisition time (sample rate, number of samples recorded).
Absolute Frequency	ON / OFF	Shifts x-axis labeling to show the absolute frequency in the center as opposed to 0 Hz, when turned off.
Spectral Density	ON / OFF	Calculate and show the spectral density. If power is enabled the power spectral density value is calculated. The spectral density is used to analyze noise.
Power	ON / OFF	Calculate and show the power value. To extract power spectral density (PSD) this button should be enabled together with Spectral Density.
Persistence	ON / OFF	Keeps previous scope shots in the display. The color scheme visualizes the number of occurrences at certain positions in time and amplitude by a multi-color scheme.
BW Limit		Selects between sample decimation and sample averaging. Averaging avoids aliasing, but may conceal signal peaks.
	OFF	Selects sample decimation for sample rates lower than the maximal available sampling rate.
	ON	Selects sample averaging for sample rates lower than the maximal available sampling rate.
Rate		Streaming rate of the scope channels. The streaming rate can be adjusted independent from the scope sampling rate. The maximum rate depends on the interface used for transfer. Note: scope streaming requires the DIG option.

Table 5.24: Scope tab: History sub-tab

Control/ Tool	Option/ Range	Description
History	History	Each entry in the list corresponds to a single trace in the history. The number of traces displayed in the plot is limited to 20. Use the toggle buttons to hide or show individual traces. Use the color picker to change the color of a trace in the plot. Double click on a list entry to edit its name.
Length	integer value	Maximum number of records in the history. The number of entries displayed in the list is limited to the 100 most recent ones.
Clear All	Clear All	Remove all records from the history list.
Clear	Clear	Remove selected records from the history list.
Load file		Load data from a file into the history. Loading does not change the data type and range displayed in the plot, this has to be adapted manually if data is not shown.
Name		Enter a name which is used as a folder name to save the history into. An additional three digit counter is added to the folder name to identify consecutive saves into the same folder name.

Control/ Tool	Option/ Range	Description
Auto Save		Activate autosaving. When activated, any measurements already in the history are saved. Each subsequent measurement is then also saved. The autosave directory is identified by the text "autosave" in the name, e.g. "sweep_autosave_001". If autosave is active during continuous running of the module, each successive measurement is saved to the same directory. For single shot operation, a new directory is created containing all measurements in the history. Depending on the file format, the measurements are either appended to the same file, or saved in individual files. For HDF5 and ZView formats, measurements are appended to the same file. For MATLAB and SXM formats, each measurement is saved in a separate file.
File Format		Select the file format in which to save the data.
Save	Save	Save the traces in the history to a file accessible in the File Manager tab. The file contains the signals in the Vertical Axis Groups of the Control sub-tab. The data that is saved depends on the selection from the pull-down list. Save All: All traces are saved. Save Sel: The selected traces are saved.

For the Math sub-tab please see the table "Plot math description" in the section called "Cursors and Math".

5.11. Data Acquisition Tab

The Data Acquisition tool is one of the powerful time domain measurement tools as introduced in Unique Set of Analysis Tools and is available on all SHFLI instruments . This tab used to be named Software Trigger tab in previous versions of the LabOne software.

5.11.1. Features

- Time-domain and frequency domain display for all continuously streamed data
- Capture and color scale display of imaging data
- Frame averaging and pixel interpolation
- Automatic trigger level determination
- Display of multiple traces
- Adjustable record history
- Mathematical toolkit for signal analysis

5.11.2. Description

The Data Acquisition tab features display and recording of shot-wise and imaging data sets upon a trigger event. Whenever the tab is closed or an additional one of the same type is needed, clicking the following icon will open a new instance of the tab.

Table 5.25: App icon and short description

Control/ Tool	Option/ Range	Description
DAQ	⊓	Provides complex trigger functionality on all continuously streamed data samples and time domain display.

The Data Acquisition tab (see Figure 5.21) is divided into a display section on the left and a configuration section on the right. The configuration section is further divided into a number of sub-tabs.

Figure 5.21: LabOne UI: Data Acquisition tab

The Data Acquisition tool brings the trigger functionality of a scope with FFT capability to the demodulator signals and other streamed data. The user can choose between a variety of different trigger and display options in the time and frequency domain.

Use the **Control** sub-tab to configure which signals are measured, both in time and in frequency domain. Measurement signals can be added to the Vertical Axis Groups section as described in Vertical Axis Groups. There is one vertical axis group for each the time domain and the frequency domain data.

The trigger condition is configured in the **Settings** sub-tab. Among the selection of Trigger Types provided here, Edge and Pulse are applicable to analog trigger sources such as demodulator data, auxiliary voltages, or oscillator frequencies. The trigger time resolution is enhanced above the sampling rate of the analog data by using interpolation. Instead of manually setting a Trigger Level, you can click on **Find** to have LabOne find a value by analyzing the data stream. In case of noisy trigger sources, both the Bandwidth and the Hysteresis setting can help preventing false trigger events. The Bandwidth setting provides a configurable low-pass filter applied to the trigger source. When enabling this function, be sure to choose a sufficiently high bandwidth to resolve the signal feature that should be triggered upon, i.e., the signal edge or pulse. The Bandwidth setting does not affect the recorded data.

For trigger sources with a slowly varying offset, the Tracking Edge and Tracking Pulse Trigger Types provide continuous adjustment of the Level and Hysteresis. In Tracking mode, the Bandwidth setting plays a different role than for the Edge and Pulse trigger types. Here, the Bandwidth should be chosen sufficiently low to filter out all fast features and only let pass the slow offset.

The Horizontal section of the Settings sub-tab contains the settings for shot Duration and Delay (negative delays correspond to pre-trigger time). Also minimum and maximum pulse width for the Pulse and Tracking Pulse trigger types are defined here.

The **Grid** sub-tab provides imaging functionality to capture and display two-dimensional data sets organized in frames consisting of rows and columns. By default, the number of rows is 1, which means the Data Acquisition tool operates similar to a scope. With a Rows setting larger than 1, every newly captured shot of data is assigned to a row until the number of rows is reached and the frame is complete. After completion of a full frame, the new data either replace the old or averaging is performed, according to the selected Operation and Repetitions setting. On the horizontal axis, the Duration of a shot is divided into a number of samples specified with the Columns setting. The Mode settings provides the functionality for post-processing of the streamed data for interpolation, resampling, and alignment with the trigger event. This is particularly helpful when capturing data from several sources, e.g. demodulators and PID controllers. As illustrated in Figure 5.22, in such situation the streamed data don't lie on the same temporal grid by default. This can be changed by setting Mode to Linear or Nearest. In these modes, the streams from several sources will be up-sampled to match the sampling rate and temporal grid of the fastest data stream. This means data processing after saving becomes more convenient, however note that the actual streamed data rate is not increased, and the data don't gain in time resolution. A two-dimensional color scale image of the data can be enabled and controlled in the Display section. The display features configurable scaling, range, and color scale.

With enabled grid mode, the data of a completed frame after averaging appear as a list entry in the **History** sub-tab. See History List for more details on how data in the history list can be managed and stored.

Figure 5.22: Samples from different sources configured with different rates: demodulator 1 at 2N kSa/s, demodulator 2 at N kSa/s and PID Error 1 at M kSa/s (N not divisible by M). Although each stream consists of equidistantly spaced samples in time, the sample timestamps from different streams are not necessarily aligned due to the different sampling rates

5.11.3. Functional Elements

Table 5.26: DAQ tab: Control sub-tab

Control/ Tool	Option/ Range	Description
Run/Stop	Run/Stop	Start and stop the Data Acquisition tool
Single	Single	Run the Data Acquisition tool once (record Count trigger events)
Force	Force	Forces a single trigger event.
Triggered	grey/green	When green, indicates that new trigger shots are being captured and displayed in the plot area.

For the Vertical Axis Groups, please see the table "Vertical Axis Groups description" in the section called "Vertical Axis Groups".

Table 5.27: DAQ tab: Settings sub-tab

Control/ Tool	Option/ Range	Description
Trigger Signal		Source signal for trigger condition. Navigate through the tree view that appears and click on the required signal.
Trigger Type		Select the type of trigger to use. Selectable options depend on the selected trigger signal.
	Continuous	Continuous triggering.
	Edge	Analog edge triggering based on high and low level. Hysteresis on the levels and low-pass filtering can be used to reduce the risk of wrong trigger for noisy trigger signals.
	Digital	Digital triggering on the 32-bit DIO lines. The bit value defines the trigger condition. The bit mask controls the bits that are used for trigger evaluation. When using a Positive Edge trigger setting, a trigger event occurs as soon as the equality (DIO Value)AND(Bit Mask) = (Bits)AND(Bit Mask) is fulfilled (and was not previously fulfilled). In order to trigger on DIO0 set bit value to 1 and bit mask to 1; to trigger on DIO1 set bit value to 2 and bit mask to 2.
	Pulse	Triggers if a pulse on an analog signal is within the min and max pulse width. Pulses can be defined as either low to high then high to low (positive), the reverse (negative) or both.
	Tracking Edge	Edge triggering with automatic adjustment of trigger levels to compensate for drifts. The tracking speed is controlled by the bandwidth of the low-pass filter. For this filter noise rejection can only be achieved by level hysteresis.
	HW Trigger	Trigger on one of the four trigger inputs. Ensure that the trigger level and the trigger coupling is correctly adjusted. The trigger input state can be monitored on the plotter.

Control/ Tool	Option/ Range	Description
	Tracking Pulse	Pulse triggering with automatic adjustment of trigger levels to compensate for drifts. The tracking speed is controlled by the bandwidth of the low-pass filter. For this filter noise rejection can only be achieved by level hysteresis.
Pulse Type	Positive/ Negative/ Both	Select between negative, positive or both pulse forms in the signal to trigger on.
Trigger Edge	Positive/ Negative/ Both	Triggers when the trigger input signal is crossing the trigger level from either high to low, low to high or both. This field is only displayed for trigger type Edge, Tracking Edge and Event Count.
Level	full signal range	Specify the trigger level value.
Find	Find	Automatically find the trigger level based on the current signal.
Hysteresis	full signal range	The hysteresis is important to trigger on the correct edge in the presence of noise. The hysteresis is applied below the trigger level for positive trigger edge selection. It is applied above for negative trigger edge selection, and on both sides for triggering on both edges.
Count	integer number	Number of trigger events to record (in Single mode)
Trigger progress	0% to 100%	The percentage of triggers already acquired (in Single mode)
Bandwidth (Hz)	0 to 0.5 * Sampling Rate	Bandwidth of the low-pass filter applied to the trigger signal. For edge and pulse trigger use a bandwidth larger than the signal sampling rate divided by 20 to keep the phase delay. For tracking filter use a bandwidth smaller than signal sampling frequency divided by 100 to just track slow signal components like drifts.
Enable	ON / OFF	Enable low-pass filtering of the trigger signal.
Hold Off Time (s)	positive numeric value	Hold off time before the trigger is rearmed. A hold off time smaller than the duration will lead to overlapping trigger frames.
Hold Off Count	integer value	Number of skipped triggers until the next trigger is recorded again.
Delay (s)	-Duration to Duration	Time delay of trigger frame position (left side) relative to the trigger edge. For delays smaller than 0, trigger edge inside trigger frame (pre trigger). For delays greater than 0, trigger edge before trigger frame (post trigger)
Refresh Rate	100 mHz to 10 Hz	Set the maximum refresh rate for plot updates. The actual refresh rate depends on other factors such as the hold-off time and duration.
Pulse Min (s)	0 to Duration	Minimum pulse width to trigger on.
Pulse Max (s)	0 to Duration	Maximum pulse width to trigger on.
Window	Cosine squared (ring-down)	Several different FFT windows to choose from. Depending on the application it makes a huge difference which of the provided window function is used. Please check the literature to find out the best trade off for your needs.
	Rectangular	
	Hann	
	Hamming	
	Blackman Harris	
	Flat Top	
	Exponential (ring-down)	
	Cosine (ring-down)	

Control/ Tool	Option/ Range	Description
Spectral Density	ON / OFF	Calculate and show the spectral density. If power is enabled the power spectral density value is calculated. The spectral density is used to analyze noise.

Table 5.28: DAQ tab: Grid sub-tab

Control/ Tool	Option/ Range	Description
Mode		Select resampling method for two-dimensional data recording.
	Off	Two-dimensional data recording is disabled.
	Nearest	Resampling is performed using substitution by closest data point.
	Linear	Resampling is performed using linear interpolation.
	Exact (on-grid)	Adjust the duration so that the grid distance matches the maximal sampling rate of the selected signals. This allows for on-grid sampling of measurement data. If a signal uses lower sampling rate it will be up-sampled by linear interpolation.
On Grid Sampling	Green or yellow	When green, indicates that all the captured data is aligned to the grid. When yellow, indicates that some data is not aligned to the grid and is interpolated. This can happen when one or more data sources have different sampling rates, or when a sampling rate changes.
Operation		Select row update method.
	Replace	New row replaces old row.
	Average	The data for each row is averaged over a number of repetitions.
	Std	The data for each row is the standard deviation over a number of repetitions.
Columns	numeric value	Number of columns. The data along the horizontal axis are resampled to a number of samples defined by this setting.
Duration	up to 1000 s	Recording length for each triggered data set. In exact sampling mode the duration is a read-only field. The duration is then defined by the maximal sampling rate and column size.
Rows	numeric value	Number of rows
Scan Direction		Select the scan direction and mode
	Forward	Scan direction from left to right
	Reverse	Scan direction from right to left
	Bidirectional	Alternate scanning in both directions
Repetitions	numeric value	Number of repetitions used for averaging
Row-wise repetition	ON / OFF	Enable row-wise repetition. With row-wise repetition, each row is calculated from successive repetitions before starting the next row. With grid-wise repetition, the entire grid is calculated with each repetition.
Waterfall	ON / OFF	Enable to show the 2D plot in waterfall mode. It will always update the last line.
Overwrite	ON / OFF	Enable to overwrite the grid in continuous mode. History will not be collected. A history element will only be created when the analysis is stopped.
Plot Type		Select the plot type.
	None	No plot displayed.
	2D	Display defined number of grid rows as one 2D plot.
	Row	Display only the trace of index defined in the Active Row field.
	2D + Row	Display 2D and row plots.

