

Zurich  
Instruments

# HF2PLL Phase-locked Loop

Dual PLL, 2 Input Channel, Quad PID,  
50 MHz Lock-in Amplifier

Product Specification  
Release date: August 2014



## Key Features

- Dual 50 MHz phase-locked loop
- Dual 50 MHz lock-in amplifier
- Dual high performance signal outputs
- 50 kHz PLL bandwidth with full parameter control
- 4 configurable PID controllers
- Easy to use HF2PLL Advisor and PID Advisor tools with transfer function analysis
- Frequency response analyzer, FFT spectrum analyzer and oscilloscope
- Application pack (included): automatic gain control, tip protection, peak analyzer
- Application pack (optional): Kelvin probe force microscopy, Q-control, dual frequency resonance tracking (DFRT), side band analyzer
- PLL harmonic mode
- PID controller auto-tune
- Frequency deviation and dissipation outputs
- Graphical user interface and programming interfaces included

## User Benefits

- Excellent PLL bandwidth enables highest speed measurements
- State-of-the-art software includes measurement tools enhancing productivity
- Demanding applications supported all in one box with application packs
- Many advanced measurements modes provide flexibility for research: higher oscillation modes, multi-frequency, KPFM, DFRT
- Multi-frequency supports simultaneous demodulation at several arbitrary frequencies
- All in one box solution simplifies any laboratory setup
- Legacy interfaces provide compatibility with most existing AFM/STM/MEMS setups
- The application know-how of Zurich Instruments customer support team

## Description

The Zurich Instruments HF2PLL (high frequency, dual phase-locked loop) combines a dual digital lock-in amplifier covering the frequency range between 0.8  $\mu$ Hz and 50 MHz in combination with 2 high frequency PLLs. There are 2 physical input channels and 2 high frequency signal outputs, which enable the replacement of 2 conventional instruments in most laboratory setups. The 128-bit digital signal processing delivers superior precision thus improving both the noise performance and the dynamic reserve. With these unprecedented capabilities, the HF2PLL provides best in class closed loop performance and a new state of the art in phase sensitive detection.

This instrument relies on the host computer for the graphical user interface. This architecture has the advantage that excellent software integration with LabVIEW, MATLAB, C and Python are standard. Furthermore this way of working is suitable for both beginners and advanced users. The software permits the running of an unlimited number of clients accessing the HF2PLL at the same time, which is ideal for complex lab setups.

## The world's fastest PLL

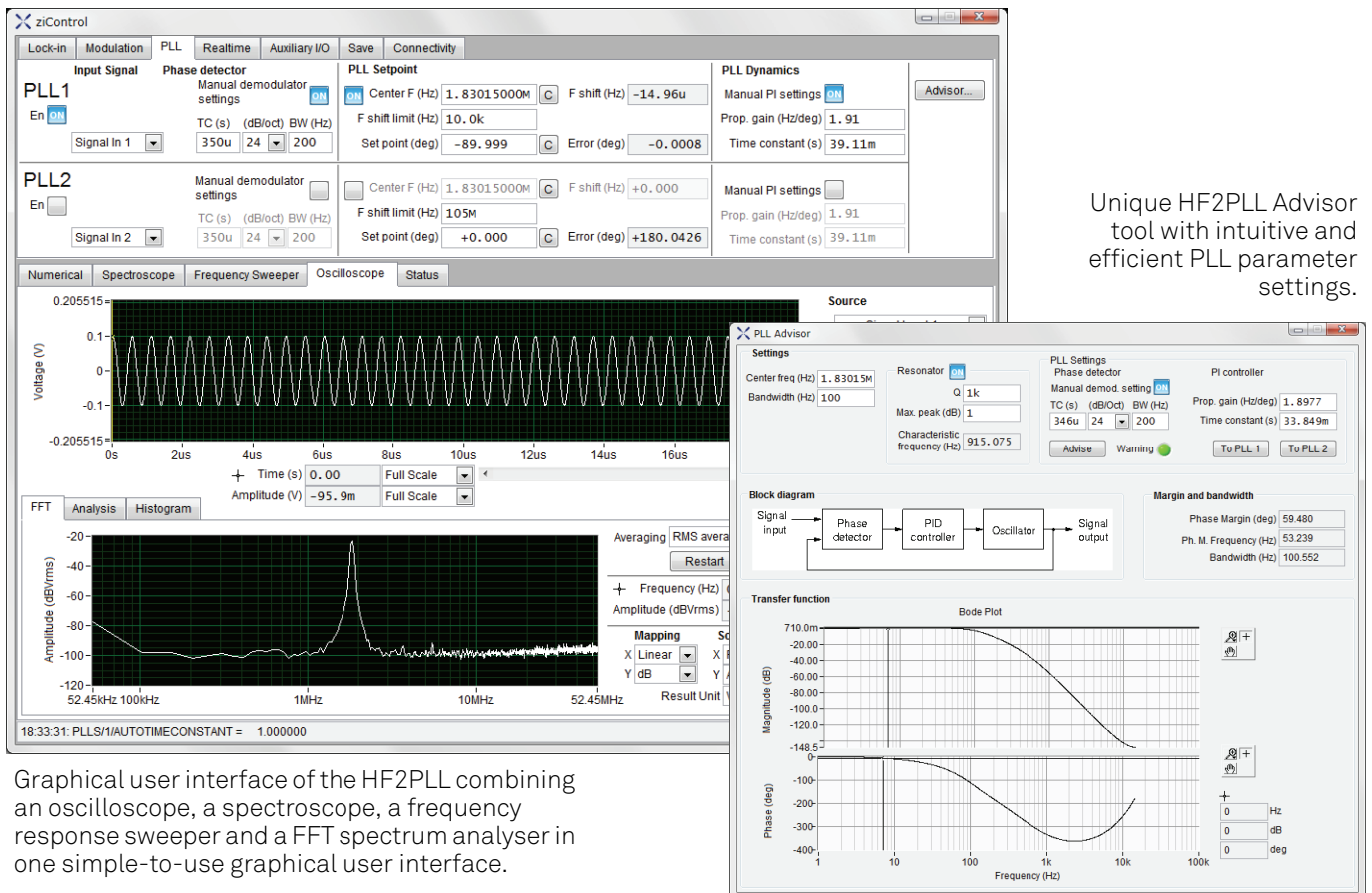
Two phase-locked loop circuits running up to 50 MHz with a bandwidth of up to 50 kHz constitutes the current world record. Users will profit by being able to produce measurements at speeds and precision not possible with other hardware.

