MFLI
Lock-in Amplifier

DC to 500 kHz and
DC to 5 MHz

Product Leaflet
Release date: August 2018

Zurich Instruments

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. Incorporating Zurich Instruments' unique LabOne control software, you can now experience the usability and power previously only available with our higher frequency products.

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

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 measured 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

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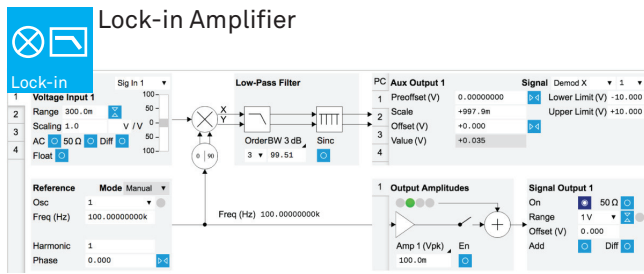
Every demodulator has a graphical representation in the form of a block-diagram for intuitive instrument understanding. In addition, the overview tab allows the control of all demodulators, signal inputs and signal outputs from a single panel.

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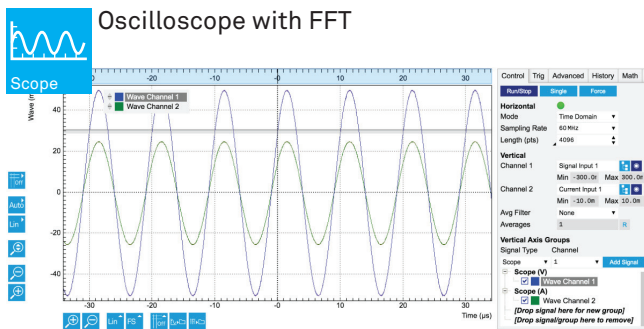
Time and frequency domain analysis of signal inputs and trigger signals with the following key features:

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

Parametric Sweeper
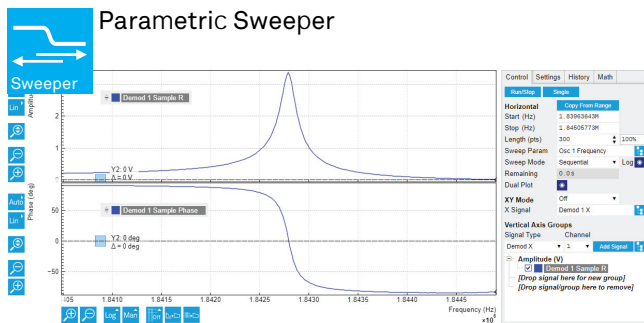
The Parametric Sweeper enables the user to automate measurements by scanning instrument parameters over a defined range with a freely adjustable number of scan steps, either linearly or logarithmically. More importantly, the recording of frequency dependence as well as the variation of bias voltages 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

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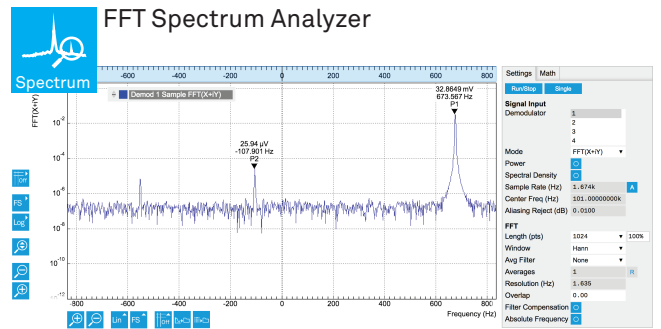
The Spectrum Analyzer takes any of the demodulators' outputs or frequency as an input and applies a Fast Fourier Transformation. The main features are:

- Modes: FFT(X+iY), FFT(R), FFT(Θ), FFT(f) and FFT((dΘ/dt)/2π)
- Auto bandwidth, auto span, filter compensation
- 4 different FFT window functions
- Amplitude, spectral density and power spectrum

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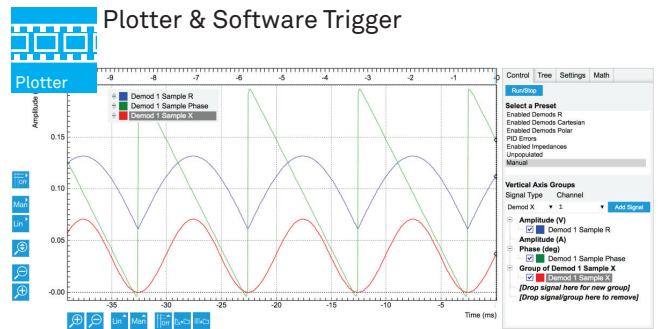
The Plotter and Software Trigger display multiple measurement data and model parameters in the time domain. The Plotter displays the data continuously and the Software Trigger captures and displays individual shots based on numerous different internal and external trigger conditions.

