

MFLI Lock-in Amplifier

DC to 500 kHz and
DC to 5 MHz

Product Leaflet

Release date: June 2025

Key Features

- DC - 500 kHz / 5 MHz, 60 MSa/s, 16 bit
- Current and differential voltage inputs
- LabOne® Toolset: Scope, Sweeper, Imaging Module, FFT Spectrum Analyzer
- Plug & Play with embedded LabOne Web Server
- USB 2.0 and 1 GbE high-speed connections
- AC line and DC supply (battery) operation
- Upgradeable in the field with options

Summary

The MFLI Lock-in Amplifier uses the latest hardware and software technologies to bring the benefits of high performance digital signal processing to lock-in amplifiers at low and medium frequencies.

The MFLI covers the frequency ranges DC to 500 kHz or DC to 5 MHz. In case your requirements change, use the MF-F5M upgrade option to extend the frequency range from 500 kHz to 5 MHz. The other upgrade options are

- MF-MD Multi-demodulator
- MF-IA Impedance Analyzer
- MF-PID Quad PID/PLL controller
- MF-MOD AM/FM Modulation
- MF-DIG Digitizer
- MF-BOX Boxcar Averager

All of these options are upgradeable in the field without sending the instrument back to Zurich.

Description

Signal Inputs and Outputs

The differential voltage and current inputs of the MFLI are optimized for low noise operation down to very low frequencies, and the high oversampling ensures high SNR.

When either of the MF-MD or MF-IA options are installed both current and voltage signals can be mea-



sured simultaneously, facilitating 4-terminal measurements for instance. At the output the MFLI can generate a low-distortion sinusoidal differential signal of up to 10 V capable to drive your device under test.

Demodulators and Oscillators

Up to 4 dual-phase demodulators and oscillators with exceptionally large numerical depth ensure high measurement precision and up to 120 dB dynamic reserve. Demodulated samples are transferred to the host computer and are also available on the auxiliary output connectors with adjustable scaling and offsets.

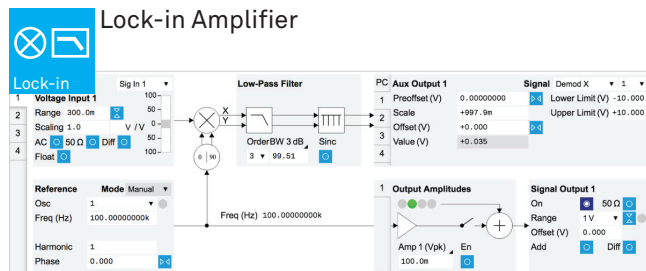
LabOne is Instrument Control

Every MFLI includes the LabOne instrument control software. Thanks to the integrated Web Server, the graphical user interface can be easily accessed by any browser and no software needs to be installed. With LabOne the computer is the cockpit for instrument control, data capture, analysis and storage where every function is only 2 clicks away. The basic functionality includes an integrated Oscilloscope, a Spectrum Analyzer, Imaging Module, a Plotter and a Parameter Sweeper.

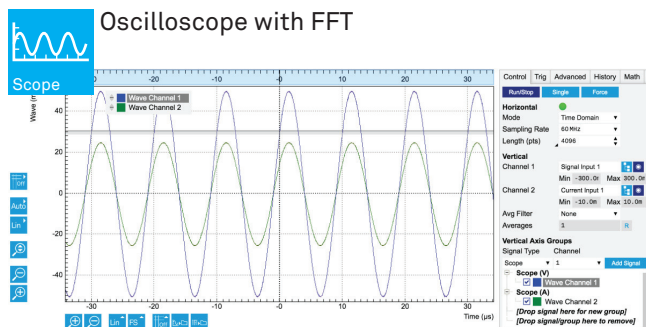
Choice of APIs

For convenient integration into existing control environments, programming interfaces for LabVIEW®, MATLAB®, .NET, C and Python are provided.

LabOne User Interface

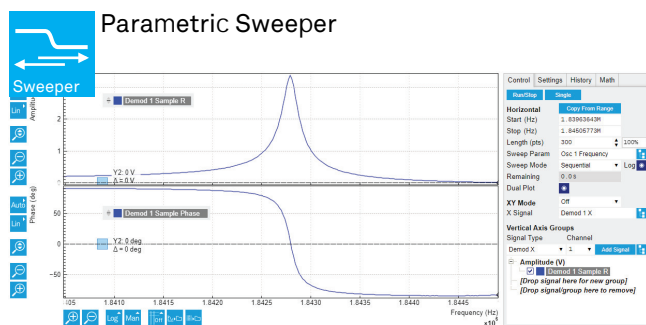


Every demodulator has a graphical representation in the form of a block-diagram for intuitive instrument understanding. In addition, the overview tab allows the control of all demodulators, signal inputs and signal outputs from a single panel.



