Digital Lock-In Amplifier

SE2011 DSP Lock-in Amplifier

Key Features

- 10 μHz - 250 kHz frequency range
- Input noise as low as 2.5 nV/$\sqrt{\text{Hz}}$
- 1 nV to 5 V full-scale sensitivity
- Time constants from 100 ns to 3 ks
- Dynamic reserve > 130 dB
- 8-channel synchronous demodulators
- 2-channel PID controllers
- Spectrum analysis, oscilloscope function

Overview

The SE2011 digital 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 SE2011 is capable of simultaneously measuring the amplitude and phase information of 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, FFT spectrum analysis function, and PID control capabilities make the SE2011 widely applicable to various needs in scientific research and industrial fields.

Input Signal Channel

The SE2011 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/$\sqrt{\text{Hz}}$. 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 SE2011 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 SE2011 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 SE2011 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 SE2011 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.

Digital Demodulator

SE2011 has 8 synchronized demodulators, which can be independently controlled. The time constant of the SE2011 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

Digital Lock-In Amplifier

SE2011 DSP Lock-in Amplifier

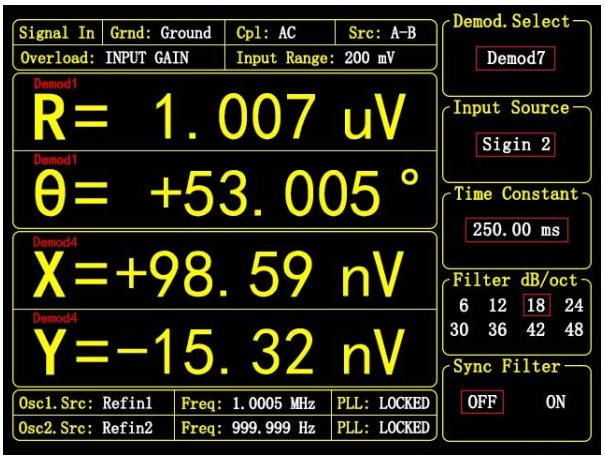
Output Signal Channel

The signal output ports of the SE2011 is based on a 32 MSPS 16-bit DAC, capable of generating high-precision sine wave signals in the frequency range of 10 μHz 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 ±5 Vdc. For external devices requiring bias voltage, such as electro-optic modulators, the SE2011 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, SE2011 supports AM/FM/PM modulation functions, allowing users to perform modulation control of the system.

Color Display Screen

The SE2011 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.



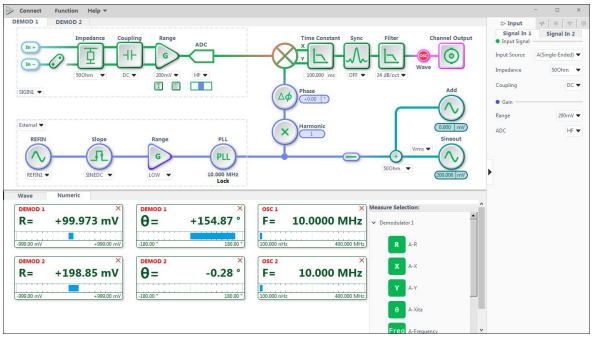
Communication Interface

The SE2011 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 SE2011 on a controlling computer, setting reasonable control parameters and reading the data measured by the instrument.

modulation technology and advanced filter structures. The SE2011 offers higher dynamic reserve (>130 dB), more precise phase (absolute phase error< 1deg), zero DC drift, and excellent orthogonal performance compared to traditional analog lock-in amplifiers. Additionally, the SE2011 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.

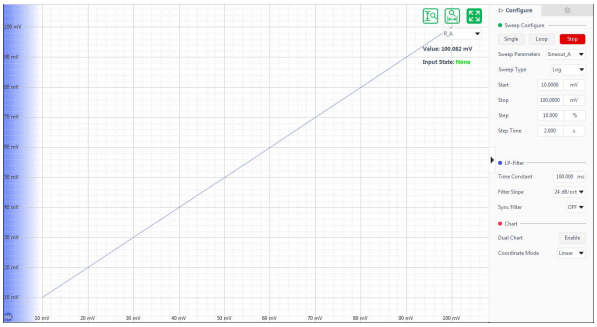
PC Software

The SE2011 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).



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.

