Digital Lock-In Amplifiers

SE2022 Dual-channel Lock-in Amplifier

10μHz to 1.5MHz

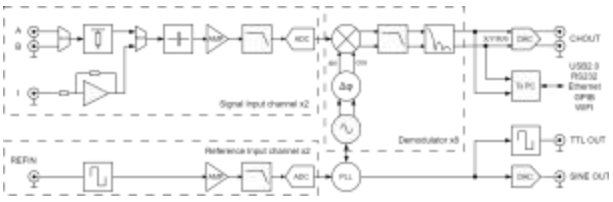
Key Features

- 2 independent synchronized input channels
- Input noise as low as 2.5nV/$\sqrt{\text{Hz}}$
- Input range from 1 nV to 5 Vrms
- Frequency range from DC to 1.5 MHz
- Dynamic reserve > 130dB
- 8-channel synchronous demodulators
- 2-channel oscilloscope with FFT analysis
- 2-channel PID controllers

Overview

The SE2022 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 SE2022 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 analyzer functions, and PID control capabilities make the SE2022 widely applicable to various needs in scientific research and industrial fields.



Block Diagram of SE2022

Input Signal Channel

The SE2022 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 nV/ Hz. The input impedance of this channel is 10 MΩ, 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 SE2022 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 SE2022 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 μdeg.

When the SE2022 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 SE2022 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.

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Output Signal Channel

The signal output ports of SE2022 is based on a 32 MSPS 16-bit DAC, capable of generating high-precision sine wave signals in the frequency range of 1 Hz to 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 ±5 Vdc. For external devices requiring bias voltage, such as electro-optic modulators, the SE2022 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, the SE2022 supports AM/FM/PM modulation functions, allowing users to perform modulation control of the system.

Digital Demodulator

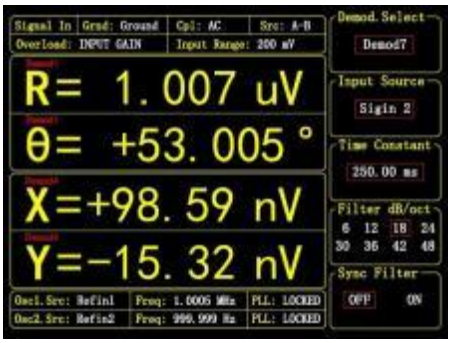
The SE2022 has 8 synchronized demodulators, which can be independently controlled. The time constant of the SE2022 can be flexibly set within the range of 100 ns to 3 ks, allowing users to customize the time constant according to their needs. The filter's roll-off rate can be selected from 6 to 48 dB/oct in 8 steps. Using digital modulation technology and advanced filter structures. The SE2022 offers higher dynamic reserve (>130 dB), more precise phase (absolute phase error < 1°), zero DC drift, and excellent orthogonal performance compared to traditional analog lock-in amplifiers. Additionally, the SE2022 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 SE2022 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 SE2022 on a controlling computer, setting reasonable control parameters and reading the data measured by the instrument.

Color Display Screen

The SE2022 features a 5.6-inch TFT color display with a resolution of 640×480, 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, θ, and configure various basic settings like filter constants, making the operation intuitive and convenient.



PC Software

The SE2022 provides professional PC software that allows configuration of each demodulator, input channel, and output channel through schematic diagrams or control panels, combining professionalism and practicality with simplicity and intuitiveness. The software features clear numerical display and real-time waveform display functions. Users can save the measurement results exportable as CSV files for subsequent analysis using professional software, enhancing the ease of testing. Furthermore, we fully support application programming interfaces (API) in Python, MATLAB, and LabVIEW.

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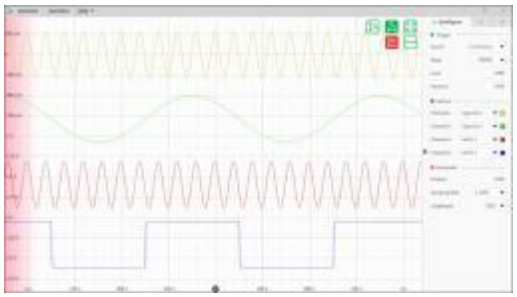
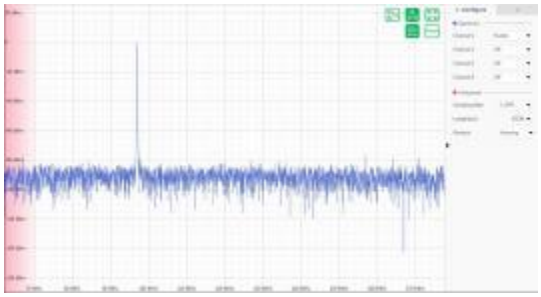
Oscilloscope

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 μs to 1 s.