Control/ Tool	Option/ Range	Description
Active Row	integer value	Set the row index to be displayed in the Row plot.
Track Active Row	ON / OFF	If enabled, the active row marker will track with the last recorded row. The active row control field is read-only if enabled.
Palette	Solar	Select the colormap for the current plot.
	Viridis	
	Inferno	
	Balance	
	Turbo	
	Grey	
Colorscale	ON / OFF	Enable/disable the colorscale bar display in the 2D plot.
Mapping		Mapping of colorscale.
	Lin	Enable linear mapping.
	Log	Enable logarithmic mapping.
	dB	Enable logarithmic mapping in dB.
Scaling	Full Scale/ Manual/Auto	Scaling of colorscale.
Clamp To Color	ON / OFF	When enabled, grid values that are outside of defined Min or Max region are painted with Min or Max color equivalents. When disabled, Grid values that are outside of defined Min or Max values are left transparent.
Start	numeric value	Lower limit of colorscale. Only visible for manual scaling.
Stop	numeric value	Upper limit of colorscale. Only visible for manual scaling.

Table 5.29: DAQ tab: History sub-tab

Control/ Tool	Option/ Range	Description
History	History	Each entry in the list corresponds to a single trace in the history. The number of traces displayed in the plot is limited to 20. Use the toggle buttons to hide or show individual traces. Use the color picker to change the color of a trace in the plot. Double click on a list entry to edit its name.
Length	integer value	Maximum number of records in the history. The number of entries displayed in the list is limited to the 100 most recent ones.
Clear All	Clear All	Remove all records from the history list.
Clear	Clear	Remove selected records from the history list.
Load file		Load data from a file into the history. Loading does not change the data type and range displayed in the plot, this has to be adapted manually if data is not shown.
Name		Enter a name which is used as a folder name to save the history into. An additional three digit counter is added to the folder name to identify consecutive saves into the same folder name.

Control/ Tool	Option/ Range	Description
Auto Save		Activate autosaving. When activated, any measurements already in the history are saved. Each subsequent measurement is then also saved. The autosave directory is identified by the text "autosave" in the name, e.g. "sweep_autosave_001". If autosave is active during continuous running of the module, each successive measurement is saved to the same directory. For single shot operation, a new directory is created containing all measurements in the history. Depending on the file format, the measurements are either appended to the same file, or saved in individual files. For HDF5 and ZView formats, measurements are appended to the same file. For MATLAB and SXM formats, each measurement is saved in a separate file.
File Format		Select the file format in which to save the data.
Save	Save	Save the traces in the history to a file accessible in the File Manager tab. The file contains the signals in the Vertical Axis Groups of the Control sub-tab. The data that is saved depends on the selection from the pull-down list. Save All: All traces are saved. Save Sel: The selected traces are saved.

For the Math sub-tab please see the table "Plot math description" in the section called "Cursors and Math".

5.12. Spectrum Analyzer Tab

The Spectrum Analyzer is one of the powerful frequency domain measurement tools introduced in Unique Set of Analysis Tools and is available on all SHFLI instruments.

5.12.1. Features

- Fast, high-resolution FFT spectrum analyzer
- Signals: demodulated data (X+iY, R, Θ, f and dΘ/dt/(2π)), and more
- Variable center frequency, frequency resolution and frequency span
- Auto bandwidth
- Waterfall display
- Choice of 4 different FFT window functions
- Continuous and block-wise acquisition with different types of averaging
- Detailed noise power analysis
- Mathematical toolbox for signal analysis

5.12.2. Description

The Spectrum Analyzer provides frequency domain analysis of demodulator data. Whenever the tab is closed or an additional one of the same type is needed, clicking the following icon will open a new instance of the tab.

Table 5.30: App icon and short description

Control/ Tool	Option/ Range	Description
Spectrum		Provides FFT functionality to all continuously streamed measurement data.

The Spectrum tab (see Figure 5.23) is divided into a display section on the left and a configuration section on the right. The configuration section is further divided into a number of sub-tabs.

Figure 5.23: LabOne UI: Spectrum analyzer tab

Important

The Spectrum Analyzer allows for spectral analysis of all the demodulator data by performing a fast Fourier transform (FFT) on the complex demodulator data samples X+iY (where i is the imaginary unit). The result of this FFT is a spectrum centered around the demodulation frequency, whereas applying a FFT directly on the raw input data would produce a spectrum centered around the channel frequency in RF or around 0 in Baseband. The latter procedure corresponds to the Frequency Domain operation in the Scope Tab. The main difference between the two is that the Spectrum Analyzer tool can acquire data for a much longer periods of time and therefore can achieve a very high frequency resolution around the demodulation frequency.

By default, the display section contains a line plot of the spectrum together with a color waterfall plot of the last few acquired spectra. The waterfall plot makes it easier to see the evolution of the spectrum over time. The display layout as well as the number of rows in the color plot can be configured in the Settings sub-tab.

Data shown in the Spectrum tab have passed through a low-pass filter with a well-defined order and bandwidth. This is most clearly visible in the shape of the noise floor. One has to take care that the selected frequency span, which equals the demodulator sampling rate, is 5 to 10 times higher than the filter bandwidth in order to prevent measurement errors due to aliasing. The Auto Bandwidth button **A** adjusts the sampling rate so that it suits the filter settings. The Spectrum tab features FFT display of a selection of data available in the Signal Type drop-down list in addition to the complex demodulator samples X+iY. Looking at the FFT of polar demodulator values R and Theta allows one to discriminate between phase noise components and amplitude noise components in the signal. The FFT of the phase derivative dΘ/dt provides a quantitative view of the spectrum of demodulator frequencies.

5.12.3. Functional Elements

Table 5.31: Spectrum tab: Settings sub-tab

Control/Tool	Option/ Range	Description
Run/Stop	Run/Stop	Run the FFT spectrum analysis continuously
Single	Single	Run the FFT spectrum analysis once
Frequency Span (Hz)	numeric value	Set the frequency span of interest for the complex FFT. A FFT based on real input data will display half of the frequency span up to the Nyquist frequency.
Refresh Rate (Hz)	numeric value	Set the maximum plot refresh rate. The actual refresh rate also depends on other parameters such as FFT length. In overlapped mode the refresh rate defines the amount of overlapping.
Power	ON / OFF	Calculate and show the power value. To extract power spectral density (PSD) this button should be enabled together with spectral density.
Spectral Density	ON / OFF	Calculate and show the spectral density. If power is enabled the power spectral density value is calculated. The spectral density is used to analyze noise.
Filter Compensation	ON / OFF	Spectrum is corrected by demodulator filter transfer function. Allows for quantitative comparison of amplitudes of different parts of the spectrum.

Control/Tool	Option/ Range	Description
FFT length	numeric value	The number of samples used for the FFT. Values entered that are not a binary power are truncated to the nearest power of 2.
Sampling Progress	0% to 100%	The percentage of the FFT buffer already acquired. The progress includes the number of rows and averages.
FFT Duration (s)	numeric value	Indicates the length in time of the samples used for a single FFT.
Window	Cosine squared (ring-down)	Several different FFT windows to choose from. Depending on the application it makes a huge difference which of the provided window function is used. Please check the literature to find out the best trade off for your needs.
	Rectangular	
	Hann	
	Hamming	
	Blackman Harris	
	Flat Top	
	Exponential (ring-down)	
	Cosine (ring-down)	
Resolution (Hz)	mHz to Hz	Spectral resolution defined by the reciprocal acquisition time (sample rate, number of samples recorded).
Rows	numeric value	Number of rows
Averages	numeric value	Number of FFT averaged for each row. Setting the value to 1 will disable any averaging.
Waterfall	ON / OFF	Enable to show the 2D plot in waterfall mode. It will always update the lowest line.
Overwrite	ON / OFF	Enable to overwrite the grid in continuous mode. History will not be collected. A history element will only be created when the analysis is stopped.
Plot Type		Select the plot type.
	None	No plot displayed.
	2D	Display defined number of grid rows as one 2D plot.
	Row	Display only the trace of index defined in the Active Row field.
	2D + Row	Display 2D and row plots.
Active Row	integer value	Set the row index to be displayed in the Row plot.
Track Active Row	ON / OFF	If enabled, the active row marker will track with the last recorded row. The active row control field is read-only if enabled.
Palette	Solar	Select the colormap for the current plot.
	Viridis	
	Inferno	
	Balance	
	Turbo	
	Grey	
Colorscale	ON / OFF	Enable/disable the colorscale bar display in the 2D plot.
Mapping		Mapping of colorscale.
	Lin	Enable linear mapping.
	Log	Enable logarithmic mapping.
	dB	Enable logarithmic mapping in dB.

Control/Tool	Option/Range	Description
Scaling	Full Scale/Manual/Auto	Scaling of colorscale.
Clamp To Color	ON / OFF	When enabled, grid values that are outside of defined Min or Max region are painted with Min or Max color equivalents. When disabled, Grid values that are outside of defined Min or Max values are left transparent.
Start	numeric value	Lower limit of colorscale. Only visible for manual scaling.
Stop	numeric value	Upper limit of colorscale. Only visible for manual scaling.

For the Math sub-tab please see the table "Plot math description" in the section called "Cursors and Math".

5.13. Sweeper Tab

The Sweeper is a highly versatile measurement tool available on all SHFLI instruments. The Sweeper enables scans of an instrument parameter over a defined range and simultaneous measurement of a selection of continuously streamed data. In the special case in which the swept parameter is a frequency, the Sweeper offers the functionality of a frequency response analyzer (FRA), a well-known class of instruments.

5.13.1. Features

- Full-featured parametric sweep tool for oscillator frequency, multi-band frequency, output amplitude, etc.
- Simultaneous display of data from multiple demodulators
- Different application modes, e.g. Frequency response analyzer (Bode plots), noise amplitude sweeps, etc.
- Different sweep types: single, continuous (run / stop), bidirectional, sequential, reversed
- Persistent display of previous sweep results
- XY Mode
- Normalization of sweeps
- Auto bandwidth, averaging and display normalization
- Phase unwrap

5.13.2. Description

The Sweeper supports a variety of experiments in which a parameter is changed stepwise and numerous measurement data can be graphically displayed. Open the tool by clicking the corresponding icon in the UI side bar. The Sweeper tab (see Figure 5.24) is divided into a plot section on the left and a configuration section on the right. The configuration section is further divided into a number of sub-tabs.

Table 5.32: App icon and short description

Control/Tool	Option/Range	Description
Sweeper		Sweep frequencies, voltages, and other quantities over a defined range and display various response functions including statistical operations.

Figure 5.24: LabOne UI: Sweeper tab

The **Control** sub-tab holds the basic measurement settings such as Sweep Parameter, Start/Stop values, and number of points (Length) in the Horizontal section. Measurement signals can be added in the Vertical Axis Groups section. A typical use of the Sweeper is to perform a frequency sweep and measure the response of the device under test in the form of a Bode plot. As an example, MEMS users can use it to determine the resonance frequency and the phase delay of their oscillators. The Sweeper can also be used to sweep parameters other than frequency, for instance signal amplitudes, demodulator phase shift or auxiliary output offset. The XY Mode allows one to use a measured signal, rather than the sweep parameter, on the horizontal axis.

For frequency sweeps, the sweep points are distributed logarithmically, rather than linearly, between the start and stop values by default. This feature is particularly useful for sweeps over several decades and can be changed with the X Distribution selector. The Sweep Mode setting is useful for identifying measurement problems caused by hysteretic sample behavior or too fast sweeping speed. Such problems would cause non-overlapping curves in a bidirectional sweep.

Note

The Sweeper actively modifies the main settings of the demodulators and oscillators. So in particular for situations where multiple experiments are served maybe even from different control computers great care needs to be taken so that the parameters altered by the sweeper module do not have unwanted effects elsewhere.

Note

In the SHFLI, the demodulator frequency is composed of two separate components: the channel center frequency and the oscillator frequency. Selecting Osc x Frequency as the swept parameter only varies the oscillator frequency around the center frequency of the demodulator's channel. To sweep beyond one measurement window, select one of the Multi-band options as the swept mode. For correct results, you need to choose the same channel and oscillator as the demodulator(s) you want to display

Note

In Multi-band sweeps, the measurement window parameters (i.e. center frequency and upper/lower boundaries) are automatically selected to guarantee best response flatness, measurement reproducibility and phase continuity

The Sweeper offers two operation modes differing in the level of detail of the accessible settings: the Application Mode and the Advanced Mode. Both of them are accessible in the **Settings** sub-tab. The Application Mode provides the choice between several measurement approaches that should help to quickly obtain correct measurement results for a large range of applications. Users who like to be in control of all the settings can access them by switching to the Advanced Mode.

In the Settling section one can control the waiting time between a parameter setting and the first measurement. The actual settling time is the maximum of the values set in units of absolute time and a time derived from the demodulator filter and a desired inaccuracy (e.g. 1 m for 0.1%). Let's consider an example. For a 4th order filter and a 3 dB bandwidth of 100 Hz we obtain a step response that reaches 90% of the value after about 4.5 ms. This can be easily measured by using the Data Acquisition tool as indicated in Figure 5.25. It is also explained in Discrete-Time Filters. In case the full range is set to 1 V this means a measurement has a maximum error caused by imperfect settling of about 0.1 V. However, for most measurements the neighboring values are close compared to the full range and hence the real error caused is usually much smaller.

In the Statistics section of the Advanced Mode one can control how data is averaged at each sweep point: either by specifying the Sample count, or by specifying the number of filter time constants (TC). The actual measurement time is determined by the larger of the two settings, taking into account the demodulator sample rate and filter settings. The Algorithm settings determines the statistics calculated from the measured data: the average for general purposes, the deviation for noise measurements, or the mean square for power measurements. The Phase Unwrap features ensures continuity of a phase measurement curve across the ±180 degree boundary.

In the Filter section of the Advanced mode, the Bandwidth Mode setting determines how the filters of the activated demodulators are configured. In Manual mode, the current setting (in the Lock-in tab) remains unchanged by the Sweeper. In Fixed mode, the filter settings can be controlled from within the Sweeper tab. In Auto mode, the Sweeper determines the filter bandwidth for each sweep point based on a desired ω suppression. The ω suppression depends on the measurement frequency and the filter steepness. For frequency sweeps, the bandwidth will be adjusted for every sweep point within the bound set by the Max Bandwidth setting. The Auto mode is particularly useful for frequency sweeps over several decades, because the continuous adjustment of the bandwidth considerably reduces the overall measurement time.

Figure 5.25: Demodulator settling time and inaccuracy: measurement carried out with the Data Acquisition tool to illustrate the settling time for a 4

By default the plot area keeps the memory and display of the last 100 sweeps represented in a list in the **History** sub-tab. See History List for more details on how data in the history list can be managed and stored. With the Reference feature, it is possible to normalize all measurements in the history to a reference measurement of choice. This is useful for instance to eliminate spurious effects in a frequency response sweep. To define a certain measurement as the reference, mark it in the list and click on Reference . Then enable the Reference mode with the checkbox below the list to update the plot display. Note that the Reference setting does not affect data saving: saved files always contain raw data.