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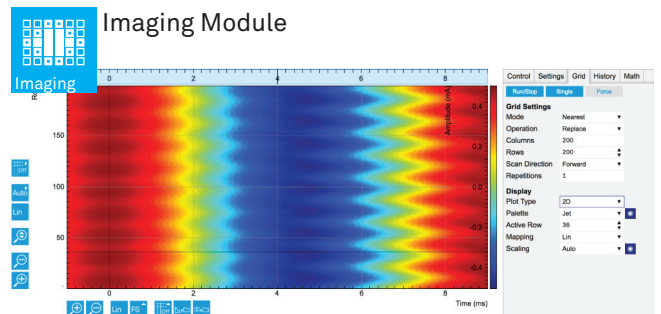
Imaging Module

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
- Store images in different formats

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.

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).

Impedance Analyzer and precision LCR Meter

Z IA

- 0.05% basic accuracy
- 1 mΩ to 1 TΩ; 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.

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.
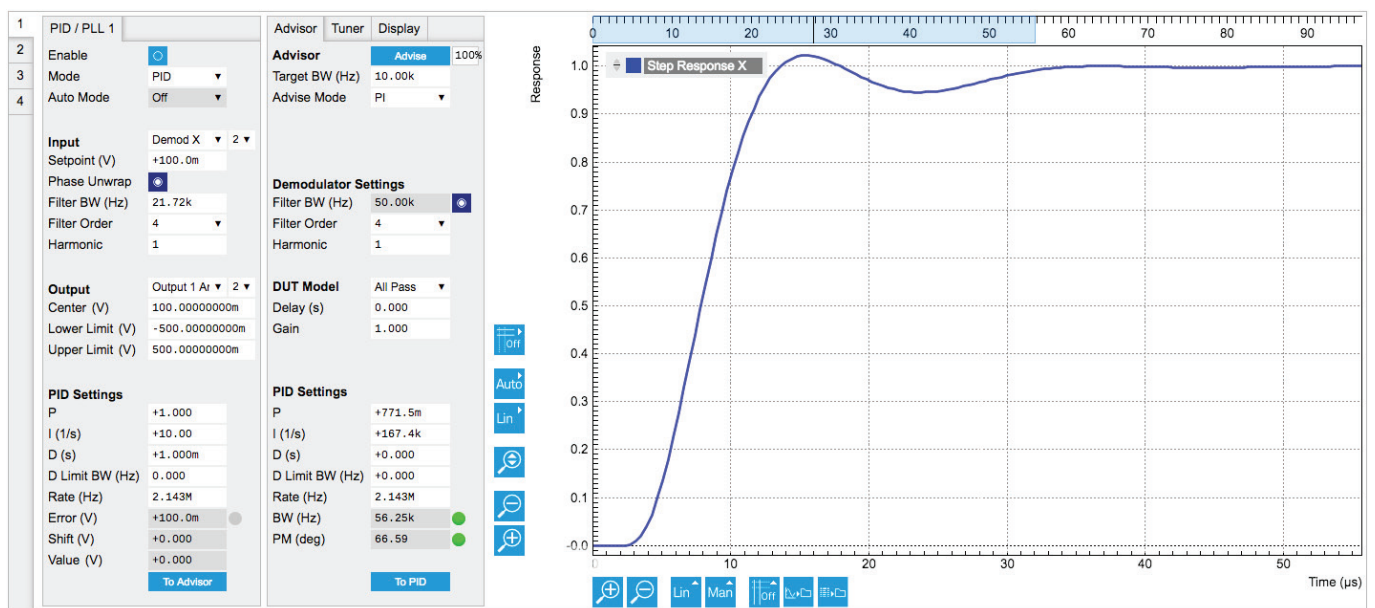
Each of the 4 PID/PLL controllers has a dedicated tab with the main controller settings in the left section, the DUT model settings and auto-tune further to the right and a large diagram to see the modelled transfer function and step-response.

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/$\sqrt{Hz}$ (> 1kHz)
Input current noise	20 fA/$\sqrt{Hz}$ (> 100 Hz)
Input ranges (voltages)	1 mV to 3 V (8 steps)
Dynamic reserve	up to 120 dB
Input 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	336 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 main Signal Output
Connectivity	USB 2.0, LAN 1GbE
Clock	10 MHz input and output
Digital I/O	4x 8 bit, bidirectional