

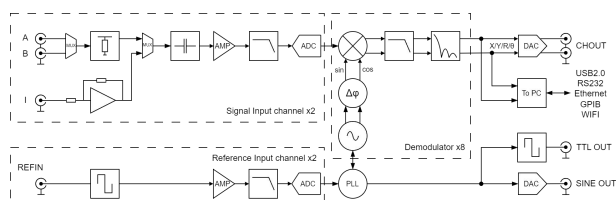


## Overview

The OE2012/OE2022 dual-channel lock-in amplifier is the latest core technology product, featuring exceptional high performance and wide bandwidth measurement capabilities. This instrument is based on digital modulation technology and is equipped with a 24-bit high-precision analog-to-digital converter (ADC) and 16-bit high-speed digital-to-analog converter (DAC).

With the newly launched LIUXI-architecture, it can accurately, quickly, and flexibly detect effective signal components hidden in strong noise.

The OE2012/OE2022 has 2 independent and synchronized input channels, capable of simultaneously measuring the amplitude and phase information of two input signals. It achieves international leading levels in key performance indicators such as measurement accuracy, operating frequency range, signal-to-noise ratio, and dynamic reserve. Additionally, the newly added multi-harmonic measurement, oscilloscope, spectrum analysis function, and PID control capabilities make the OE2012/OE2022 widely applicable to various needs in scientific research and industrial fields.



Block Diagram of OE2012/OE2022

## Key Features

- 2-independent synchronized input channels
- DC - 250 kHz / 1.5 MHz frequency range
- Input noise as low as  $2.5 \text{ nV}/\sqrt{\text{Hz}}$
- 1 nV to 5 V full-scale sensitivity
- Dynamic reserve  $> 130 \text{ dB}$
- 8-channel synchronous demodulators
- 2-channel oscilloscopes with FFT analysis
- 2-channel PID controllers

## Input Signal Channel

The OE2012/OE2022 is equipped with a low-noise analog amplifier that efficiently processes single-ended or differential signals, with an equivalent input noise as low as  $2.5 \text{ nV}/\sqrt{\text{Hz}}$ . The input impedance of this channel is  $10 \text{ M}\Omega$ , and the full-scale range is from 1 nVrms to 5 Vrms. Furthermore, the signal input channel uses a high-precision 24-bit ADC, achieving a dynamic range over 130 dB.

## Reference Signal Channel

The reference signal of the OE2012/OE2022 can be selected as either a sine wave or square wave signal based on user requirements, or it can use an internally digitally synthesized reference signal. When the OE2012/OE2022 is set to internal reference signal mode, the instrument's internal high-precision oscillator and digital synthesis algorithm generate a sine wave signal for multiplication with the input signal, with the internal reference signal being nearly unaffected by phase noise. Through digital phase shifting technology, the phase resolution of the internal reference signal can reach  $1 \mu\text{deg}$ .

When the OE2012/OE2022 operates in external reference signal mode, it accepts sine wave signals or TTL logic levels as external reference signals, which are locked by the internal digital phase-locked loop. Based on the frequency of the reference signal, the OE2012/OE2022 can detect signals at the fundamental frequency and its harmonics, detecting up to 10,000 times the fundamental frequency. But it provided that the maximum harmonic frequency does not exceed the upper limit of the instrument's measurement bandwidth.

## Output Signal Channel

The signal output ports of OE2012 / OE2022 is based on a 32 MSPS 16-bit DAC, capable of generating high-precision sine wave signals in the frequency range of DC to 250 kHz / 1.5 MHz, with adjustable DC offset. The signal amplitude range is from 0.1 Vrms to 5 Vrms, and the DC offset range is  $\pm 5$  Vdc. For external devices requiring bias voltage, such as electro-optic modulators, the OE2012/OE2022 can drive devices directly without the need for additional level conversion amplifiers. The output signal phase is synchronized with the instrument's internal oscillator. It can be independently set for phase offset.

Additionally, OE2012/OE2022 supports AM/FM/PM modulation functions, allowing users to perform modulation control of the system.

## Digital Demodulator

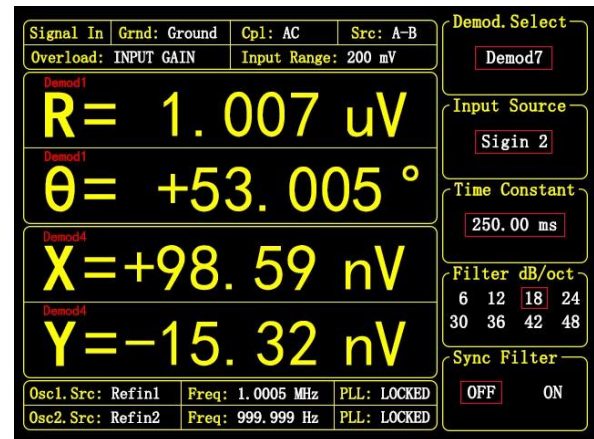
OE2012/OE2022 has 8 synchronized demodulators, which can be independently controlled. The time constant of the OE2012/OE2022 can be flexibly set within the range of 100 ns to 3 ks, allowing users to customize the time constant according to their needs. The filter's roll-off rate can be selected from 6 to 48 dB/oct in 8 steps. Using digital modulation technology and advanced filter structures. The OE2012/OE2022 offers higher dynamic reserve ( $>130$  dB), more precise phase (absolute phase error  $< 1$ deg), zero DC drift, and excellent orthogonal performance compared to traditional analog lock-in amplifiers. Additionally, the OE2012/OE2022 provides an optional synchronous filter that can quickly eliminate the effects of signal harmonics, ensuring that the instrument accurately detects low-frequency signals while responding rapidly.