Note

The Sweeper can get stuck whenever it does not receive any data. A common mistake is to select to display demodulator data without enabling the data transfer of the associated demodulator in the Lock-in tab.

Note

Once a sweep is performed the sweeper stores all data from the enabled demodulators even when they are not displayed immediately in the plot area. This data can be accessed at a later point in time simply by choosing the corresponding signal display settings (Input Channel).

5.13.3. Functional Elements

Table 5.33: Sweeper tab: Control sub-tab

Control/ Tool	Option/ Range	Description
Run/Stop	Run/Stop	Runs the sweeper continuously.
Single	Single	Runs the sweeper once.

Control/ Tool	Option/ Range	Description
Copy From X-Axis		Takes over start and stop value from the X-axis.
Copy From X-Cursors		Takes over start and stop value from X-cursors. Button is disabled when one or both X cursors are not visible.
Start (unit)	numeric value	Start value of the sweep parameter. The unit adapts according to the selected sweep parameter.
Stop (unit)	numeric value	Stop value of the sweep parameter. The unit adapts according to the selected sweep parameter.
Length	integer value	Sets the number of measurement points.
Progress	0 to 100%	Reports the sweep progress as ratio of points recorded.
Sweep Param	🔲	Selects the parameter to be swept. Navigate through the tree view that appears and click on the required parameter. The available selection depends on the configuration of the device.
Sweep Mode		Select the scanning type, default is sequential (incremental scanning from start to stop value)
	Sequential	Sequential sweep from Start to Stop value
	Binary	Non-sequential sweep continues increase of resolution over entire range
	Bidirectional	Sequential sweep from Start to Stop value and back to Start again
	Reverse	Reverse sweep from Stop to Start value
X Distribution	Linear / Logarithmic	Selects between linear and logarithmic distribution of the sweep parameter.
Remaining	numeric value	Reporting of the remaining time of the current sweep. A valid number is only displayed once the sweeper has been started. An undefined sweep time is indicated as NaN.
Invert Y Axis	ON / OFF	The xy-plot is displayed with inverted y-axis. This mode is used for Nyquist plots that allow for displaying -imag(z) on the y-axis and real(z) on the x-axis.
X Signal	🔲	Selects the signal that defines the x-axis for xy-plots. The available selection depends on the configuration of the device. Displaying the selected signal source will result in a diagonal straight line.

For the Vertical Axis Groups, please see the table "Vertical Axis Groups description" in the section called "Vertical Axis Groups".

Table 5.34: Sweeper tab: Settings sub-tab

Control/ Tool	Option/ Range	Description
Order	numeric value	Selects the filter roll off to set on the device in Fixed and Auto bandwidth modes. It ranges from 1 (6 dB/octave) to 8 (48 dB/octave).
Filter		Application Mode: preset configuration. Advanced Mode: manual configuration.
	Application Mode	The sweeper sets the filters and other parameters automatically.
	Advanced Mode	The sweeper uses manually configured parameters.
Application		Select the sweep application mode
	Parameter Sweep	Only one data sample is acquired per sweeper point.

Control/ Tool	Option/ Range	Description
	Parameter Sweep Averaged	Multiple data samples are acquired per sweeper point of which the average value is displayed.
	Noise Amplitude Sweep	Multiple data samples are acquired per sweeper point of which the standard deviation is displayed (e.g. to determine input noise). For accurate noise measurement, the signal amplitude R is replaced by its quadrature components X and Y.
	Freq Response Analyzer	Narrow band frequency response analysis. Averaging is enabled.
	3-Omega Sweep	Optimized parameters for 3-omega application. Averaging is enabled.
	FRA (Sinc Filter)	The sinc filter helps to speed up measurements for frequencies below 50 Hz in FRA mode. For higher frequencies it is automatically disabled. Averaging is off.
Precision		Choose between a high speed scan speed or high precision and accuracy.
	Low -> fast sweep	Medium accuracy/precision is optimized for sweep speed.
	High -> standard speed	Medium accuracy/precision takes more measurement time.
	Very high -> slow sweep	High accuracy/precision takes more measurement time.
Bandwidth Mode		Automatically is recommended in particular for logarithmic sweeps and assures the whole spectrum is covered.
	Auto	All bandwidth settings of the chosen demodulators are automatically adjusted. For logarithmic sweeps the measurement bandwidth is adjusted throughout the measurement.
	Fixed	Define a certain bandwidth which is taken for all chosen demodulators for the course of the measurement.
	Manual	The sweeper module leaves the demodulator bandwidth settings entirely untouched.
Time Constant/ Bandwidth Select		Defines the display unit of the low-pass filter to use for the sweep in fixed bandwidth mode: time constant (TC), noise equivalent power bandwidth (NEP), 3 dB bandwidth (3 dB).
	TC	Defines the low-pass filter characteristic using time constant of the filter.
	Bandwidth NEP	Defines the low-pass filter characteristic using the noise equivalent power bandwidth of the filter.
	Bandwidth 3 dB	Defines the low-pass filter characteristic using the cut-off frequency of the filter.
Time Constant/ Bandwidth	numeric value	Defines the measurement bandwidth for Fixed bandwidth sweep mode, and corresponds to either noise equivalent power bandwidth (NEP), time constant (TC) or 3 dB bandwidth (3 dB) depending on selection.
Max Bandwidth (Hz)	numeric value	Maximal bandwidth used in auto bandwidth mode. The effective bandwidth will be calculated based on this max value, the frequency step size, and the omega suppression.
BW Overlap	ON / OFF	If enabled the bandwidth of a sweep point may overlap with the frequency of neighboring sweep points. The effective bandwidth is only limited by the maximal bandwidth setting and omega suppression. As a result, the bandwidth is independent of the number of sweep points. For frequency response analysis bandwidth overlap should be enabled to achieve maximal sweep speed.

Control/ Tool	Option/ Range	Description
Omega Suppression (dB)	numeric value	Suppression of the omega and 2-omega components. Large suppression will have a significant impact on sweep time especially for low filter orders.
Min Settling Time (s)	numeric value	Minimum wait time in seconds between a sweep parameter change and the recording of the next sweep point. This parameter can be used to define the required settling time of the experimental setup. The effective wait time is the maximum of this value and the demodulator filter settling time determined from the Inaccuracy value specified.
Inaccuracy	numeric value	Demodulator filter settling inaccuracy defining the wait time between a sweep parameter change and recording of the next sweep point. The settling time is calculated as the time required to attain the specified remaining proportion [1e-13, 0.1] of an incoming step function. Typical inaccuracy values: 10 m for highest sweep speed for large signals, 100 u for precise amplitude measurements, 100 n for precise noise measurements. Depending on the order the settling accuracy will define the number of filter time constants the sweeper has to wait. The maximum between this value and the settling time is taken as wait time until the next sweep point is recorded.
Settling Time (TC)	numeric value	Calculated wait time expressed in time constants defined by the specified filter settling inaccuracy.
Algorithm		Selects the measurement method.
	Averaging	Calculates the average on each data set.
	Standard Deviation	Calculates the standard deviation on each data set.
	Average Power	Calculates the electric power based on a 50 Ω input impedance.
Count (Sa)	integer number	Sets the number of data samples per sweeper parameter point that is considered in the measurement. The maximum between samples, time and number of time constants is taken as effective calculation time.
Count (s)	numeric value	Sets the time during which data samples are processed. The maximum between samples, time and number of time constants is taken as effective calculation time.
Count (TC)	0/5/15/50/100 TC	Sets the effective measurement time per sweeper parameter point that is considered in the measurement. The maximum between samples, time and number of time constants is taken as effective calculation time.
Phase Unwrap	ON / OFF	Allows for unwrapping of slowly changing phase evolutions around the +/-180 degree boundary.
Spectral Density	ON / OFF	Selects whether the result of the measurement is normalized versus the demodulation bandwidth.
Sinc Filter	ON / OFF	Enables sinc filter if sweep frequency is below 50 Hz. Will improve the sweep speed at low frequencies as omega components do not need to be suppressed by the normal low-pass filter.

Table 5.35: Sweeper tab: History sub-tab

Control/ Tool	Option/ Range	Description
History	History	Each entry in the list corresponds to a single trace in the history. The number of traces displayed in the plot is limited to 20. Use the toggle buttons to hide or show individual traces. Use the color picker to change the color of a trace in the plot. Double click on a list entry to edit its name.
Length	integer value	Maximum number of records in the history. The number of entries displayed in the list is limited to the 100 most recent ones.
Clear All	Clear All	Remove all records from the history list.
Clear	Clear	Remove selected records from the history list.

Control/ Tool	Option/ Range	Description
Load file		Load data from a file into the history. Loading does not change the data type and range displayed in the plot, this has to be adapted manually if data is not shown.
Name		Enter a name which is used as a folder name to save the history into. An additional three digit counter is added to the folder name to identify consecutive saves into the same folder name.
Auto Save		Activate autosaving. When activated, any measurements already in the history are saved. Each subsequent measurement is then also saved. The autosave directory is identified by the text "autosave" in the name, e.g. "sweep_autosave_001". If autosave is active during continuous running of the module, each successive measurement is saved to the same directory. For single shot operation, a new directory is created containing all measurements in the history. Depending on the file format, the measurements are either appended to the same file, or saved in individual files. For HDF5 and ZView formats, measurements are appended to the same file. For MATLAB and SXM formats, each measurement is saved in a separate file.
File Format		Select the file format in which to save the data.
Save	Save	Save the traces in the history to a file accessible in the File Manager tab. The file contains the signals in the Vertical Axis Groups of the Control sub-tab. The data that is saved depends on the selection from the pull-down list. Save All: All traces are saved. Save Sel: The selected traces are saved.
Reference	Reference	Use the selected trace as reference for all active traces.
Reference On	ON / OFF	Enable/disable the reference mode.
Reference name	name	Name of the reference trace used.

For the Math sub-tab please see the table "Plot math description" in the section called "Cursors and Math".

5.14. Auxiliary Tab

The Auxiliary tab provides access to the settings of the Auxiliary Outputs; it is available on all SHFLI instruments.

5.14.1. Features

- Auxiliary output signal sources: Demodulators and manual setting
- Define Offsets, Pre-offsets and Scaling for auxiliary output values
- Control over the 4 High-speed and 4 High-precision auxiliary outputs

5.14.2. Description

The Auxiliary tab serves mainly to control the auxiliary outputs. Whenever the tab is closed or an additional one of the same type is needed, clicking the following icon will open a new instance of the tab.

Table 5.36: App icon and short description

Control/ Tool	Option/ Range	Description
Aux	⊡	Controls all settings regarding the auxiliary inputs and auxiliary outputs.

The Auxiliary tab (see Figure 5.26) allows to associate any of the measured signals to one of the 8 auxiliary outputs on the instrument front panel. With the action buttons next to the Preoffset and

Offset values the effective voltage on the auxiliary outputs can be automatically set to zero (this functionality will be available soon).

Figure 5.26: LabOne UI: Auxiliary tab

5.14.3. Functional Elements

Table 5.37: Auxiliary tab

Control/ Tool	Option/Range	Description
Preoffset	numerical value in signal units	Add a pre-offset to the signal before scaling is applied. Auxiliary Output Value = (Signal+Preoffset)*Scale + Offset
Auto-zero	▷◁	Automatically adjusts the Pre-offset to set the Auxiliary Output Value to zero.
Scale	numerical value	Multiplication factor to scale the signal. Auxiliary Output Value = (Signal+Preoffset)*Scale + Offset
Offset	numerical value in Volts	Add the specified offset voltage to the signal after scaling. Auxiliary Output Value = (Signal+Preoffset)*Scale + Offset
Signal		Select the signal source to be represented on the Auxiliary Output.
	X	Select the demodulator X component for auxiliary output.
	Y	Select the demodulator Y component for auxiliary output.
	Manual	Manually define an auxiliary output voltage using the offset field.
Channel	index	Select the channel according to the selected signal source.

5.15. DIO Tab

The DIO tab provides access to the settings and controls of the Trigger channels and is available on SHFLI instruments.

5.15.1. Features

- Monitor and control of digital I/O connectors
- Control settings for triggering

5.15.2. Description

The DIO tab is the main panel to control the digital inputs and outputs as well as the trigger levels. Whenever the tab is closed or an additional one of the same type is needed, clicking the following icon will open a new instance of the tab.

Table 5.38: App icon and short description

Control/ Tool	Option/ Range	Description
DIO	![icon]	Gives access to all controls relevant for the digital inputs and outputs including DIO, Trigger Inputs, Trigger Outputs, and Marker Outputs.

Figure 5.27: LabOne UI: DIO tab

Note

The Input Level determines the trigger threshold for trigger state discrimination. Also a 60 mV hysteresis is applied that cannot be adjusted such that a minimum amplitude of more than 60 mV is needed for the Trigger inputs to work reliably.

Note

Please note that some elements will be implemented in a future LabOne release, including the trigger output settings.

5.16. Config Tab

The Config tab provides access to all major LabOne settings and is available on all SHFLI instruments.

5.16.1. Features

- define instrument connection parameters
- browser session control
- define UI appearance (grids, theme, etc.)
- store and load instrument settings and UI settings
- configure data recording

5.16.2. Description

The Config tab serves as a control panel for all general LabOne settings and is opened by default on start-up. Whenever the tab is closed or an additional one of the same type is needed, clicking the following icon will open a new instance of the tab.

Table 5.39: App icon and short description

Control/Tool	Option/Range	Description
Config	![icon]	Provides access to software configuration.

The Config tab (see LabOne UI: Config tab) is divided into four sections to control connections, sessions, settings, user interface appearance and data recording.

Figure 5.28: LabOne UI: Config tab

The **Connection** section provides information about connection and server versions. Access from remote locations can be restricted with the connectivity setting.

The **Session** section provides the session number which is also displayed in the status bar. Clicking on Session Dialog opens the session dialog window (same as start up screen) that allows one to load different settings files as well as to connect to other instruments.

The **Settings** section allows one to load and save instrument and UI settings. The saved settings are later available in the session dialog.

The **User Preferences** section contains the settings that are continuously stored and automatically reloaded the next time an SHFLI instrument is used from the same computer account.

For low ambient light conditions the use of the dark display theme is recommended (see Figure 5.29).