## High-Precision Inputs

The 2 input paths of the HF2PLL are optimized for very low noise operation. The sampling rate of 210 Msa/s is 4 times the analog bandwidth, ensuring full capture of the signal and reducing aliasing.

## Quad PID Controller

Four fully configurable PID controllers with a wide selection of input and output units support the efficient implementation of control loops. The advisor and tuning tools greatly simplify the tedious optimization of control parameters. The maximum bandwidth depends on the chosen configuration, but is at least 5 kHz per PID controller for any application.



Unique HF2PLL Advisor tool with intuitive and efficient PLL parameter settings.

Graphical user interface of the HF2PLL combining an oscilloscope, a spectroscopy, a frequency response sweeper and a FFT spectrum analyser in one simple-to-use graphical user interface.

### Demodulators and Filters

The HF2PLL provides 6 dual-phase demodulators. Each demodulator can be configured with its own filter properties. The advantages of digital versus analog instruments include higher dynamic reserve, zero drift, precise phase shifts, and orthogonality.

### Excellent Measurement and Configuration Tools

Integrated tooling provides a comprehensive set of analysis features making use of external equipment, such as an oscilloscope, obsolete. The internal oscilloscope with memory for 2048 samples provides immediate signal-vs-time plots. A sweeper can function as frequency response analyzer providing high-resolution signal-vs-frequency plots, as well as sweeper over other internally controlled quantities like voltages or time constants. An FFT spectrum analyzer provides very high resolution signal analysis on frequency spans of up to 200 kHz. Finally the HF2PLL Advisor and the PID Advisor ensure efficient closed-loop parameter settings.





### Application Pack

A selection of product options enable many additional modes of operation and measurement. In particular the HF2LI-MF and the HF2LI-MOD option provide the multi-harmonic mode (MHM), dual frequency resonance tracking (DFRT), frequency modulated Kelvin probe force microscopy (FM-KPFM) and Q-Control. It is easy to extend the application support at any time as both mentioned options can be upgraded in the field.

### Example Applications

- Atomic force microscopy (AFM)
- Scanning tunnelling microscopy (STM)
- Scanning near-field optical microscopy (SNOM)
- Micro electromechanical systems (MEMS)
- Magnetic resonance force microscopy (MRFM)
- Resonator characterization
- Sensors and actuators
- Frequency combs: time reference definition
- Semiconductor characterization and testing

### Overview on available options

	<h4>HF2LI-MF Multi-frequency option</h4> <ul style="list-style-type: none"> <li>■ Simultaneous arbitrary frequency demodulation</li> <li>■ 6 independent oscillators for arbitrary frequency generation</li> <li>■ Individual demodulator filter settings</li> <li>■ Enables FM-KPFM, Q-Control and DRFT</li> </ul>
	<h4>HF2LI-MOD AM/FM Modulation option</h4> <ul style="list-style-type: none"> <li>■ Amplitude and frequency modulation and demodulation</li> <li>■ Two-channel operation for input and output</li> <li>■ Direct side-band demodulation instead of tandem demodulation</li> <li>■ Supports FM-KPFM and other dual modulated setups</li> </ul>
	<h4>HF2LI-UHS Ultra-high Stability option</h4> <ul style="list-style-type: none"> <li>■ Long term result reproducibility</li> <li>■ Extreme temperature stability</li> <li>■ Excellent short term stability</li> <li>■ Reliable aging characteristics, Minimal phase noise</li> </ul>
	<h4>HF2LI-RT Real-time option</h4> <ul style="list-style-type: none"> <li>■ User programmability for embedded processor</li> <li>■ 32-bit processing unit at 64 MHz, 32-bit floating point unit, 64 MByte of RAM</li> <li>■ Real-time system reaction time better than 10 µs</li> <li>■ Access to all settings, input and output channels</li> </ul>

