

Zurich  
Instruments

# HF2PLL

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

Product Specification  
Release date: February 2011



## Key Features

- Dual 50 MHz phase-locked loop
- 2 fully configurable 50 MHz lock-in amplifiers
- 2 high frequency, high performance signal generators
- 50 kHz PLL bandwidth with full parameter control
- Atomic force microscopy (AFM) application pack: automatic gain control, Q-control, Kelvin probe feedback
- Harmonic mode
- Jitter-free frequency deviation output
- State-of-the art software integration
- Easy to use HF2PLL Advisor tool

## User Benefits

- The world's fastest fully digital PLL enables the fastest measurements
- High performance satisfies demanding application requirements
- High frequency supports higher oscillation modes
- Multi-frequency supports simultaneous demodulation at several arbitrary frequencies
- The combination with HF2PLL-MF and HF2PLL-MOD options boosts the opportunities for application
- Unmatched feature integration, all in 1 box to simplify 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 0.7  $\mu$ Hz and 50 MHz in combination with 2 high-frequency PLLs. There are 2 physical input channels and 2 high-frequency signal generators which will 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 a new level in state-of-the-art phase sensitive measurements and enables new applications in the high-frequency range.

This non-standalone instrument relies on the host computer for the graphical user interface. This architectural choice provides unprecedented software integration with LabVIEW, MATLAB, C, and almost every other programming language. This way of working is suitable for both beginners and advanced users. In addition the software permits the running of an unlimited number of clients accessing the HF2PLL at the same time, which is ideal for complex applications.

## The world's fastest PLL

Two phase-locked loop circuits running at 50 MHz with a bandwidth of up to 100 kHz constitutes the current world record. Users will profit by being able to produce measurements at speeds and accuracy not previously possible.

## High-Precision Inputs

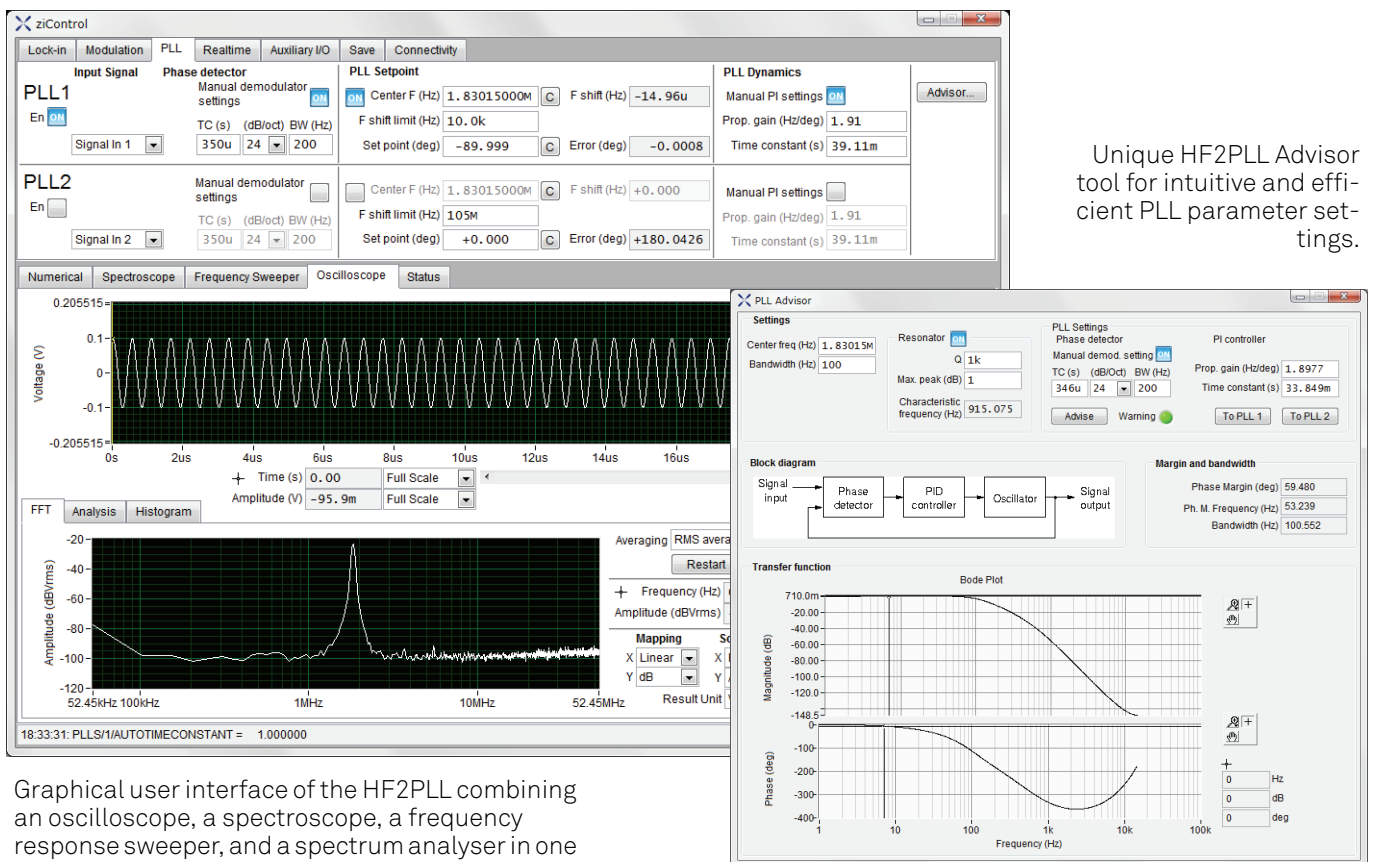
The 2 input paths of the HF2PLL are optimized for very low noise operation. The sampling rate of 210 MS/s is 4-times the analog bandwidth, ensuring full capture of the signal and avoiding aliasing.