Figure 5.29: LabOne UI: Config tab - dark theme

The **Record Data** section contains all settings necessary to obtain hard copies of measurement data. The tree structure (see Tree Selector section) provides access to a large number of signals and instrument settings. Use the View Filter in order to reduce the tree structure to the most commonly used nodes such as the demodulator sample nodes. Whenever the Record button is enabled, all selected nodes get saved continuously in MATLAB, comma-separated value (CSV), or other supported file formats. For each selected node at least one file gets generated, but the data may be distributed over several files during long recordings. See Saving and Loading Data for more information on data saving. The quickest way to inspect the files after recording is to use the File Manager tab described in File Manager Tab. Apart from the numerical data and settings, the files contain timestamps. These integer numbers encode the measurement time in units of the instrument clock period 1/(4 GHz). The timestamps are universal within one instrument and can be used to align the data from different files.

5.16.3. Functional Elements

Table 5.40: Config tab

Control/ Tool	Option/Range	Description
About	About	Get information about LabOne software.
Web Server Version and Revision	string	Web Server version and revision number
Host	default is localhost: 127.0.0.1	IP-Address of the LabOne Web Server
Port	4 digit integer	LabOne Web Server TCP/IP port
Data Server Version and Revision	string	Data Server version and revision number
Host	default is localhost: 127.0.0.1	IP-Address of the LabOne Data Server
Port	default is 8004	TCP/IP port used to connect to the LabOne Data Server.

Control/ Tool	Option/Range	Description
Connect/ Disconnect		Connect/disconnect the LabOne Data Server of the currently selected device. If a LabOne Data Server is connected only devices that are visible to that specific server are shown in the device list.
Status	grey/green	Indicates whether the LabOne User Interface is connected to the selected LabOne data server. Grey: no connection. Green: connected. Red: error while connecting.
Connectivity	From Everywhere	Forbid/Allow to connect to this Data Server from other computers.
	Localhost Only	
File Upload	drop area	Drag and drop files in this box to upload files. Clicking on the box opens a file dialog for file upload. Supported files: Settings (*.xml).
Session Id	integer number	Session identifier. A session is a connection between a client and LabOne Data Server.
Session Manager	Session Manager	Open the session manager dialog. This allows for device or session change. The current session can be continued by pressing cancel.
File Name	selection of available file names	Save/load the device and user interface settings to/from the selected file on the internal flash drive. The setting files can be downloaded/uploaded using the Files tab.
Include		Enable Save/Load of particular settings.
	No Include Settings	Please enable settings type to be included during Save/ Load.
	Include Device	Enable Save/Load of Device settings.
	Include UI	Enable Save/Load of User Interface settings.
	Include UI and Device	Enable Save/Load of User Interface and Device settings.
	Include Preferences	Enable loading of User Preferences from settings file.
	Include UI, Device and Preferences	Enable Save/Load of User Interface, Device and User Preferences.
Save	Save	Save the user interface and device setting to a file.
Load	Load	Load the user interface and device setting from a file.
Language		Choose the language for the tooltips.
Display Theme	Dark	Choose theme of the user interface.
	Light	
Plot Print Theme	Dark	Choose theme for printing SVG plots.
	Light	
Plot Grid	None	Select active grid setting for all SVG plots.
	Dashed	
	Solid	
Plot Rendering		Select rendering hint about what tradeoffs to make as the browser renders SVG plots. The setting has impact on rendering speed and plot display for both displayed and saved plots.
	Auto	Indicates that the browser shall make appropriate tradeoffs to balance speed, crisp edges and geometric precision, but with geometric precision given more importance than speed and crisp edges.

Control/Tool	Option/Range	Description
	Optimize Speed	The browser shall emphasize rendering speed over geometric precision and crisp edges. This option will sometimes cause the browser to turn off shape anti-aliasing.
	Crisp Edges	Indicates that the browser shall attempt to emphasize the contrast between clean edges of artwork over rendering speed and geometric precision. To achieve crisp edges, the user agent might turn off anti-aliasing for all lines and curves or possibly just for straight lines which are close to vertical or horizontal.
	Geometric Precision	Indicates that the browser shall emphasize geometric precision over speed and crisp edges.
Resampling Method		Select the resampling interpolation method. Resampling corrects for sample misalignment in subsequent scope shots. This is important when using reduced sample rates with a time resolution below that of the trigger.
	Linear	Linear interpolation
	PCHIP	Piecewise Cubic Hermite Interpolating Polynomial
Show Shortcuts	ON / OFF	Displays a list of keyboard and mouse wheel shortcuts for manipulating plots.
Dynamic Tabs	ON / OFF	If enabled, sections inside the application tabs are collapsed automatically depending on the window width.
Graphical Mode	Collapsed	Select the display mode for the graphical elements. Auto format will select the format which fits best the current window width.
	Auto	
	Expanded	
Log Format	.NET	Choose the command log format. See status bar and [User]\Documents\Zurich Instruments\LabOne\WebServer\Log
	MATLAB	
	Python	
CSV Delimiter	Tab	Select which delimiter to insert for CSV files.
	Comma	
	Semicolon	
CSV Locale	System locale. Use the symbols set in the language and region settings of the computer	Select the locale used for defining the decimal point and digit grouping symbols in numeric values in CSV files. The default locale uses dot for the decimal point and no digit grouping, e.g. 1005.07. The system locale uses the symbols set in the language and region settings of the computer.
	Default locale. Dot for the decimal point and no digit grouping, e.g. 1005.07	
HDF5 Saving	Multiple files. Each measurement goes in a separate file	For HDF5 file format only: Select whether each measurement should be stored in a separate file, or whether all measurements should be saved in a single file.
	Single file. All measurements go in one file	
Auto Start	ON / OFF	Skip session manager dialog at start-up if selected device is available. In case of an error or disconnected device the session manager will be reactivated.
Update Reminder	ON / OFF	Display a reminder on start-up if the LabOne software wasn't updated in 180 days.

Control/ Tool	Option/Range	Description
Update Check	ON / OFF	Periodically check for new LabOne software over the internet.
Drive		Select the drive for data saving.
Format	SXM (Nanonis)	File format of recorded and saved data.
	MATLAB	
	CSV	
Open Folder		Open recorded data in the system File Explorer.
Folder	path indicating file location	Folder containing the recorded data.
Save Interval	Time in seconds	Time between saves to disk. A shorter interval means less system memory consumption, but for certain file formats (e.g. MATLAB) many small files on disk. A longer interval means more system memory consumption, but for certain file formats (e.g. MATLAB) fewer, larger files on disk.
Queue	integer number	Number of data chunks not yet written to disk.
Size	integer number	Accumulated size of saved data in the current session.
Record	ON / OFF	Start and stop saving data to disk as defined in the selection filter. Length of the files is determined by the Window Length setting in the Plotter tab.
Writing	grey/green	Indicates whether data is currently written to disk.
Display	filter or regular expression	Display specific tree branches using one of the preset view filters or a custom regular expression.
Tree	ON / OFF	Click on a tree node to activate it.
All		Select all tree elements.
None		Deselect all tree elements.

For more information on the tree functionality in the Record Data section, please see Tree Selector.

5.17. Device Tab

The Device tab is the main settings tab for the connected instrument and is available on all SHFLI instruments.

5.17.1. Features

- Option and upgrade management
- External clock referencing (10/100 MHz)
- Instrument connectivity parameters
- Device monitor

5.17.2. Description

The **Device tab** serves mainly as a control panel for all settings specific to the instrument that is controlled by LabOne in this particular session. Whenever the tab is closed or an additional one of the same type is needed, clicking the following icon will open a new instance of the tab.

Table 5.41: App icon and short description

Control/Tool	Option/Range	Description
Device		Provides instrument specific settings.

The Device tab (see LabOne UI: Device tab) is divided into five sections: general instrument information, configuration, communication parameters, device presets, and a device monitor.

Figure 5.30: LabOne UI: Device tab

The **Information** section provides details about the instrument hardware and indicates the installed upgrade options. This is also the place where new options can be added by entering the provided option key.

The **Configuration** section allows one to change the reference from the internal clock to an external 10 / 100 MHz reference. The reference is to be connected to the Clock Input on the instrument back panel. The section also allows one to select a frequency of 10 or 100 MHz of the reference clock output, which is generated at the Clock Output on the instrument back panel.

The **Communication** section offers access to the instruments TCP/IP settings.

The **Statistics** section gives an overview on communication statistics.

The **Device Monitor** section is collapsed by default and generally only needed for servicing. It displays vitality signals of some of the instrument's hardware components.

5.17.3. Functional Elements

Table 5.42: Device tab

Control/Tool	Option/Range	Description
Serial	1-4 digit number	Device serial number
Type	string	Device type
FPGA	integer number	HDL firmware revision.
Digital Board	version number	Hardware revision of the FPGA base board.
Firmware	integer number	Revision of the device internal controller software.
Installed Options	short names for each option	Options that are installed on this device.
Install	Install	Click to install options on this device. Requires a unique feature code and a power cycle after entry.
More Information		Display additional device information in a separate browser tab.
Upgrade Device Options		Display available upgrade options.
Input Reference Clock Source		Selects Internal, External or the ZSync clock source as reference. Instruments will be disconnected from ZSync if clock source is changed to Internal or External.
	Internal	The internal 100MHz clock is used as the frequency and time base reference.
	External	An external clock is intended to be used as the frequency and time base reference. Provide a clean and stable 10MHz or 100MHz reference to the appropriate back panel connector.
	ZSync	A ZSync clock is intended to be used as the frequency and time base reference.
Actual Input Reference Clock Source		Currently active clock source. This might differ from the Set Source choice if the set clock is not available.
	Internal	Internal 100MHz clock is actually used as the frequency and time base reference.
	External	An external clock is actually used as the frequency and time base reference.

Control/Tool	Option/Range	Description
	ZSync	ZSync clock is actually used as the frequency and time base reference.
Input Reference Clock Frequency		Indicates the frequency of the input reference clock.
		Indicates the status of the input reference clock. Green: locked. Yellow: the device is busy trying to lock onto the input reference clock signal. Red: there was an error locking onto the input reference clock signal. The instrument is currently not operational.
Output Reference Clock Enable		Enable clock signal on the reference clock output.
Output Reference Clock Frequency		Selects the frequency of the output reference clock to be 10MHz or 100MHz.
Synchronization Source		Selects the source for synchronization of channels: internal (default) or external
	Internal	Synchronization of all channels of a device that have the corresponding synchronization setting enabled.
	External	Same as internal plus synchronization to other devices via ZSync.
Load Factory Default	Load	Load the factory default settings.
Busy	grey/green	Indicates that the device is busy with either loading, saving or erasing a preset.
Error		Returns a 0 if the last preset operation was successfully completed or 1 if the last preset operation was illegal.
	0	Last preset operation was successfully completed.
	1	Last preset operation was illegal.
Error LED	grey/red	Turns red if the last operation was illegal.
Interface		Active interface between device and data server. In case multiple options are available, the priority as indicated on the left applies.
MAC Address	80:2F:DE:xx:xx:xx	MAC address of the device. The MAC address is defined statically, cannot be changed and is unique for each device.
IPv4 Address	default 192.168.1.10	Current IP address of the device. This IP address is assigned dynamically by a DHCP server, defined statically, or is a fall-back IP address if the DHCP server could not be found (for point to point connections).
Static IP	ON / OFF	Enable this flag if the device is used in a network with fixed IP assignment without a DHCP server.
IPv4 Address	default 192.168.1.10	Static IP address to be written to the device.
IPv4 Mask	default 255.255.255.0	Static IP mask to be written to the device.
Gateway	default 192.168.1.1	Static IP gateway
Program	Program	Click to program the specified IPv4 address, IPv4 Mask and Gateway to the device.
Pending	integer value	Number of buffers ready for receiving command packets from the device.
Processing	integer value	Number of buffers being processed for command packets. Small values indicate proper performance. For a TCP/IP interface, command packets are sent using the TCP protocol.
Packet Loss	integer value	Number of command packets lost since device start. Command packets contain device settings that are sent to and received from the device.

Control/Tool	Option/Range	Description
Bandwidth	numeric value	Command streaming bandwidth usage on the physical network connection between device and data server.
Pending	integer value	Number of buffers ready for receiving data packets from the device.
Processing	integer value	Number of buffers being processed for data packets. Small values indicate proper performance. For a TCP/IP interface, data packets are sent using the UDP protocol.
Packet Loss	integer value	Number of data packets lost since device start. Data packets contain measurement data.
Bandwidth	numeric value	Data streaming bandwidth usage on the physical network connection between device and data server.

5.18. File Manager Tab

The File Manager tab provides a quick access to measurement files, log files and setting files in the local file system.

5.18.1. Features

- Quick access to measurement files, log files and settings files
- File preview for settings files and log files

5.18.2. Description

The File Manager tab provides standard tools to see and organize the files relevant for the use of the instrument. Files can be conveniently copied, renamed and deleted. Whenever the tab is closed or an additional one of the same type is needed, clicking the following icon will open a new instance of the tab.

Table 5.43: App icon and short description

Control/Tool	Option/Range	Description
Files	🗀	Access settings and measurement data files on the host computer.

The Files tab (see LabOne UI: File Manager tab) provides three windows for exploring. The left window allows one to browse through the directory structure, the center window shows the files of the folder selected in the left window, and the right window displays the content of the file selected in the center window, e.g. a settings file or log file.

Figure 5.31: LabOne UI: File Manager tab

5.18.3. Functional Elements

Table 5.44: File tab

Control/Tool	Option/Range	Description
New Folder	New Folder	Create new folder at current location.
Rename	Rename	Rename selected file or folder.

Control/ Tool	Option/ Range	Description
Delete	Delete	Delete selected file(s) and/or folder(s).
Copy	Copy	Copy selected file(s) and/or folder(s) to Clipboard.
Cut	Cut	Cut selected file(s) and/or folder(s) to Clipboard.
Paste	Paste	Paste file(s) and/or folder(s) from Clipboard to the selected directory.
Upload	Upload	Upload file(s) and/or folder(s) to the selected directory.
Download	Download	Download selected file(s) and/or folder(s).

5.19. ZI Labs Tab

The ZI Labs tab contains experimental LabOne functionalities added by the ZI development team. The settings found here are often relevant to special applications, but have not yet found their definitive place in one of the other LabOne tabs. Naturally this tab is subject to frequent changes, and the documentation of the individual features would go beyond the scope of this user manual. Clicking the following icon will open a new instance of the tab.

Table 5.45: App Icon and short description

Control/Tool	Option/Range	Description
ZI Labs		Experimental settings and controls.

5.20. Upgrade Tab

The Upgrade tab serves as a source of information about the possible upgrade options for the instrument in use. The tab has no functional purpose but provides the user with a quick link to further information about the upgrade options online.

6. Specifications

Important

Unless otherwise stated, all specifications apply after 30 minutes of instrument warm-up.

Important

Important changes in the specification parameters are explicitly mentioned in the revision history of this document.