# Specifications

## General

dimensions	45 x 35 x 10 cm (19" rack)
weight	6.2 kg
power supply	110-120, 220-240 V 50/60 Hz

## PLL operation and performance

constant excitation	yes
constant amplitude (automatic gain control)	yes
Q-control	yes with MF option
Kelvin probe force microscopy	yes with MF and MOD option
frequency range	1 Hz to 50 MHz
centre frequency	1 Hz to 50 MHz
PLL bandwidth	16 Hz to 50 kHz (> 1 MHz)
phase noise	-100 dBc/Hz (at 100 kHz and 100 Hz distance)

## HF signal inputs

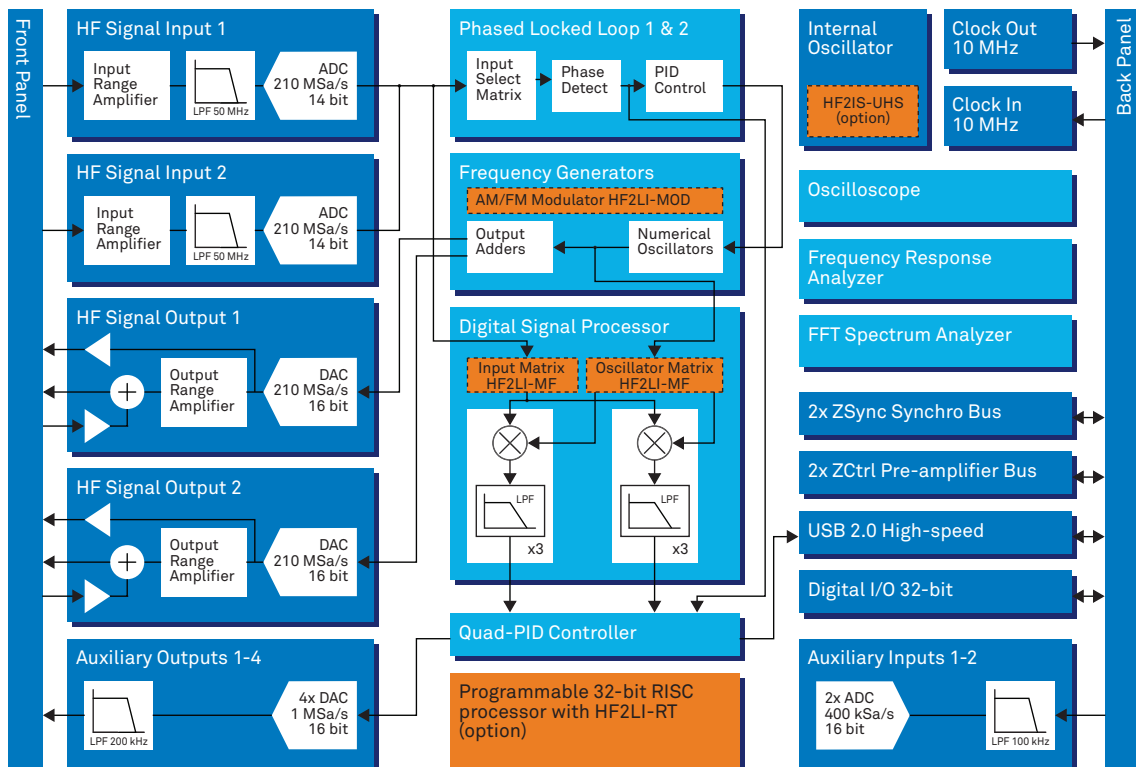
frequency range	0.8 $\mu$ Hz - 50 MHz
input noise voltage	5 nV/ $\sqrt$ Hz (> 10 kHz)
dynamic reserve	120 dB
input full range sensitivity	1 nV to 1.5 V
A/D conversion	14 bit, 210 MSa/s

## HF signal outputs

frequency range	DC - 50 MHz
output ranges	$\pm$ 10 mV, $\pm$ 100 mV, $\pm$ 1 V, $\pm$ 10 V
signal adder	$\pm$ 10 V, DC to 50 MHz
D/A conversion	16 bit, 210 MSa/s

## Demodulators and reference

number of demodulators	6 dual-phase
output sample rate	USB: up to 460 kSa/s Aux outputs: 1 MSa/s
time constant	1 $\mu$ s to 500 s
measurement bandwidth	80 $\mu$ Hz to 200 kHz
filter slope (dB/Oct)	6, 12, 18, 24, 30, 36, 42, 48
reference frequency res.	0.8 $\mu$ Hz
reference phase res.	1.0 $\mu$ $^\circ$



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About Zurich Instruments  
 Zurich Instruments makes lock-in amplifiers, phase-locked loops, and impedance spectroscopes that have revolutionized instrumentation in the high-frequency (HF) and ultra-high-frequency (UHF) ranges by combining frequency-domain tools and time-domain tools within each product. This reduces the complexity of laboratory setups, removes sources of problems and provides new measurement approaches that support the progress of research.

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