## Communication Interface

The OE2012/OE2022 includes USB 2.0, 1000 Mbps RJ45 Ethernet port, WIFI network interface, RS232 serial port, and GPIB interface. Through these interfaces, users can effectively utilize all testing functions of the OE2012/OE2022 on a controlling computer, setting reasonable control parameters and reading the data measured by the instrument.

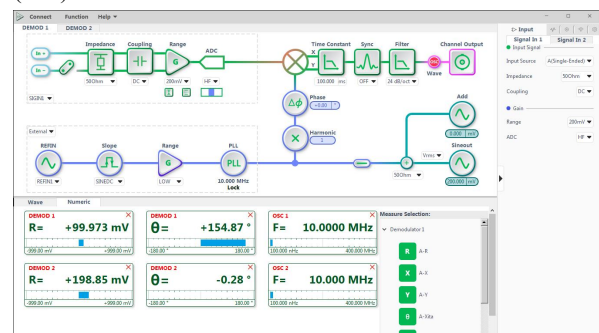
## Color Display Screen

The OE2012/OE2022 features a 5.6-inch TFT color display with a resolution of  $640 \times 480$ , serving as the main user interface, allowing full independent control of the instrument via keyboard. On the display, users can easily heed parameters such as demodulator X, Y, R,  $\theta$ , and configure various basic settings like filter constants, making the operation intuitive and convenient.



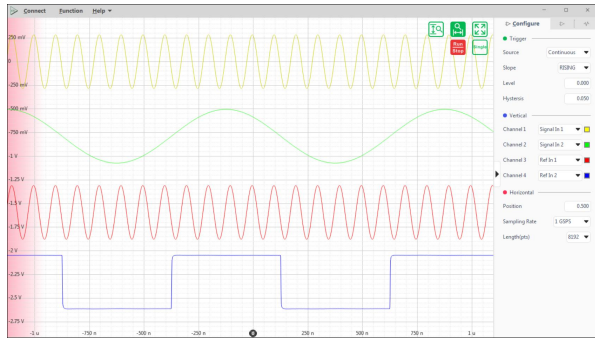
## PC Software

OE2012/OE2022 is equipped with graphical upper computer software. With quick graphic buttons and rich graphic operation functions, in addition, this software has a clear numerical value display and waveform display function, real-time display of measurement data, measurement results can be saved in excel format output for subsequent analysis of professional software, so that the test is easy to use. In addition, we also fully support Python, MATLAB and LabVIEW application program interface (API).



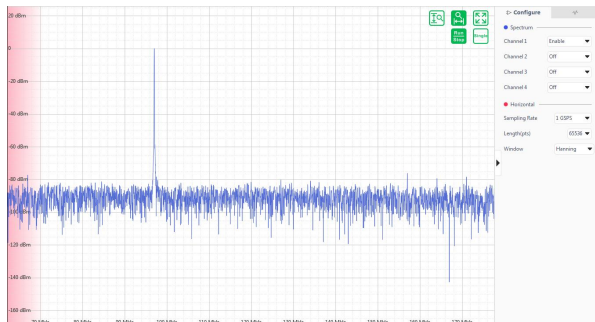
## Oscilloscope

The oscilloscope function features 2 signal channels, selectable for signal input, reference input, signal output, and auxiliary input/output, providing various triggering methods for real-time display of time-domain signals. Each channel has a maximum sampling depth of 65,536 and adjustable sampling durations from 65  $\mu$ s to 1 s.



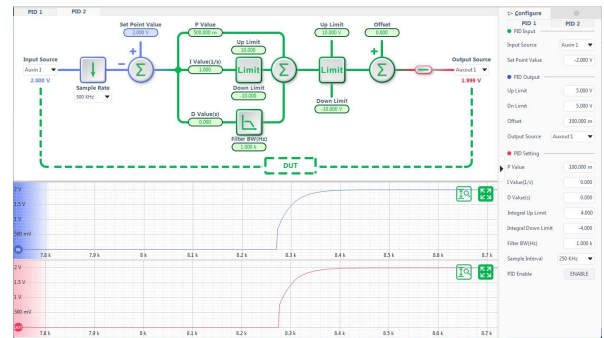
## FFT Spectrum Analysis

The FFT spectrum analysis provides the frequency domain information of signals based on waveforms captured by the oscilloscope. Depending on the sampling rate and sampling depth, the frequency resolution range of the spectrum analysis is approximately 1 Hz to 31 kHz.