6.1. General Specifications

Table 6.1: General and storage

Parameter	Min	Typ	Max
storage temperature	−25 °C	-	65 °C
storage relative humidity (non-condensing)	-	-	95%
operating temperature	5 °C	-	40 °C
operating relative humidity (non-condensing)	-	-	90%
specification temperature	18 °C	-	28 °C
power consumption	-	-	300 W
operating environment	IEC61010, indoor location, installation category II, pollution degree 2		
operating altitude	up to 2000 meters		
power inlet fuses	250 V, 2 A, fast acting, 5 x 20 mm		
power supply AC line	100-240 V (±10%), 50/60 Hz		
dimensions (width x depth x height)	45.0 × 39.7 × 13.2 cm (no handle), 17.7 × 15.6 × 5.2 inch, 19 inch rack compatible		
weight	15 kg (33 lb)		
recommended calibration interval	2 years		

Table 6.2: Maximum ratings

Parameter	Min	Typ	Max
damage threshold Signal Out	-10 V	-	+10 V
damage threshold Signal In	-3 V	-	+3 V
damage threshold Trig Out	−0.7 V	-	+4 V
damage threshold Ref/Trig In (1 kΩ input impedance)	−11 V	-	+11 V
damage threshold Ref/Trig In (50 Ω input impedance)	−6 V	-	+6 V
damage threshold Aux In (DC)	-10 V	-	+10 V
damage threshold Aux In (AC)	-3 V	-	+3 V
damage threshold External Clk In (DC)	−3 V	-	+3 V
damage threshold External Clk In (AC, with DC offset 0 V)	-1.5 V	-	+1.5 V
damage threshold External Clk Out (DC)	−3 V	-	+3 V

Parameter	Min	Typ	Max
MDS In / Out	−0.7 V	-	+4 V
DIO In / Out in default configuration 3.3 V CMOS/TTL	−0.7 V	-	+4 V
torque limit front panel SMA connectors	-	-	0.5 Nm
torque limit back panel SMA connectors	-	-	1.0 Nm

Table 6.3: Host computer requirements

Parameter	Description
supported Windows operating systems	Windows 10, 11 on x86-64
supported macOS operating systems	macOS 10.11+ on x86-64 and ARMv8
supported Linux distributions	GNU/Linux (Ubuntu 14.04+, CentOS 7+, Debian 8+) on x86-64 and ARMv8
supported processors	x86-64 (Intel, AMD), ARMv8 (e.g., Raspberry Pi 4 and newer, Apple M-series)

6.2. Analog Interface Specifications

Table 6.4: Signal Outputs

Parameter	Details	Min	Typ	Max
connectors	-	SMA, front panel single-ended		
impedance	-	-	50 Ω	-
coupling	Baseband	AC/DC		
	RF	AC		
D/A converter vertical resolution	-	14 bit		
D/A converter sampling rate	after internal x3 interpolation	6 GSa/s		
measurement band	RF (measurement band around the selected center frequency)	±500 MHz		
	Baseband	800 MHz		
total frequency range		DC	-	8.5 GHz
power range (into 50Ω)	Baseband	-30 dBm	-	+5 dBm
	RF	-30 dBm	-	+10 dBm
amplitude range (into 50Ω)	Baseband	10 mV$_{pk}$	-	0.5 V$_{pk}$
	RF	10 mV$_{pk}$	-	1 V$_{pk}$
level accuracy	into 50 Ω, in a selected amplitude range	-	±1 dBm	-
frequency resolution	-	7 µHz		
phase noise	100 MHz (Baseband)	offset 0.1 kHz	-	-141 dBc/Hz	-
		offset 1 kHz	-	-156.1 dBc/Hz	-

Parameter	Details		Min	Typ	Max
	1 GHz (RF)	offset 0.1 kHz	-	-102 dBc/Hz	-
		offset 1 kHz	-	-111 dBc/Hz	-
		offset 10 kHz	-	-114 dBc/Hz	-
		offset 100 kHz	-	-117 dBc/Hz	-
	4 GHz (RF)	offset 0.1 kHz	-	-99 dBc/Hz	-
		offset 1 kHz	-	-108 dBc/Hz	-
		offset 10 kHz	-	-114 dBc/Hz	-
		offset 100 kHz	-	-117 dBc/Hz	-
	6 GHz (RF)	offset 0.1 kHz	-	-101 dBc/Hz	-
		offset 1 kHz	-	-111 dBc/Hz	-
		offset 10 kHz	-	-112 dBc/Hz	-
		offset 100 kHz	-	-115 dBc/Hz	-
	8 GHz (RF)	offset 0.1 kHz	-	-97 dBc/Hz	-
		offset 1 kHz	-	-107 dBc/Hz	-
		offset 10 kHz	-	-111 dBc/Hz	-
		offset 100 kHz	-	-113 dBc/Hz	-
voltage spectral noise density	Baseband, 300 mV$_{pk}$ range, into 50 Ω	100 MHz	-	8.6 nV/$\sqrt{\text{Hz}}$	-
	RF, 1 V$_{pk}$ range, into 50 Ω, center freq offset > 200 kHz	1 GHz	-	40 nV/$\sqrt{\text{Hz}}$	-
		4 GHz	-	23 nV/$\sqrt{\text{Hz}}$	-
		6 GHz	-	14 nV/$\sqrt{\text{Hz}}$	-
		8 GHz	-	14 nV/$\sqrt{\text{Hz}}$	-

Table 6.5: Signal Inputs

Parameter	Details	Min	Typ	Max
connectors	-	SMA, front panel single-ended		
impedance	-	-	50 Ω	-
coupling	Baseband	AC/DC		
	RF	AC		
A/D converter vertical resolution	-	14 bit		

Parameter	Details		Min	Typ	Max
A/D converter sampling rate	before internal x2 decimation		4 GSa/s		
measurement band	RF (measurement band around the selected center frequency)		±500 MHz		
	Baseband		800 MHz		
total frequency range			DC	-	8.5 GHz
power range (into 50 Ω)	Baseband		-30 dBm	-	+10 dBm
	RF		-50 dBm	-	+10 dBm
amplitude range (into 50 Ω)	Baseband		10 mV$_{pk}$	-	1 V$_{pk}$
	RF		1 mV$_{pk}$	-	1 V$_{pk}$
offset amplitude	Baseband		-	5%	-
voltage spectral noise density	Baseband, 100 kHz - 800 MHz, 10 mV range		-	≤3.5 nV/√Hz	-
	RF, > 800 MHz, 10 mV range		-	≤2.5 nV/√Hz	-
spurious free dynamic range (excluding harmonics)	signal at center frequency, max. amplitude, -500 to 500 MHz	10 dBm	-	52 dBc	-
		0 dBm	-	52 dBc	-
		-10 dBm	-	52 dBc	-
		-20 dBm	-	47 dBc	-
		-30 dBm	-	52 dBc	-
		-40 dBm	-	52 dBc	-
		-45 dBm	-	47 dBc	-
		-50 dBm	-	42 dBc	-
3rd order intermodulation distortion	dual tone with -7 dBFS of range with 150 MHz Splitting from 1 GHz to 8 GHz	10 dBm	-	45 dBc	-
		0 dBm	-	54 dBc	-
		-10 dBm	-	54 dBc	-
		-20 dBm	-	56 dBc	-
		-30 dBm	-	54 dBc	-
		-40 dBm	-	50 dBc	-
		-50 dBm	-	40 dBc	-

Table 6.6: Demodulators

Parameter	Details		Min	Typ	Max
number of demodulators	-		8		
demodulator harmonic setting range	-		1	-	1023
demodulator filter time constant	-		14 ns	-	21 s
demodulator filter bandwidth	-		3.2 mHz	-	11 MHz (with filter bypass)
demodulator filter slope/roll-off	-		6, 12, 18, 24 dB, consisting of 4 cascaded filters		
data transfer	>1 Gbit/s undisturbed connection to the host computer	Continuous	-	-	2 MSa/s
		Triggered	-	-	50 MSa/s

Table 6.7: Auxiliary outputs and inputs

Parameter	Details	min	typ	max
high-speed auxiliary output	connectors	BNC, 4 outputs on front panel		
	sampling	50 MSa/s, 14 bit		
	bandwidth (3 dB)	15 MHz		
	impedance	50 Ω		
	amplitude (into 50 Ω)	-4 V	-	+4 V
high-precision auxiliary output	connectors	BNC, 4 outputs on front panel		
	sampling	1 MSa/s, 18 bit		
	bandwidth (3 dB)	200 kHz		
	impedance	50 Ω		
	amplitude (into 50 Ω)	-4 V	-	+4 V

Table 6.8: Trigger Outputs & Inputs

Parameter	Details	Min	Typ	Max
trigger outputs	-	2 per channel, SMA output on front panel		
trigger output high voltage	-	-	3.3 V	-
trigger output low voltage	-	-	0 V	-
trigger output impedance	-	-	50 Ω	-
trigger output rise time 20% to 80%	-	-	300 ps	-
trigger output period jitter	square wave, 100 MHz	-	60 ps p-p	-
trigger inputs	-	2 per channel, 2 SMA on front panel		
trigger input impedance	-	50 Ω / 1 kΩ		
trigger input voltage range	50 Ω impedance	−5 V	-	5 V
	1 kΩ impedance	−10 V	-	10 V
trigger input threshold range	50 Ω impedance	−5 V	-	5 V
	1 kΩ impedance	−10 V	-	10 V
trigger input threshold resolution	-	-	< 0.4 mV	-
trigger input threshold hysteresis	-	-	> 60 mV	-
trigger input min. pulse width	-	-	5 ns	-

Parameter	Details	Min	Typ	Max
trigger input max. operating frequency	-	-	300 MHz	-

Table 6.9: Other Inputs and Outputs

Parameter	Details	min	Typ	Max
reference clock input	-	SMA on back panel		
reference clock input impedance	-	50 Ω, AC coupled		
reference clock input frequency	-	10 / 100 MHz		
reference clock input amplitude	10 MHz	-4 dBm	-	+13 dBm
	100 MHz	−5 dBm	-	+13 dBm
reference clock output	-	SMA on back panel		
reference clock output impedance		50 Ω, AC coupled		
reference clock output amplitude	into 50 Ω	2 Vpp	-	5 Vpp
reference clock output frequency		10/100 MHz		
reference clock output jitter	derived from integrated phase noise measurement (12 kHz to 20 MHz offset frequency)	-	280 fs RMS	-

Table 6.10: Oscillator and Clocks

Parameter	Details	Min	Typ	Max
internal clock type	-	OCXO		
internal clock long term accuracy / aging	-	-	-	±0.3 ppm/year
internal clock short term stability (1 s)	-	-	-	±0.05 ppm
internal clock initial accuracy	-	-	-	±0.5 ppm
internal clock temperature stability	−20°C to 70°C	-	-	±0.5 ppm
internal clock phase noise	offset 100 Hz	-	−135 dBc/Hz	-
	offset 1 kHz	-	−157 dBc/Hz	-

6.3. Digital Interface Specifications

Table 6.11: Digital Interfaces

Parameter	Description
host computer connection	USB 3.0, 1.6 Gbit/s (1 communication, 1 maintenance)
	1GbE, LAN / Ethernet, 1 Gbit/s
DIO port	4 x 8 bit, general purpose digital input/output port, 3.3 V TTL specification
ZSync peripheral port	connector for ZI proprietary bus to communicate with external peripherals (2 times)

6.3.1. DIO Port

The DIO port is a VHDCI 68 pin connector as introduced by the SPI-3 document of the SCSI-3 specification. It is a female connector that requires a 32 mm wide male connector. The interface standard is switchable between LVDS (low-voltage differential signalling) and LVCMOS/LVTTL. The DIO port features 32 user-controlled bits that can all be configured byte-wise as inputs or outputs in LVCMOS/LVTTL mode, whereas in LVDS mode, half of the bits are always configured as inputs. For more specifics on how the user-definable pins can be set.

Figure 6.1: DIO HD 68 pin connector

Table 6.12: Electrical Specifications

Parameter	Details	Min	Typ	Max
supported DIO interface standards	-	LVCMOS/LVTTL (single-ended, 3.3 V); LVDS (differential)		
high-level input voltage VIH	LVCMOS/ LVTTL	2.0 V	-	-
low-level input voltage VIL	LVCMOS/ LVTTL	-	-	0.8 V
high-level output voltage VOH	LVCMOS/ LVTTL at IOH < 12 mA	2.6 V	-	-
low-level output voltage VOL	LVCMOS/ LVTTL at IOL < 12 mA	-	-	0.4 V
high-level output current IOH (sourcing)	LVCMOS/ LVTTL	-	-	12 mA
low-level output current IOL (sinking)	LVCMOS/ LVTTL	-	-	12 mA
input differential voltage VID	LVDS	100 mV	-	600 mV
input common-mode voltage VICM	LVDS	0.3 V	-	2.35 V
output differential voltage VOD	LVDS	247 mV	-	454 mV
output common-mode voltage VOCM	LVDS	1.125 V	-	1.375 V

Table 6.13: DIO Pin Assignment in LVCMOS/LVTTL Mode

Pin	Name	Description
68	CLKI	digital input
67	unused	leave unconnected
66 .. 59	DIO[31:24]	digital input or output byte (set by user)
58 .. 51	DIO[23:16]	digital input or output byte (set by user)
50 .. 43	DIO[15:8]	digital input or output byte (set by user)

Pin	Name	Description
42 .. 35	DIO[7:0]	digital input or output byte (set by user)
34	GND	digital ground
33	unused	leave unconnected
32 .. 1	GND	digital ground

Table 6.14: DIO Pin Assignment in LVDS Mode

Pin	Name	Description
68	CLKI+	digital input
67	unused	leave unconnected
66 .. 59	DI+[31:24]	digital input byte
58 .. 51	DI+[23:16]	digital input byte
50 .. 43	DIO+[15:8]	digital input or output byte (set by user)
42 .. 35	DIO+[7:0]	digital input or output byte (set by user)
34	CLKI−	digital input
33	unused	leave unconnected
32 .. 25	DI−[31:24]	digital input byte
24 .. 17	DI−[23:16]	digital input byte
16 .. 9	DIO−[15:8]	digital input or output byte (set by user)
8 .. 1	DIO−[7:0]	digital input or output byte (set by user)

7. Device Node Tree

This chapter contains reference documentation for the settings and measurement data available on SHFLI Instruments. Whilst Functional Description describes many of these settings in terms of the features available in the LabOne User Interface, this chapter describes them on the device level and provides a hierarchically organized and comprehensive list of device functionality.

Since these settings and data streams may be written and read using the LabOne APIs (Application Programming Interfaces) this chapter is of particular interest to users who would like to perform measurements programmatically via LabVIEW, Python, MATLAB, .NET or C.