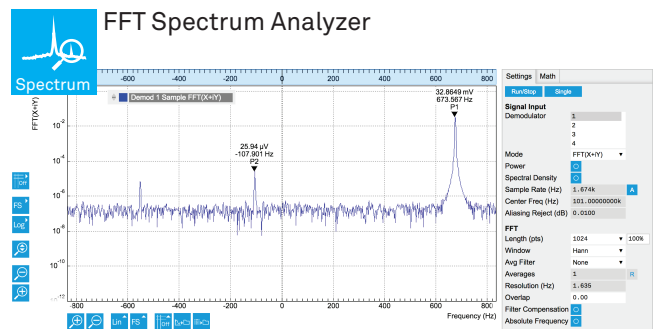
Time and frequency domain analysis of signal inputs and trigger signals with the following key features:

- Signal sources: signal inputs, trigger inputs, etc.
- Multiple trigger sources and trigger methods
- Upgradable to 2.5 MSa memory with MF-DIG



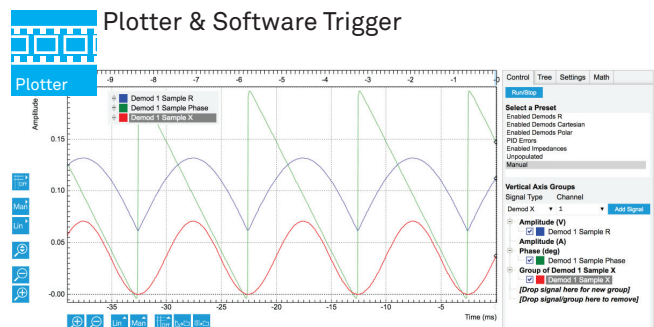
The Parametric Sweeper enables the user to automate measurements by scanning instrument parameters over a defined range with a freely adjustable number of scan steps, either linearly or logarithmically. More importantly, the recording of frequency dependence as well as the variation of bias voltages or test signal amplitudes can be easily automated. A variety of application modes help the user to measure with optimal settings and get the most accurate results in a minimum of measurement time without tedious manual tweaking.

- Sweep parameters: frequency, phase shift, output amplitude, signal offset, etc.
- Frequency response analyzer (Bode plots)
- Application modes: FRA, Noise, 3-Omega, etc.
- Normalization, auto bandwidth, averaging and standard deviation



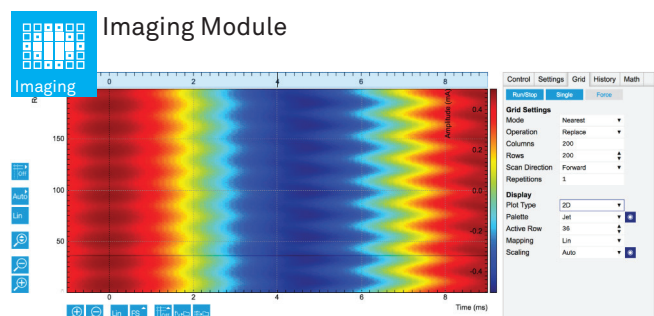
The Spectrum Analyzer takes any of the demodulators' outputs or frequency as an input and applies a Fast Fourier Transformation. The main features are:

- Modes: FFT(X+iY), FFT(R), FFT(I), FFT(f) and $FFT((dI/dt)/2\pi)$
- Auto bandwidth, auto span, filter compensation
- 4 different FFT window functions
- Amplitude, spectral density and power spectrum



The Plotter and Software Trigger display multiple measurement data and model parameters in the time domain. The Plotter displays the data continuously and the Software Trigger captures and displays individual shots based on numerous different internal and external trigger conditions.

- Multi-trace support with axis grouping for flexible axis scaling
- Polar and Cartesian data format
- Cursor math: Location, Area, Tracking, Wave, Peak, Histogram



The imaging module converts any of the measurement signals into images and supports

- A clear definition of a "line" based on a line trigger and a user-defined duration
- Resampling to a defined number of pixels with a suitable interpolation and/or averaging

Upgrade Options

Multi-Demodulator and Oscillators



Lock-in

- 4 demodulators instead of 1
- 4 oscillators instead of 1
- 2 external reference PLLs instead of 1

Increase the numbers of oscillators and demodulators from 1 to 4 in order to measure current and voltage signals at multiple frequencies simultaneously. Each demodulator's input, filter settings and sampling rate can be set entirely independently.