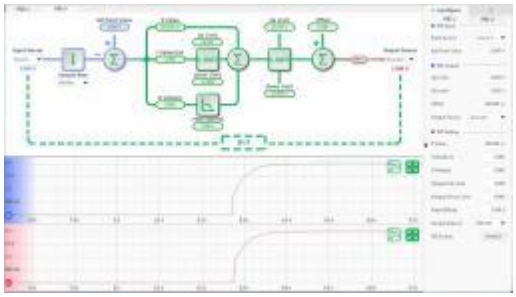
FFT Spectrum Analyzer

The FFT spectrum analyzer analyzes 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 analyzer is approximately 1 Hz to 31 kHz.



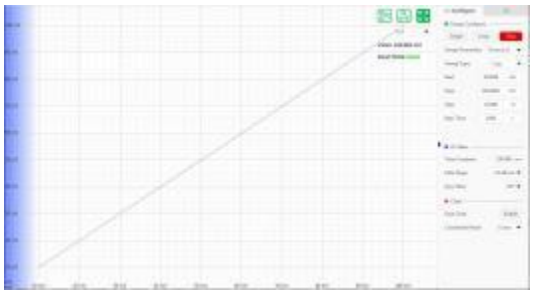
PID Controllers

The SE2022 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.



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Input Signal Channel

Input Channel Number	2
Input Mode	
Voltage	Single-ended or Differential
Current	Single-ended
Full-Scale Sensitivity	1 nV to 5 Vrms
Range Levels	2mV to 5V, total 7 levels
Input Coupling Mode	DC or AC coupling
Input Impedance	10 MΩ ‖ 25 pF (Voltage) 100Ω or1 kΩ (Current)
Input Shield Grounding	Grounding or 10 kΩ floating
Dynamic Reserve	>130 dB
Gain Accuracy	0.5% typical, 1% max
Input Voltage Noise	3.5 nV/ Hz（f≥ 1 kHz） 2.5 nV/ Hz（f≥ 10 kHz）
Input Current Noise	20 fA/ Hz（f= 97Hz）
ADC Bit	24 bit

Reference Signal Channel

Reference Channel Number	2
Reference Signal	
Frequency Range	10 μHz – 1.5 MHz
Supported Waveform	Square or sine wave
Input Impedance	1 MΩ
Reference Levels	
Square	$3V<V_{IH}<5V$, $-0.1V<V_{IL}<0.5V$
Sine	300 mV < V_{pp} < 10 V
Phase	
Resolution	1.0 μdeg
Phase Error	±0.5 deg typical, ±1 deg max
Harmonic Detection	< 200 ppm/°C
Acquisition Time	1-10000F (nF < 1.5 MHz)
Internal Reference	Instantaneous acquisition
External Reference	10 or 100 signal cycles

Oscillator

Oscillator Number	2
Oscillator Parameters	
Accuracy	0.3 ppm
Temperature Stability	0.5 ppm / ℃
Aging Rate	<1 ppm/year
Phase Noise	-145 dBc/Hz (@1kHz)

Communication Interfaces

RS-232	DB-9 female interface
USB2.0	480 Mbpshigh-speed interface
Ethernet	RJ45-1000Mbps wireless network interface
GPIB	IEEE-488.2interface

Output Signal Channel

Output Channel Number	2
Frequency Range	DC – 1.5MHz
Frequency Accuracy	2 ppm + 1 μHz
Frequency Resolution	1 nHz
Sine Amplitude	0.1 μVrms to 5 Vrms
Accuracy	0.5% typical, 2% max
Resolution	0.1 μVrms
Driving Current	± 80 mA max
Temperature Stability	<200 ppm/°C
Output Impedance	50 Ω
Adjustable DC Offset	-5 V_{DC} to 5 V_{DC}
Synchronous Output	3.3V TTL/CMOS level output impedance 50 Ω
Additional Features	AM/FM/PM modulation output
DAC Parameter	16 bit, 32 MSPS

Demodulator

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

Auxiliary Inputs/Outputs

AUX Input	
Function	4-channel input
Amplitude	±10V, 0.1 mV resolution
Input Impedance	1MΩ
ADC	16 bit, 150 kSPS
AUX Output	
Function	4-channel output
Amplitude	±10V, 0.1 mV resolution
Driving Current	±30 mA max
DAC	16 bit, 500 kSPS

Others

Power Supply	
Voltage	220~240 VAC 100~120 VAC(optional)
Power	50 W typical, 70 W max
Power Noise Suppression	70dB@1MHz
Dimensions	448mm×532mm×148mm
Weight	12 kg