Please see:

- Introduction for an introduction of how the instrument's settings and measurement data are organized hierarchically in the Data Server's so-called "Node Tree".
- Reference Node Documentation for a reference list of the settings and measurement data available on SHFLI Instruments, organized by branch in the Node Tree.

7.1. Introduction

This chapter provides an overview of how an instrument's configuration and output is organized by the Data Server.

All communication with an instrument occurs via the Data Server program the instrument is connected to (see LabOne Software Architecture for an overview of LabOne's software components). Although the instrument's settings are stored locally on the device, it is the Data Server's task to ensure it maintains the values of the current settings and makes these settings (and any subscribed data) available to all its current clients. A client may be the LabOne User Interface or a user's own program implemented using one of the LabOne Application Programming Interfaces, e.g., Python.

The instrument's settings and data are organized by the Data Server in a file-system-like hierarchical structure called the node tree. When an instrument is connected to a Data Server, its device ID becomes a top-level branch in the Data Server's node tree. The features of the instrument are organized as branches underneath the top-level device branch and the individual instrument settings are leaves of these branches.

For example, the auxiliary outputs of the instrument with device ID "dev1000" are located in the tree in the branch:

```
/dev1000/auxouts/
```

In turn, each individual auxiliary output channel has its own branch underneath the "AUXOUTS" branch.

```
/dev1000/auxouts/0/
/dev1000/auxouts/1/
/dev1000/auxouts/2/
/dev1000/auxouts/3/
```

Whilst the auxiliary outputs and other channels are labelled on the instrument's panels and the User Interface using 1-based indexing, the Data Server's node tree uses 0-based indexing. Individual settings (and data) of an auxiliary output are available as leaves underneath the corresponding channel's branch:

```
/dev1000/auxouts/0/demodselect
/dev1000/auxouts/0/limitlower
/dev1000/auxouts/0/limitupper
/dev1000/auxouts/0/offset
/dev1000/auxouts/0/outputselect
/dev1000/auxouts/0/preoffset
/dev1000/auxouts/0/scale
/dev1000/auxouts/0/value
```

These are all individual node paths in the node tree; the lowest-level nodes which represent a single instrument setting or data stream. Whether the node is an instrument setting or data-stream and

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which type of data it contains or provides is well-defined and documented on a per-node basis in the Reference Node Documentation section in the relevant instrument-specific user manual. The different properties and types are explained in Node Properties and Data Types .

For instrument settings, a Data Server client modifies the node's value by specifying the appropriate path and a value to the Data Server as a (path, value) pair. When an instrument's setting is changed in the LabOne User Interface, the path and the value of the node that was changed are displayed in the Status Bar in the bottom of the Window. This is described in more detail in Exploring the Node Tree.

Module Parameters

LabOne Core Modules, such as the Sweeper, also use a similar tree-like structure to organize their parameters. Please note, however, that module nodes are not visible in the Data Server's node tree; they are local to the instance of the module created in a LabOne client and are not synchronized between clients.

7.1.1. Node Properties and Data Types

A node may have one or more of the following properties:

Property	Description
Read	Data can be read from the node.
Write	Data can be written to the node.
Setting	The node corresponds to a writable instrument configuration. The data of these nodes are persisted in snapshots of the instrument and stored in the LabOne XML settings files.
Streaming	A node with the read attribute that provides instrument data, typically at a user-configured rate. The data is usually a more complex data type, for example demodulator data is returned as `ZIDemodSample`. A full list of streaming nodes is available in the Programming Manual in the Chapter Instrument Communication. Their availability depends on the device class (e.g. MF) and the option set installed on the device.

A node may contain data of the following types:

Integer	Integer data.
Double	Double precision floating point data.
String	A string array.
Integer (enumerated)	As for Integer, but the node only allows certain values.
Composite data type	For example, `ZIDemodSample`. These custom data types are structures whose fields contain the instrument output, a timestamp and other relevant instrument settings such as the demodulator oscillator frequency. Documentation of custom data types is available in

7.1.2. Exploring the Node Tree

In the LabOne User Interface

A convenient method to learn which node is responsible for a specific instrument setting is to check the Command Log history in the bottom of the LabOne User Interface. The command in the Status Bar gets updated every time a configuration change is made. Figure 7.1 shows how the equivalent MATLAB command is displayed after modifying the value of the auxiliary output 1's offset. The format of the LabOne UI's command history can be configured in the Config Tab (MATLAB, Python and .NET are available). The entire history generated in the current UI session can be viewed by clicking the "Show Log" button.

Figure 7.1: When a device's configuration is modified in the LabOne User Interface, the Status Bar displays the equivalent command to perform the same configuration via a LabOne programming interface. Here, the MATLAB code to modify auxiliary output 1's offset value is provided. When "Show Log" is clicked the entire configuration history is displayed in a new browser tab.

In a LabOne Programming Interface

A list of nodes (under a specific branch) can be requested from the Data Server in an API client using the `listNodes` command (MATLAB, Python, .NET) or `ziAPIListNodes()` function (C API). Please see each API's command reference for more help using the `listNodes` command. To obtain a list of all the nodes that provide data from an instrument at a high rate, so-called streaming nodes, the `streamingonly` flag can be provided to `listNodes`. More information on data streaming and streaming nodes is available in the LabOne Programming Manual.

The detailed descriptions of nodes that is provided in Reference Node Documentation is accessible directly in the LabOne MATLAB or Python programming interfaces using the "help" command. The `help` command is `daq.help(path)` in Python and `ziDAQ('help', path)` in MATLAB. The command returns a description of the instrument node including access properties, data type, units and available options. The "help" command also handles wildcards to return a detailed description of all nodes matching the path. An example is provided below.

```
daq = zhinst.core.ziDAQServer('localhost', 8004, 6)
daq.help('/dev1000/auxouts/0/offset')
# Out:
# /dev1000/auxouts/0/OFFSET#
# Add the specified offset voltage to the signal after scaling. Auxiliary
Output
# Value = (Signal+Preoffset)*Scale + Offset
# Properties: Read, Write, Setting
# Type: Double
# Unit: V
```

7.1.3. Data Server Nodes

The Data Server has nodes in the node tree available under the top-level `/zi/` branch. These nodes give information about the version and state of the Data Server the client is connected to. For example, the nodes:

- `/zi/about/version`
- `/zi/about/revision`

are read-only nodes that contain information about the release version and revision of the Data Server. The nodes under the `/zi/devices/` list which devices are connected, discoverable and visible to the Data Server.

The nodes:

- `/zi/config/open`
- `/zi/config/port`

are settings nodes that can be used to configure which port the Data Server listens to for incoming client connections and whether it may accept connections from clients on hosts other than the localhost.

Nodes that are of particular use to programmers are:

- `/zi/debug/logpath` - the location of the Data Server's log in the PC's file system,
- `/zi/debug/level` - the current log-level of the Data Server (configurable; has the Write attribute),
-

`/zi/debug/log` - the last Data Server log entries as a string array.

The Global nodes of the LabOne Data Server are listed in the Instrument Communication chapter of the LabOne Programming Manual

7.2. Reference Node Documentation

This section describes all the nodes in the data server's node tree organized by branch.

7.2.1. AUXOUTS

/dev..../auxouts/n/highprecision/offset

Properties:	Read, Write, Setting
Type:	Double
Unit:	V

Adds the specified offset voltage to the signal after scaling. Auxiliary Output Value = (Signal+Preoffset)*Scale + Offset

/dev..../auxouts/n/highprecision/outputchannel

Properties:	Read, Write, Setting
Type:	Integer (64 bit)
Unit:	None

Selects the channel of the selected signal source.

/dev..../auxouts/n/highprecision/outputselect

Properties:	Read, Write, Setting
Type:	Integer (enumerated)
Unit:	None

Selects the signal source for the Auxiliary Output.

-1	"manual": Selects Manual as the output option.
0	"demod_x": Selects Demod X as the output option.
1	"demod_y": Selects Demod Y as the output option.
2	"demod_r": Select Demod R as the output option.
3	"demod_theta": Select Demod Theta as the output option.

/dev..../auxouts/n/highprecision/preoffset

Properties:	Read, Write, Setting
Type:	Double
Unit:	Dependent

Adds a pre-offset to the signal before scaling is applied. Auxiliary Output Value = (Signal+Preoffset)*Scale + Offset

/dev..../auxouts/n/highprecision/scale

Properties:	Read, Write, Setting
Type:	Double
Unit:	None

Multiplication factor to scale the signal. Auxiliary Output Value = (Signal+Preoffset)*Scale + Offset

/dev..../auxouts/n/highspeed/offset

Properties:	Read, Write, Setting
Type:	Double
Unit:	V

Adds the specified offset voltage to the signal after scaling. Auxiliary Output Value = (Signal+Preoffset)*Scale + Offset

/dev..../auxouts/n/highspeed/outputchannel

Properties:	Read, Write, Setting
Type:	Integer (64 bit)
Unit:	None

Selects the channel of the selected signal source.

/dev..../auxouts/n/highspeed/outputselect

Properties:	Read, Write, Setting
Type:	Integer (enumerated)
Unit:	None

Selects the signal source for the Auxiliary Output.

-1	"manual": Selects Manual as the output option.
0	"demod_x": Selects Demod X as the output option.
1	"demod_y": Selects Demod Y as the output option.
2	"demod_r": Select Demod R as the output option.
3	"demod_theta": Select Demod Theta as the output option.

/dev..../auxouts/n/highspeed/preoffset

Properties:	Read, Write, Setting
Type:	Double
Unit:	Dependent

Adds a pre-offset to the signal before scaling is applied. Auxiliary Output Value = (Signal+Preoffset)*Scale + Offset

/dev..../auxouts/n/highspeed/scale

Properties:	Read, Write, Setting
Type:	Double
Unit:	None

Multiplication factor to scale the signal. Auxiliary Output Value = (Signal+Preoffset)*Scale + Offset

7.2.2. CLOCKBASE

/dev..../clockbase

Properties:	Read
Type:	Double
Unit:	Hz

Returns the internal clock frequency of the device.

7.2.3. DEMODS

/dev..../demods/n/adcselect

Properties:	Read, Write, Setting
Type:	Integer (enumerated)
Unit:	None

Selects the input signal for the demodulator.

0	"sigin0", "signal_input0": Sig In 1
1	"sigin1", "signal_input1": Sig In 2

/dev..../demods/n/burstlen

Properties:	Read, Write, Setting
Type:	Integer (64 bit)
Unit:	None

Defines how many (complex) samples should be acquired with each trigger.

/dev..../demods/n/bypass

Properties:	Read, Write, Setting
Type:	Integer (enumerated)
Unit:	None

Allows to bypass the demodulator low-pass filter, thus increasing the bandwidth.

0	"disabled": disabled
1	"enabled": enabled

/dev..../demods/n/droppedvectors

Properties:	Read
Type:	Integer (64 bit)
Unit:	None

Indicates the number of times demodulator streaming data (vectors) where dropped leading to gaps in the acquired signals.

/dev..../demods/n/enable

Properties:	Read, Write, Setting
Type:	Integer (enumerated)
Unit:	None

Enables the data acquisition for the corresponding demodulator. Note: increasing number of active demodulators increases load on the physical connection to the host computer.

0	"off": OFF: demodulator inactive
1	"on": ON: demodulator active

/dev..../demods/n/freq

Properties:	Read
Type:	Double
Unit:	Hz

Indicates the frequency used for demodulation and for output generation. The demodulation frequency is calculated with oscillator frequency times the harmonic factor. When the MOD option is used linear combinations of oscillator frequencies including the harmonic factors define the demodulation frequencies.

/dev..../demods/n/harmonic

Properties:	Read, Write, Setting
Type:	Integer (64 bit)
Unit:	None

Multiplies the demodulator's reference frequency by an integer factor. If the demodulator is used as a phase detector in external reference mode (PLL), the effect is that the internal oscillator locks to the external frequency divided by the integer factor.

/dev..../demods/n/missedtrigbusy

Properties:	Read
Type:	Integer (64 bit)
Unit:	None

Indicates the number of times the acquisition unit was busy (still recording previous burst) and a trigger was omitted.

/dev..../demods/n/missedtrigfull

Properties:	Read
Type:	Integer (64 bit)
Unit:	None

Indicates the number of times the memory was full and a trigger was omitted.

/dev..../demods/n/order

Properties:	Read, Write, Setting
Type:	Integer (enumerated)
Unit:	None

Selects the filter roll off between 6 dB/oct and 24 dB/oct.

1	1st order filter 6 dB/oct
2	2nd order filter 12 dB/oct
3	3rd order filter 18 dB/oct
4	4th order filter 24 dB/oct

/dev..../demods/n/oscselect

Properties:	Read, Write, Setting
Type:	Integer (enumerated)
Unit:	None

Connects the demodulator with the supplied oscillator. Number of available oscillators depends on the installed options.

0	Oscillator 1
1	Oscillator 2
2	Oscillator 3
3	Oscillator 4
4	Oscillator 5
5	Oscillator 6
6	Oscillator 7
7	Oscillator 8

/dev..../demods/n/phaseshift

Properties:	Read, Write, Setting
Type:	Double
Unit:	deg

Phase shift applied to the reference input of the demodulator.

/dev..../demods/n/rate

Properties:	Read, Write, Setting
Type:	Double
Unit:	1/s

Defines the demodulator sampling rate, the number of samples that are sent to the host computer per second. A rate of about 7-10 higher as compared to the filter bandwidth usually provides sufficient aliasing suppression. This is also the rate of data received by LabOne Data Server and saved to the computer hard disk. This setting has no impact on the sample rate on the auxiliary outputs connectors. Note: the value inserted by the user may be approximated to the nearest value supported by the instrument.

/dev..../demods/n/sample

Properties:	Read, Stream
Type:	ZIVectorData
Unit:	Dependent

Contains streamed demodulator samples with sample interval defined by the demodulator data rate.

/dev..../demods/n/timeconstant

Properties:	Read, Write, Setting
Type:	Double
Unit:	s

Sets the integration time constant or in other words, the cutoff frequency of the demodulator low pass filter.

/dev..../demods/n/trigger/mode

Properties:	Read, Write, Setting
Type:	Integer (enumerated)
Unit:	None

Selects the trigger mode.

1	"rising_edge": Demodulator data is streamed to the host computer on the trigger's rising edge.
2	"falling_edge": Demodulator data is streamed to the host computer on the trigger's falling edge.
3	"both_edge": Demodulator data is streamed to the host computer on both trigger's edges.

/dev..../demods/n/trigger/source

Properties:	Read, Write, Setting
Type:	Integer (enumerated)
Unit:	None

Selects the trigger input for the demodulator.