Digitizer



Digitizer

- Dual-trace oscilloscope with FFT
- 2.5 MSa memory per channel
- High-definition mode HD24
- Segmented memory

Extend the functionality of the scope to measure the differential voltage input and the current input concurrently, utilize continuous streaming, cross-domain triggering and the segmented memory.



Impedance Analyzer and precision LCR Meter

- 0.05% basic accuracy
- 1 m Ω to 1 T Ω ; 1 mHz to 5 MHz
- Compensation Advisor and Confidence Indicator for accurate measurements



Enjoy the full digital impedance analyzer and precision LCR meter functionality that sets the new standard for impedance measurements in the frequency range from DC to 500 kHz / 5 MHz. The instrument has a high measurement repeatability and a small temperature drift. The test fixture is included such that you can start your measurements out of the box. The LabOne Compensation Advisor and Confidence Indicator support the inexperienced user by validating each measurement and guiding them through the setup compensation.

Quad PID/PLL Controllers



PID

- 50 kHz maximum loop filter bandwidth
- LabOne Advisor and Auto-tune
- $\pm 1024 \pi$ phase-unwrap for reliable locking and stable PLL operation

The 4 PID controllers are seamlessly integrated into the lock-in and can take all input and measurement signals as inputs and provide feedback via signal amplitudes, phase shifts, signal offsets, auxiliary outputs and more. The LabOne PID Advisor and Auto-tune feature support you to achieve locking quickly and with high performance. Analyze the lock parameters with the Spectrum Analyzer, Software Trigger and Scope to directly compare the results with your DUT model transfer function and step response, as depicted in the PID tab (see below).

AM/FM Modulation



MOD

- AM and FM modulation/demodulation
- Single sideband operation
- Higher harmonics of carriers and higher order sidebands

Measure at up to 2 phase coherent linear combinations of 2 oscillator frequencies. The filter settings for each frequency component can be individually set.

MF-BOX Boxcar Averager



Boxcar

- 1 Boxcar unit
- Voltage or Current Input
- Baseline suppression
- Zero acquisition dead time

The MF-BOX is a fully digital boxcar averager enabling a performance step-up analyzing non-sinusoidal signals with small duty cycles. It operates as a high speed digitizer synchronized to an oscillator and therefore captures every sample without any dead time while rejecting all non-periodic signal components.

Specification

General

Dimensions	28.3 × 23.2 × 10.2 cm 11.1 × 9.2 × 4 inch
Weight	3.8 kg; 8.4 lbs
Power supply	AC: 100 – 240 V; DC: 12 V, 2 A

Signal Inputs (voltage and current)

Frequency range	DC to 500 kHz DC to 5 MHz (with MF-F5M)
Input impedance	50 Ω or 10 MΩ 27 pF
Input voltage noise	2.5 nV/√Hz (> 1 kHz)
Input current noise	20 fA/√Hz (> 100 Hz)
Input ranges (V In)	1 mV to 3 V (8 steps)
Dynamic reserve	up to 120 dB
Full range sensitivity	1 nV to 3 V
A/D conversion	16 bit, 60 MSa/s

Signal Outputs

Frequency range	DC to 500 kHz DC to 5 MHz (with MF-F5M)
Output ranges	±10 mV, 100 mV, 1 V, 10 V
D/A conversion	16 bit, 60 MSa/s

Demodulators & Reference

Number of demodulators	1 dual-phase (4 with MF-MD)
Number of oscillators	1 (4 with MF-MD)
Output sample rate	1 GbE: up to 200 kSa/s Aux Outputs: 612 kSa/s
Time constant	337 ns to 83 s
Measurement bandwidth	276 μHz to 206 kHz (4th order filter)
Filter slope (dB/Oct)	6, 12, 18, 24, 30, 36, 42, 48
Phase resolution	10 μdeg
Frequency resolution	1 μHz

Auxiliary & Others

Auxiliary Outputs	4 Channels, ±10 V, 18 bit, 612 kSa/s, Offset, Scaling
Auxiliary Inputs	2 Channels, ±10 V, 16 bit, 15 MSa/s; signal can be added to Signal Output
Connectivity	USB 2.0, LAN 1GbE
Clock	10 MHz input and output
Digital I/O	4x 8 bit, bidirectional