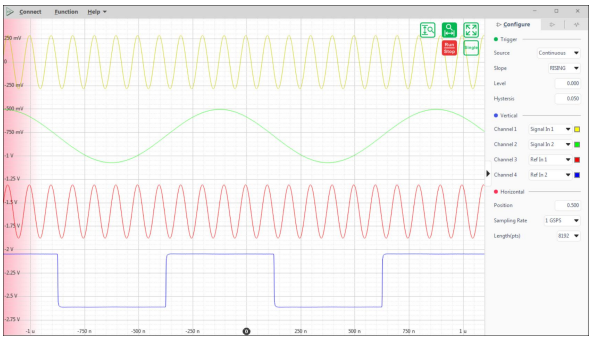


Digital Lock-In Amplifier

SE2011 DSP Lock-in Amplifier

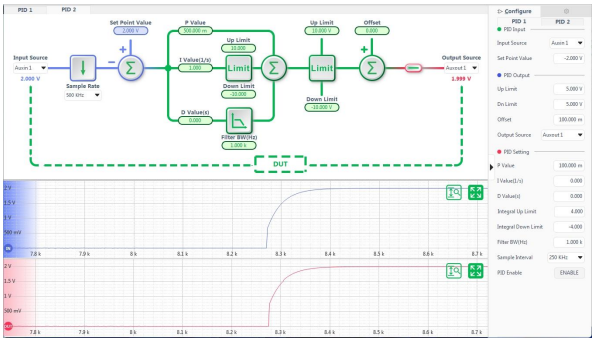
Oscilloscope

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.



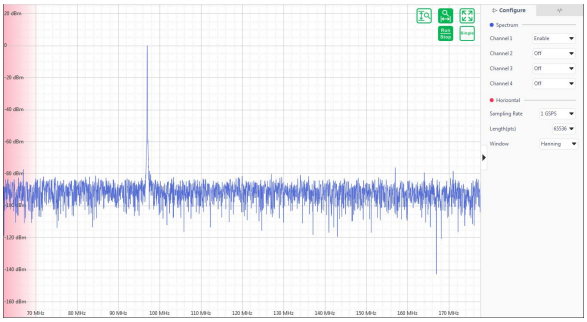
PID Controllers

The SE2011 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.



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 is approximately 1 Hz to 31 kHz.



Digital Lock-In Amplifier

SE2011 DSP Lock-in Amplifier

Input Signal Channel

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 kΩ, 1 MΩ, 100 MΩ three levels
Range Levels	1 mV to 5 V, total 7 levels
Input Coupling Mode	DC or AC coupled
Input Impedance	10 MΩ‖ 25 pF（Voltage）
	100 Ω or 1 kΩ（Current）
Input Shield Grounding	Grounding or 10 kΩ 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/$\sqrt{Hz}$（f ≥ 1 kHz）
	2.5 nV/$\sqrt{Hz}$（f ≥ 10 kHz）
Input Current Noise	20 fA/$\sqrt{Hz}$（f = 97Hz）
ADC Bit	24 bit

Reference Signal Channel

Channel Number	2
Signal	
Frequency Range	10 µHz - 250 kHz(SE2011)
Supported Waveform	Square or sine wave
Input Impedance	1 MΩ
Reference Levels	
Square	3V<V_{IH}<5V, -0.1V<V_{IL}<0.5V
Sine	Frequency>1 Hz
	300 mV < V_{pp} < 10 V
Phase	
Resolution	1.0 µdeg
Phase Error	±0.5 deg typ., ±1 deg max
Temperature Drift	< 200 ppm/℃
Harmonic Detection	1-10000F (nF < 1.5 MHz)
Acquisition Time	
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 Interface

Ethernet	WIFI 2.4GHz network interface
Ethernet	RJ45-1000Mbps
RS-232	DB-9 female interface
USB2.0	480Mbps high-speed interface
GPIB	IEEE-488.2interface

Output Signal Channel

Frequency Range	10 µHz - 250 kHz(SE2011)
Accuracy	2 ppm + 1 µHz
Resolution	1 nHz
Sine Amplitude	0.1 µVrms to 5 Vrms
Accuracy	0.5% typ., 2% max
Resolution	0.1 µVrms
Driving Current	± 80 mA max
Stability	<200 ppm/℃
Impedance	50Ω
Adjustable DC Offset	-5 VDC to 5 VDC
Synchronous Output	3.3V TTL/CMOS level
	output impedance 50Ω
Additional Features	AM/FM/PM modulation
DAC Parameter	16 bit, 32 MSPS

Demodulator

Demodulator Number	8
Demodulator Bit	64 bit
Time Constant	100ns - 3ks
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 Inputs	
Function	4-channel input
Amplitude	±10V，0.1 mV resolution
Impedance	1MΩ
ADC	16 bit, 150 kSPS
AUX Outputs	
Function	4-channel output
Amplitude	±10V，0.1 mV resolution
Driving Current	±30mA max
DAC	16 bit, 500 kSPS

General

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