## PID Controllers

The OE2012/OE2022 has an internal independent 2-channel digital PID controller with a maximum sampling rate of 4 MSPS. The PID controller is closely linked with the lock-in amplifier, controlling the output signal's amplitude, phase, frequency, and other signals based on the measurements from the demodulator, achieving precise control of multiple parameters.



## Parametric Scanner

The parameter scanner provides users with convenient quick scanning capabilities, allowing for the instant plotting of frequency response, amplitude response curves, and offering single or loop scanning modes.



## Input Signal Channel

Channel Number	2
Input Mode	
Voltage	Single-ended or Differential
Current	Single-ended
Full-Scale Sensitivity	1 nV - 5 V (voltage input) 1 fA - 5 mA (current input)
Transimpedance Gain	1 k $\Omega$ , 1 M $\Omega$ , 100 M $\Omega$ three levels
Range Levels	1 mV to 5 V, total 7 levels
Input Coupling Mode	DC or AC coupled
Input Impedance	10 M $\Omega$    25 pF (Voltage) 100 $\Omega$ or 1 k $\Omega$ (Current)
Input Shield Grounding	Grounding or 10 k $\Omega$ floating
C.M.R.R	>110dB to 1kHz, Decreasing by 6dB/oct
Dynamic Reserve	>130 dB
Gain Accuracy	0.5% typ., 1% max
Input Voltage Noise	3.5 nV/ $\sqrt{\text{Hz}}$ ( $f \geq 1$ kHz) 2.5 nV/ $\sqrt{\text{Hz}}$ ( $f \geq 10$ kHz)
Input Current Noise	20 fA/ $\sqrt{\text{Hz}}$ ( $f = 97$ Hz)
ADC Bit	24 bit

## Reference Signal Channel

Channel Number	2
Signal	
Frequency Range	DC - 250 kHz (OE2012) DC - 1.5 MHz (OE2022)
Supported Waveform	Square or sine wave
Input Impedance	1 M $\Omega$
Reference Levels	
Square	$3\text{V} < V_{\text{IH}} < 5\text{V}$ , $-0.1\text{V} < V_{\text{IL}} < 0.5\text{V}$
Sine	$300\text{ mV} < V_{\text{pp}} < 10\text{ V}$
Phase	
Resolution	1.0 $\mu$ deg
Phase Error	$\pm 0.5$ deg typ., $\pm 1$ deg max
Temperature Drift	< 200 ppm/ $^{\circ}\text{C}$
Harmonic Detection	1-10000F (nF < 1.5 MHz)
Acquisition Time	10 or 100 signal cycles (External Ref)

## Demodulator

Demodulator Number	8
Demodulator Bit	64 bit
Input Signal Options	2 input channels selectable
Time Constant	100ns - 3ks
Bandwidth	50 $\mu$ Hz – 1.6 MHz
Filter Slope(dB/oct)	6,12,18,24,30,36,42,48
Synchronous Filter	<1000 Hz effective

## Communication Interface

USB2.0	480 Mbps high-speed interface
RS-232	DB-9 female interface

GPIO	IEEE-488.2 interface
Ethernet	RJ45-1000Mbps WIFI 2.4GHz network interface

## Output Signal Channel

Channel Number	2
Frequency Range	DC - 250 kHz (OE2012) DC - 1.5 MHz (OE2022)
Accuracy	2 ppm + 1 $\mu$ Hz
Resolution	1 nHz
Sine Amplitude	0.1 $\mu$ Vrms to 5 Vrms
Accuracy	0.5% typ., 2% max
Resolution	0.1 $\mu$ Vrms
Driving Current	$\pm 80$ mA max
Stability	<200 ppm/ $^{\circ}\text{C}$
Impedance	50 $\Omega$
Adjustable DC Offset	-5 VDC to 5 VDC
Synchronous Output	3.3V TTL/CMOS level output impedance 50 $\Omega$
Additional Features	AM/FM/PM modulation
DAC Parameter	16 bit, 32 MSPS

## Oscillator

Oscillator Number	2
Oscillator Parameters	
Accuracy	0.3 ppm
Temperature	0.5 ppm / $^{\circ}\text{C}$
Stability	
Aging Rate	<1 ppm/year
Phase Noise	-145 dBc/Hz (@1kHz)

## Auxiliary Inputs/Outputs

AUX Inputs	
Function	4-channel input
Amplitude	$\pm 10\text{V}$ , 0.1 mV resolution
Impedance	1M $\Omega$
ADC	16 bit, 150 kSPS
AUX Outputs	
Function	4-channel output
Amplitude	$\pm 10\text{V}$ , 0.1 mV resolution
Driving Current	$\pm 30\text{mA}$ max
DAC	16 bit, 500 kSPS

## General

Power requirements	
Voltage	100/120/220/240 V AC
Power	50 W typ., 70 W max
Noise Suppression	70dB@1MHz
Dimensions	448mm $\times$ 532mm $\times$ 148mm
Weight	12 kg

# Digital Lock-In Amplifier

OE2012/OE2022 -Dual-channel Lock-in Amplifier

V250421