0	"trigin1": Trigger input 1.
1	"trigin2": Trigger input 2.
2	"trigin3": Trigger input 3.
3	"trigin4": Trigger input 4.
1024	"swtrig0", "software_trigger0": Software Trigger 1.

/dev..../demods/n/trigger/triggeracq

Properties:	Read, Write, Setting
Type:	Integer (enumerated)
Unit:	None

Enables the triggered acquisition.

0	"continuous": Continuous Demodulator data acquisition (triggering is disabled).
1	"triggered": Triggered Demodulator data acquisition.

7.2.4. DIOS

/dev..../dios/n/drive

Properties:	Read, Write, Setting
Type:	Integer (64 bit)
Unit:	None

When on (1), the corresponding 8-bit bus is in output mode. When off (0), it is in input mode. Bit 0 corresponds to the least significant byte. For example, the value 1 drives the least significant byte, the value 8 drives the most significant byte.

/dev..../dios/n/input

Properties:	Read
Type:	Integer (64 bit)
Unit:	None

Gives the value of the DIO input for those bytes where drive is disabled.

/dev..../dios/n/interface

Properties:	Read, Write, Setting
Type:	Integer (64 bit)
Unit:	None

Selects the interface standard to use on the 32-bit DIO interface. A value of 0 means that a 3.3 V CMOS interface is used. A value of 1 means that an LVDS compatible interface is used.

/dev..../dios/n/mode

Properties:	Read, Write, Setting
Type:	Integer (enumerated)
Unit:	None

Select DIO mode

0	"manual": Enables manual control of the DIO output bits.

/dev..../dios/n/output

Properties:	Read, Write, Setting
Type:	Integer (64 bit)
Unit:	None

Sets the value of the DIO output for those bytes where 'drive' is enabled.

7.2.5. EXTREFS

/dev..../extrefs/n/adcselect

Properties:	Read
Type:	Integer (enumerated)
Unit:	None

Indicates the input signal selection for the selected demodulator.

0	"sigin0", "signal_input0": Signal Input 1 is connected to the corresponding demodulator.
1	"sigin1", "signal_input1": Signal Input 2 is connected to the corresponding demodulator.
8	"auxin0", "auxiliary_input0": Auxiliary Input 1 is connected to the corresponding demodulator.

/dev..../extrefs/n/automode

Properties:	Read, Write, Setting
Type:	Integer (enumerated)
Unit:	None

This defines the type of automatic adaptation of parameters in the PID used for Ext Ref.

2	"low_bandwidth", "pid_coeffs_filter_low_bw": The PID coefficients, the filter bandwidth and the output limits are automatically set using a low bandwidth.
3	"high_bandwidth", "pid_coeffs_filter_high_bw": The PID coefficients, the filter bandwidth and the output limits are automatically set using a high bandwidth.
4	"all", "pid_coeffs_filter_auto_bw": The PID coefficient, the filter bandwidth and the output limits are dynamically adapted.

/dev..../extrefs/n/demodselect

Properties:	Read
Type:	Integer (64 bit)
Unit:	None

Indicates the demodulator connected to the extref channel.

/dev..../extrefs/n/enable

Properties:	Read, Write, Setting
Type:	Integer (64 bit)
Unit:	None

Enables the external reference.

/dev..../extrefs/n/locked

Properties:	Read
Type:	Integer (64 bit)
Unit:	None

Indicates whether the external reference is locked.

/dev..../extrefs/n/oscselect

Properties:	Read
Type:	Integer (64 bit)
Unit:	None

Indicates which oscillator is being locked to the external reference.

7.2.6. FEATURES

/dev..../features/code

Properties:	Write
Type:	String
Unit:	None

Node providing a mechanism to enter feature codes into the instrument.

/dev..../features/devtype

Properties:	Read
Type:	String
Unit:	None

Returns the device type.

/dev..../features/options

Properties:	Read
Type:	String
Unit:	None

Returns enabled options.

/dev..../features/serial

Properties:	Read
Type:	String
Unit:	None

Device serial number.

7.2.7. OSCS

/dev..../oscs/n/freq

Properties:	Read, Write, Setting
Type:	Double
Unit:	Hz

Frequency control for each oscillator.

7.2.8. PIDS

/dev..../pids/n/center

Properties:	Read, Write, Setting
Type:	Double
Unit:	Dependent

Sets the center value for the PID output. After adding the Center value, the signal is clamped to Center + Lower Limit and Center + Upper Limit.

/dev..../pids/n/d

Properties:	Read, Write, Setting
Type:	Double
Unit:	Dependent

PID derivative gain.

/dev..../pids/n/demod/adcselect

Properties:	Read
Type:	Integer (enumerated)
Unit:	None

Indicates the signal source which is connected to the chosen input demodulator channel.

0	"sigin0", "signal_input0": Signal Input 1 is connected to the corresponding demodulator.
1	"sigin1", "signal_input1": Signal Input 2 is connected to the corresponding demodulator.

/dev..../pids/n/demod/harmonic

Properties:	Read, Write, Setting
Type:	Integer (64 bit)
Unit:	None

Multiplier of the for the reference frequency of the current demodulator.

/dev..../pids/n/demod/order

Properties:	Read, Write, Setting
Type:	Integer (enumerated)
Unit:	None

Selects the filter roll off between 6 dB/oct and 48 dB/oct of the current demodulator.

1	1st order filter 6 dB/oct
2	2nd order filter 12 dB/oct
3	3rd order filter 18 dB/oct
4	4th order filter 24 dB/oct
5	5th order filter 30 dB/oct
6	6th order filter 36 dB/oct
7	7th order filter 42 dB/oct
8	8th order filter 48 dB/oct

/dev..../pids/n/demod/timeconstant

Properties:	Read, Write, Setting
Type:	Double
Unit:	s

Defines the characteristic time constant (cut off) of the demodulator filter used as an input.

/dev..../pids/n/dlimittimeconstant

Properties:	Read, Write, Setting
Type:	Double
Unit:	s

The cutoff of the low-pass filter for the D limitation given as time constant. When set to 0, the low-pass filter is disabled.

/dev..../pids/n/enable

Properties:	Read, Write, Setting
Type:	Integer (64 bit)
Unit:	None

Enable the PID controller.

/dev..../pids/n/error

Properties:	Read
Type:	Double
Unit:	Dependent

Error = Set point - PID Input.

/dev..../pids/n/i

Properties:	Read, Write, Setting
Type:	Double
Unit:	Dependent

PID integral gain I.

/dev..../pids/n/input

Properties:	Read, Write, Setting
Type:	Integer (enumerated)
Unit:	None

Select input source of PID controller.

0	"demod_x": Demodulator X
1	"demod_y": Demodulator Y
2	"demod_r": Demodulator R
3	"demod_theta": Demodulator Theta

/dev..../pids/n/inputchannel

Properties:	Read, Write, Setting
Type:	Integer (64 bit)
Unit:	None

Select input channel of PID controller.

/dev..../pids/n/keepint

Properties:	Read, Write, Setting
Type:	Integer (64 bit)
Unit:	Dependent

If enabled, the accumulated integral error is maintained upon restart of the PID. If is disabled, the integral error is set to zero when the PID is disabled.

/dev..../pids/n/limitlower

Properties:	Read, Write, Setting
Type:	Double
Unit:	Dependent

Sets the lower limit for the PID output. After adding the Center value, the signal is clamped to Center + Lower Limit and Center + Upper Limit.

/dev..../pids/n/limitupper

Properties:	Read, Write, Setting
Type:	Double
Unit:	Dependent

Sets the upper limit for the PID output. After adding the Center value, the signal is clamped to Center + Lower Limit and Center + Upper Limit.

/dev..../pids/n/mode

Properties:	Read, Write, Setting
Type:	Integer (enumerated)
Unit:	None

Sets the operation mode of the PID module.

0	"pid": PID
1	"pll": PLL (phase locked loop)
2	"extref": ExtRef (external reference)

/dev..../pids/n/output

Properties:	Read, Write, Setting
Type:	Integer (enumerated)
Unit:	None

Select output of the PID controller.

0	"sigout0_amp", "signal_output0_amplitude": Driving Signal Output 1 amplitudes
1	"sigout1_amp", "signal_output1_amplitude": Driving Signal Output 2 amplitudes
2	"oscillator_frequency": Controlling any of the internal oscillator frequencies

/dev..../pids/n/outputchannel

Properties:	Read, Write, Setting
Type:	Integer (64 bit)
Unit:	None

Select the output channel of the driven output of PID controller.

/dev..../pids/n/p

Properties:	Read, Write, Setting
Type:	Double
Unit:	Dependent

PID Proportional gain P.

/dev..../pids/n/phaseunwrap

Properties:	Read, Write, Setting
Type:	Integer (64 bit)
Unit:	None

Enables the phase unwrapping to track phase errors past the +/-180 degree boundary and increase PLL bandwidth.

/dev..../pids/n/pll/automode

Properties:	Read, Write, Setting
Type:	Integer (enumerated)
Unit:	None

This defines the type of automatic adaptation of parameters in the PID.

0	"no_adaption": No automatic adaption.
1	"pid_coeffs": The PID coefficients are automatically set based on the filter parameters.
2	"pid_coeffs_filter_low_bw": The PID coefficients, the filter bandwidth and the output limits are automatically set using a low bandwidth.
3	"pid_coeffs_filter_high_bw": The PID coefficients, the filter bandwidth and the output limits are automatically set using a high bandwidth.

/dev..../pids/n/pll/locked

Properties:	Read
Type:	Integer (64 bit)
Unit:	None

Indicates when the PID, configured as PLL, is locked.

/dev..../pids/n/rate

Properties:	Read, Write, Setting
Type:	Double
Unit:	1/s

PID sampling rate and update rate of PID outputs. Needs to be set substantially higher than the targeted loop filter bandwidth.

/dev..../pids/n/setpoint

Properties:	Read, Write, Setting
Type:	Double
Unit:	Dependent

PID controller setpoint

/dev..../pids/n/shift

Properties:	Read
Type:	Double
Unit:	Dependent

Difference between the current output value Out and the Center. Shift = PError + IInt(Error, dt) + D*dError/dt

/dev..../pids/n/value

Properties:	Read
Type:	Double
Unit:	Dependent

Gives the current PID output value.

7.2.9. SCOPES

/dev..../scopes/n/averaging/count

Properties:	Read, Write, Setting
Type:	Integer (64 bit)
Unit:	None

Configures the number of Scope measurements to average.

/dev..../scopes/n/averaging/enable

Properties:	Read, Write, Setting
Type:	Integer (64 bit)
Unit:	None

Enables averaging of Scope measurements.

/dev..../scopes/n/channels/n/enable

Properties:	Read, Write, Setting
Type:	Integer (64 bit)
Unit:	Dependent

Enables recording for this Scope channel.

/dev..../scopes/n/channels/n/inputselect

Properties:	Read, Write, Setting
Type:	Integer (enumerated)
Unit:	None

Selects the scope input signal.

0	"sigin0", "signal_input0": Signal Input Channel 1
1	"sigin1", "signal_input1": Signal Input Channel 2
8	Aux Input Channel 1
9	Aux Input Channel 2
16	"auxin0", "auxiliary_input0": Aux Input Channel 1
17	"auxin1", "auxiliary_input1": Aux Input Channel 2

/dev..../scopes/n/channels/n/wave

Properties:	Read
Type:	ZIVectorData
Unit:	Dependent

Contains the acquired Scope measurement data.

/dev..../scopes/n/enable

Properties:	Read, Write, Setting
Type:	Integer (64 bit)
Unit:	None

Enables the acquisition of scope shots.

/dev..../scopes/n/length

Properties:	Read, Write, Setting
Type:	Integer (64 bit)
Unit:	None

Defines the length of the recorded Scope shot in number of samples.

/dev..../scopes/n/segments/count

Properties:	Read, Write, Setting
Type:	Integer (64 bit)
Unit:	None

Specifies the number of segments to be recorded in device memory. The maximum scope shot size is given by the available memory divided by the number of segments. This functionality requires the DIG option.

/dev..../scopes/n/segments/enable

Properties:	Read, Write, Setting
Type:	Integer (64 bit)
Unit:	None

Enable segmented scope recording. This allows for full bandwidth recording of scope shots with a minimum dead time between individual shots. This functionality requires the DIG option.

/dev..../scopes/n/single

Properties:	Read, Write, Setting
Type:	Integer (64 bit)
Unit:	None

Puts the Scope into single shot mode.

/dev..../scopes/n/time

Properties:	Read, Write, Setting
Type:	Integer (64 bit)
Unit:	None

Defines the time base of the scope from the divider exponent of the instrument's clock base. The resulting sampling time is 2^n/clockbase.

/dev..../scopes/n/trigger/channel

Properties:	Read, Write, Setting
Type:	Integer (enumerated)
Unit:	None

Selects the trigger source signal.

0	"trigin1": Trigger Input 1.
1	"trigin2": Trigger Input 2.
2	"trigin3": Trigger Input 3.
3	"trigin4": Trigger Input 4.
1024	"swtrig0", "software_trigger0": Software Trigger 1.

/dev..../scopes/n/trigger/delay

Properties:	Read, Write, Setting
Type:	Double
Unit:	s

The delay of a Scope measurement. A negative delay results in data being acquired before the trigger point. The resolution is 2 ns.

/dev..../scopes/n/trigger/enable

Properties:	Read, Write, Setting
Type:	Integer (enumerated)
Unit:	None

When triggering is enabled scope data are acquired every time the defined trigger condition is met.

0	"off": OFF: Continuous scope shot acquisition
1	"on": ON: Trigger based scope shot acquisition

7.2.10. SIGINS

/dev..../sigins/n/ac

Properties:	Read, Write, Setting
Type:	Integer (enumerated)
Unit:	None

Defines the input coupling for the Signal Inputs. AC coupling inserts a high-pass filter.

0	"dc": OFF: DC coupling
1	"ac": ON: AC coupling

/dev..../sigins/n/on

Properties:	Read, Write, Setting
Type:	Integer (64 bit)
Unit:	None

Enables the signal input.

/dev..../sigins/n/overrangecount

Properties:	Read
Type:	Integer (64 bit)
Unit:	None

Indicates the number of times the Signal Input was in an overrange condition within the last 200 ms. It is checked for an overrange condition every 10 ms.

/dev..../sigins/n/range

Properties:	Read, Write, Setting
Type:	Double
Unit:	dBm

Sets the maximal Range of the Signal Input power. The instrument selects the closest available Range with a resolution of 5 dBm.