## Signal Generators

The HF2PLL provides 2 high-frequency spurious-free outputs as a linear combination of up to 6 sinusoids in the range up to 50 MHz. The harmonic distortion is as low as 80 dB. The amplitude, the frequency, and the phase shift can be set for each component.

## Demodulators and Filters

The HF2PLL provides 6 dual-phase demodulators. Each demodulator can be configured with its own filter properties. The filters are implemented in advanced 128-bit digital technology. The advantages over common analog



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

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

instruments include higher dynamic reserve, zero drift, accurate phase shifts, and orthogonality.

### Powerful Measurement Tools


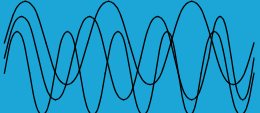
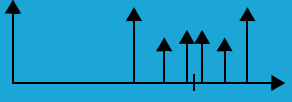

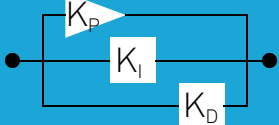
An integrated oscilloscope with memory for 2048 samples provides immediate signal-vs.-time plots without the need to connect external hardware. A frequency-response sweeper provides accurate signal-vs.-frequency plots, delivering a de-facto network analyzer in the same box. A Zoom FFT spectrum analyzer provides very high resolution signal analysis on up to 200 kHz bandwidth. The HF2PLL Advisor ensures support to efficient PLL parameter settings.

### Example Applications

- Atomic force microscopy (AFM)
- Scanning tunnelling microscopy (STM)
- Scanning near-field optical microscopy (SNOM)
- Micro electromechanical systems (MEMS)
- Resonators such as magnetometers
- Frequency combs: time reference definition
- Semiconductor characterization and testing

### Available Options



Ultra-high stability 	<b>HF2PLL-UHS</b>	<ul style="list-style-type: none"> <li>■ Long term result reproducibility</li> <li>■ Extreme temperature stability</li> <li>■ Reliable short term stability</li> <li>■ Excellent aging characteristics</li> <li>■ Minimal phase noise</li> </ul>
Multi-frequency 	<b>HF2PLL-MF</b>	<ul style="list-style-type: none"> <li>■ Arbitrary frequency generation with 6 oscillators</li> <li>■ Simultaneous arbitrary operation of 6 demodulators</li> <li>■ Oscillator select switch matrix</li> <li>■ Individual demodulator filter settings</li> </ul>
AM/FM modulation 	<b>HF2PLL-MOD</b>	<ul style="list-style-type: none"> <li>■ Dual channel operation</li> <li>■ Amplitude and frequency modulation &amp; demodulation</li> <li>■ Tandem demodulation implemented with 1 lock-in amplifier</li> <li>■ Bi-modal / multi-modal modulation for AFM</li> </ul>
Real-time 	<b>HF2PLL-RT</b>	<ul style="list-style-type: none"> <li>■ User programmability for processor embedded inside instrument</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>
PID Control 	<b>HF2PLL-PID</b>	<ul style="list-style-type: none"> <li>■ 4 fully programmable PID controllers</li> <li>■ 1 kHz total bandwidth</li> <li>■ Pre-configured settings for automatic gain control (AGC) and Kelvin probe feedback (KPF)</li> <li>■ PID Advisor tool</li> </ul>

# Specifications

**Table 1 - General**

dimensions	45 x 28 x 9 cm (19" rack)
weight	6.2 kg
power supply	110, 120, 220, 240 V 50, 60 Hz

**Table 2 - PLL Operation and Performance**

constant excitation	yes
constant amplitude	yes with PID option (automatic gain control)
Q-control	yes
Kelvin probe feedback	yes with PID option
frequency range	1 Hz to 50 MHz
centre frequency	1 Hz to 50 MHz
PLL bandwidth (at 1 MHz)	16 Hz to 50 kHz
phase noise (at 100 kHz at 100 Hz distance)	-120 dBc/Hz (typical)

**Table 3 - HF Signal Inputs**

frequency range	0.7 $\mu$ Hz - 50 MHz
input voltage noise	5 nV/ $\sqrt$ Hz
dynamic reserve	120 dB
input full range sensitivity	1 nV to 1.5 V
A/D conversion	14 bit, 210 MS/s

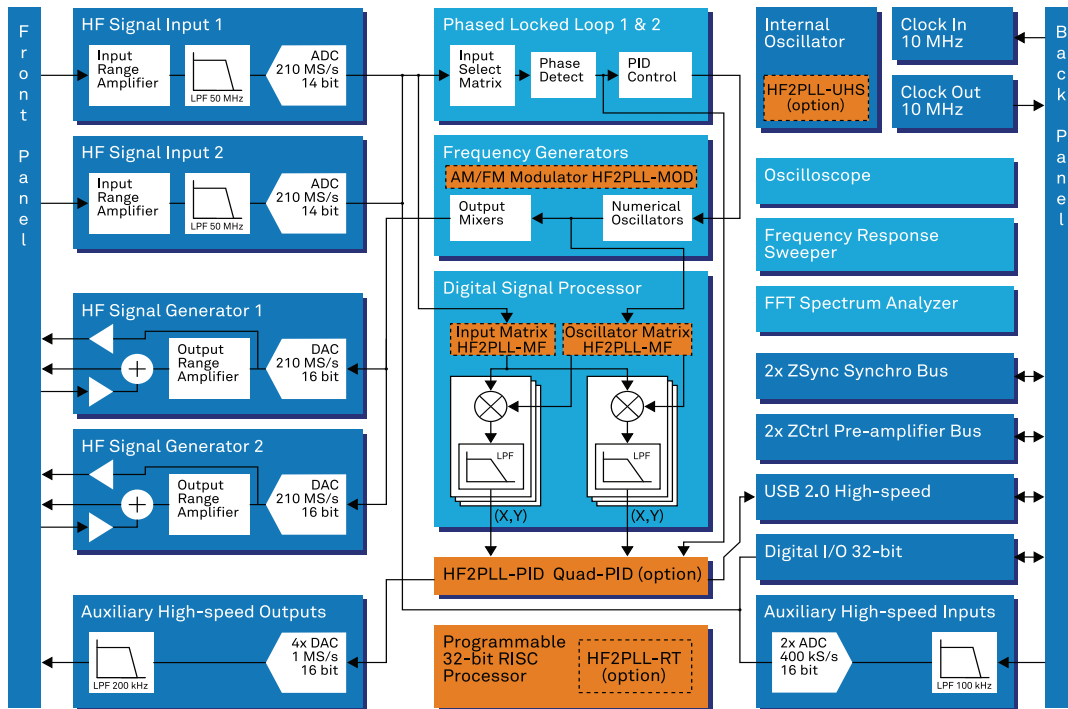
**Table 4 - HF Signal Outputs**

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 MS/s

**Table 5 - Demodulators & Reference**

number of demodulators	6 dual-phase
output sample rate	on USB: 100 kS/s per dem. on Aux outputs: 1 MS/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.	0.7 $\mu$ Hz
reference phase res.	1.0 $\mu$ $^\circ$

# Functional Diagram



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