/dev..../sigins/n/rfpath

Properties:	Read, Write, Setting
Type:	Integer (enumerated)
Unit:	None

Switches between radio frequency and baseband signal paths.

0	"BB": Baseband path
1	"RF": Radio frequency path

7.2.11. SIGOUTS

/dev..../sigouts/n/filter

Properties:	Read
Type:	Integer (enumerated)
Unit:	None

Reads the selected analog filter before the Signal Output.

0	"lowpass_1500": Low-pass filter of 1.5 GHz.
1	"lowpass_3000": Low-pass filter of 3 GHz.
2	"bandpass_3000_6000": Band-pass filter between 3 GHz - 6 GHz
3	"bandpass_6000_10000": Band-pass filter between 6 GHz - 10 GHz

/dev..../sigouts/n/generators/n/amplitude

Properties:	Read, Write, Setting
Type:	Double
Unit:	V

Sets the amplitude of the generator output.

/dev..../sigouts/n/generators/n/enable

Properties:	Read, Write, Setting
Type:	Integer (64 bit)
Unit:	None

Enables (1) or disables (0) the generator output.

/dev..../sigouts/n/on

Properties:	Read, Write, Setting
Type:	Integer (64 bit)
Unit:	None

Enabling/Disabling the Signal Output. Corresponds to the blue LED indicator on the instrument front panel.

/dev..../sigouts/n/overrangecount

Properties:	Read
Type:	Integer (64 bit)
Unit:	None

Indicates the number of times the Signal Output was in an overrange condition within the last 200 ms. It is checked for an overrange condition every 10 ms.

/dev..../sigouts/n/range

Properties:	Read, Write, Setting
Type:	Double
Unit:	dBm

Sets the maximal Range of the Signal Output power. The instrument selects the closest available Range with a resolution of 5 dBm.

/dev..../sigouts/n/rfinterlock

Properties:	Read, Write, Setting
Type:	Integer (enumerated)
Unit:	None

Enables (1) or disables (0) the RF interlock between input and output of the same channel. If enabled, the output is always configured according to the input.

0	"disabled": RF interlock disabled.
1	"enabled": RF interlock enabled.

/dev..../sigouts/n/rfpath

Properties:	Read, Write, Setting
Type:	Integer (enumerated)
Unit:	None

Switches between radio frequency and baseband signal paths.

0	"BB": Baseband path.
1	"RF": Radio frequency path.

7.2.12. STATS

/dev..../stats/physical/auxouts/n/temperatures/n

Properties:	Read
Type:	Double
Unit:	°C

Provides internal temperature readings on the Auxiliary Output board for monitoring.

/dev..../stats/physical/auxouts/n/voltages/n

Properties:	Read
Type:	Double
Unit:	V

Provides internal voltage measurement on the Auxiliary Output board for monitoring.

/dev..../stats/physical/currents/n

Properties:	Read
Type:	Double
Unit:	mA

Internal current measurements.

/dev..../stats/physical/fanspeeds/n

Properties:	Read
Type:	Integer (64 bit)
Unit:	RPM

Speed of the internal cooling fans for monitoring.

/dev..../stats/physical/fpga/aux

Properties:	Read
Type:	Double
Unit:	V

Supply voltage of the FPGA.

/dev..../stats/physical/fpga/core

Properties:	Read
Type:	Double
Unit:	V

Core voltage of the FPGA.

/dev..../stats/physical/fpga/pstemp

Properties:	Read
Type:	Double
Unit:	°C

Internal temperature of the FPGA's processor system.

/dev..../stats/physical/fpga/temp

Properties:	Read
Type:	Double
Unit:	°C

Internal temperature of the FPGA.

/dev..../stats/physical/overtemperature

Properties:	Read
Type:	Integer (64 bit)
Unit:	None

This flag is set to 1 if the temperature of the FPGA exceeds 85°C. It will be reset to 0 after a restart of the device.

/dev..../stats/physical/power/currents/n

Properties:	Read
Type:	Double
Unit:	A

Currents of the main power supply.

/dev..../stats/physical/power/temperatures/n

Properties:	Read
Type:	Double
Unit:	°C

Temperatures of the main power supply.

/dev..../stats/physical/power/voltages/n

Properties:	Read
Type:	Double
Unit:	V

Voltages of the main power supply.

/dev..../stats/physical/sigins/n/currents/n

Properties:	Read
Type:	Double
Unit:	A

Provides internal current readings on the Signal Input board for monitoring.

/dev..../stats/physical/sigins/n/temperatures/n

Properties:	Read
Type:	Double
Unit:	°C

Provides internal temperature readings on the Signal Input board for monitoring.

/dev..../stats/physical/sigins/n/voltages/n

Properties:	Read
Type:	Double
Unit:	V

Provides internal voltage measurement on the Signal Input board for monitoring.

/dev..../stats/physical/sigouts/n/currents/n

Properties:	Read
Type:	Double
Unit:	A

Provides internal current readings on the Signal Output board for monitoring.

/dev..../stats/physical/sigouts/n/temperatures/n

Properties:	Read
Type:	Double
Unit:	°C

Provides internal temperature readings on the Signal Output board for monitoring.

/dev..../stats/physical/sigouts/n/voltages/n

Properties:	Read
Type:	Double
Unit:	V

Provides internal voltage readings on the Signal Output board for monitoring.

/dev..../stats/physical/synthesizer/currents/n

Properties:	Read
Type:	Double
Unit:	A

Provides internal current readings on the Synthesizer board for monitoring.

/dev..../stats/physical/synthesizer/temperatures/n

Properties:	Read
Type:	Double
Unit:	°C

Provides internal temperature readings on the Synthesizer board for monitoring.

/dev..../stats/physical/synthesizer/voltages/n

Properties:	Read
Type:	Double
Unit:	V

Provides internal voltage readings on the Synthesizer board for monitoring.

/dev..../stats/physical/temperatures/n

Properties:	Read
Type:	Double
Unit:	°C

Internal temperature measurements.

/dev..../stats/physical/voltages/n

Properties:	Read
Type:	Double
Unit:	V

Internal voltage measurements.

7.2.13. STATUS

/dev..../status/adc0max

Properties:	Read
Type:	Integer (64 bit)
Unit:	None

The maximum value on Signal Input 1 (ADC0) during 100 ms.

/dev..../status/adc0min

Properties:	Read
Type:	Integer (64 bit)
Unit:	None

The minimum value on Signal Input 1 (ADC0) during 100 ms

/dev..../status/adc1max

Properties:	Read
Type:	Integer (64 bit)
Unit:	None

The maximum value on Signal Input 2 (ADC1) during 100 ms.

/dev..../status/adc1min

Properties:	Read
Type:	Integer (64 bit)
Unit:	None

The minimum value on Signal Input 2 (ADC1) during 100 ms

/dev..../status/flags/binary

Properties:	Read
Type:	Integer (64 bit)
Unit:	None

A set of binary flags giving an indication of the state of various parts of the device. Reserved for future use.

/dev..../status/time

Properties:	Read
Type:	Integer (64 bit)
Unit:	None

The current timestamp.

7.2.14. SYNTHESIZERS

/dev..../synthesizers/n/centerfreq

Properties:	Read, Write, Setting
Type:	Double
Unit:	Hz

The Center Frequency of the detection band at the input/output of the instrument

7.2.15. SYSTEM

/dev..../system/activeinterface

Properties:	Read
Type:	String
Unit:	None

Currently active interface of the device.

/dev..../system/boardrevisions/n

Properties:	Read
Type:	String
Unit:	None

Hardware revision of the FPGA base board

/dev..../system/clocks/referenceclock/in/freq

Properties:	Read
Type:	Double
Unit:	Hz

Indicates the frequency of the reference clock.

/dev..../system/clocks/referenceclock/in/source

Properties:	Read, Write, Setting
Type:	Integer (enumerated)
Unit:	None

The intended reference clock source. When the source is changed, all the instruments connected with ZSync links will be disconnected. The connection should be re-established manually.

0	"internal": The internal clock is intended to be used as the frequency and time base reference.
1	"external": An external clock is intended to be used as the frequency and time base reference. Provide a clean and stable 10 MHz or 100 MHz reference to the appropriate back panel connector.

/dev..../system/clocks/referenceclock/in/sourceactual

Properties:	Read
Type:	Integer (enumerated)
Unit:	None

The actual reference clock source.

0	"internal": The internal clock is used as the frequency and time base reference.
1	"external": An external clock is used as the frequency and time base reference.

/dev..../system/clocks/referenceclock/in/status

Properties:	Read
Type:	Integer (enumerated)
Unit:	None

Status of the reference clock.

0	"locked": Reference clock has been locked on.
1	"error": There was an error locking onto the reference clock signal.
2	"busy": The device is busy trying to lock onto the reference clock signal.

/dev..../system/clocks/referenceclock/out/enable

Properties:	Read, Write, Setting
Type:	Integer (64 bit)
Unit:	None

Enable clock signal on the reference clock output.

/dev..../system/clocks/referenceclock/out/freq

Properties:	Read, Write, Setting
Type:	Double
Unit:	Hz

Select the frequency of the output reference clock. Only 10 MHz and 100 MHz are allowed.

/dev..../system/digitalmixer/phasesyncenable

Properties:	Read, Write, Setting
Type:	Integer (enumerated)
Unit:	None

Configures the NCO reset mode.

0	"disabled": If disabled, the instrument does not automatically reset NCOs when switching a channel between BB and RF modes.
1	"enabled": If enabled, the instrument automatically resets the NCOs of all channels whenever a channel is switched between BB and RF, in order to restore alignment.

/dev..../system/fpgarevision

Properties:	Read
Type:	Integer (64 bit)
Unit:	None

HDL firmware revision.

/dev..../system/fwlog

Properties:	Read
Type:	String
Unit:	None

Returns log output of the firmware.

/dev..../system/fwlogenable

Properties:	Read, Write
Type:	Integer (64 bit)
Unit:	None

Enables logging to the fwlog node.

/dev..../system/fwrevision

Properties:	Read
Type:	Integer (64 bit)
Unit:	None

Revision of the device-internal controller software.

/dev..../system/identify

Properties:	Read, Write
Type:	Integer (64 bit)
Unit:	None

Setting this node to 1 will cause the device to blink the power led for a few seconds.

/dev..../system/kerneltype

Properties:	Read
Type:	String
Unit:	None

Returns the type of the data server kernel (mdk or hpk).

/dev..../system/nics/n/defaultgateway

Properties:	Read, Write
Type:	String
Unit:	None

Default gateway configuration for the network connection.

/dev..../system/nics/n/defaultip4

Properties:	Read, Write
Type:	String
Unit:	None

IPv4 address of the device to use if static IP is enabled.

/dev..../system/nics/n/defaultmask

Properties:	Read, Write
Type:	String
Unit:	None

IPv4 mask in case of static IP.

/dev..../system/nics/n/gateway

Properties:	Read
Type:	String
Unit:	None

Current network gateway.

/dev..../system/nics/n/ip4

Properties:	Read
Type:	String
Unit:	None

Current IPv4 of the device.

/dev..../system/nics/n/mac

Properties:	Read
Type:	String
Unit:	None

Current MAC address of the device network interface.

/dev..../system/nics/n/mask

Properties:	Read
Type:	String
Unit:	None

Current network mask.

/dev..../system/nics/n/saveip

Properties:	Read, Write
Type:	Integer (64 bit)
Unit:	None

If written, this action will program the defined static IP address to the device.

/dev..../system/nics/n/static

Properties:	Read, Write
Type:	Integer (64 bit)
Unit:	None

Enable this flag if the device is used in a network with fixed IP assignment without a DHCP server.

/dev..../system/properties/centerfreqstepsize

Properties:	Read
Type:	Double
Unit:	Hz

Step size for center frequency changes.

/dev..../system/properties/freqresolution

Properties:	Read
Type:	Integer (64 bit)
Unit:	None

The number of bits used to represent a frequency.

/dev..../system/properties/freqscaling

Properties:	Read
Type:	Double
Unit:	None

The scale factor to use to convert a frequency represented as a freqresolution-bit integer to a floating point value.

/dev..../system/properties/maxdemodrate

Properties:	Read
Type:	Double
Unit:	1/s

The maximum demodulator rate that can be set. Only relevant for lock-in amplifiers.

/dev..../system/properties/maxfreq

Properties:	Read
Type:	Double
Unit:	None

The maximum oscillator frequency that can be set.

/dev..../system/properties/maxtimeconstant

Properties:	Read
Type:	Double
Unit:	s

The maximum demodulator time constant that can be set. Only relevant for lock-in amplifiers.

/dev..../system/properties/minfreq

Properties:	Read
Type:	Double
Unit:	None

The minimum oscillator frequency that can be set.

/dev..../system/properties/mintimeconstant

Properties:	Read
Type:	Double
Unit:	s

The minimum demodulator time constant that can be set. Only relevant for lock-in amplifiers.

/dev..../system/properties/negativefreq

Properties:	Read
Type:	Integer (64 bit)
Unit:	None

Indicates whether negative frequencies are supported.

/dev..../system/properties/timebase

Properties:	Read
Type:	Double
Unit:	s

Minimal time difference between two timestamps. The value is equal to 1/(maximum sampling rate).

/dev..../system/shutdown

Properties:	Read, Write
Type:	Integer (64 bit)
Unit:	None

Sending a '1' to this node initiates a shutdown of the operating system on the device. It is recommended to trigger this shutdown before switching the device off with the hardware switch at the back side of the device.

/dev..../system/stall

Properties:	Read, Write
Type:	Integer (64 bit)
Unit:	None

Indicates if the network connection is stalled.

/dev..../system/swtriggers/n/single

Properties:	Read, Write
Type:	Integer (64 bit)
Unit:	None

Issues a single software trigger event.

/dev..../system/update

Properties:	Read, Write
Type:	Integer (64 bit)
Unit:	None

Requests update of the device firmware and bitstream from the dataserver.

7.2.16. TRIGINS

/dev..../trigins/n/imp50

Properties:	Read, Write, Setting
Type:	Integer (enumerated)
Unit:	None

Trigger input impedance: When on, the trigger input impedance is 50 Ohm, when off 1 kOhm.

0	"1_kOhm": OFF: 1 kOhm
1	"50_Ohm": ON: 50 Ohm

/dev..../trigins/n/level

Properties:	Read, Write, Setting
Type:	Double
Unit:	V

Trigger voltage level at which the trigger input toggles between low and high. Use 50% amplitude for digital input and consider the trigger hysteresis.

/dev..../trigins/n/value

Properties:	Read
Type:	Integer (64 bit)
Unit:	None

Shows the value of the digital Trigger Input. The value is integrated over a period of 100 ms. Values are: 1: low; 2: high; 3: was low and high in the period.