Digital Lock-In Amplifiers

SE1022D-DSP Lock-In Amplifier

1 mHz to 102 kHz

Features

- *2 independent input channels*
- *2 signal generators*
- *1 mHz to 102 kHz frequency range*
- *1 nV to 1 V full-scale sensitivity*
- *Time constants from 10 μs to 3 ks*
- *>100 dB dynamic reserve*
- *Automatic adjustment*
- *Multiple-harmonic measurement*
- *5.6 inch color TFT-LCD screen*

Overview

SE1022D Digital Lock-in Amplifier provides an excellent performance within its bandwidth from 1 mHz to 102 kHz. With the advantage of the latest digital signal processing technology and high-precision 24-bit ADC, SE1022D can easily detect the phase and the magnitude of weak signals overwhelmed by various large noise. The performance of SE1022D is as good as other lock-in amplifiers all over the world, even better than them in some certain parameters, such as measurement accuracy, SNR, dynamic reserve. More importantly, the SE1022D has two independent input channels and two independent high-precision signal generators. Each input channel and signal generator can be used independently, which is equivalent to a traditional lock-in amplifier. This means that the SE1022D is equivalent to two traditional lock-in amplifiers. Moreover, due to the twin symmetrical design, the two independent input channels and signal generators have ultra high synchronicity, which meets the measurement requirements demanding extremely high synchronization. This performance is not achievable in two traditional lock-in amplifiers.

Input Channel

Two independent input channels have high synchronicity and can be individually configured as a single-ended mode or a differential voltage mode. With an ultra low-noise pre-amplifier, the input noise is as low as 6 nV/√Hz@997 Hz.

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The input impedance is 10 MΩ and the full-scale and the full-scale input voltage sensitivity ranges from 1 nV to 1 V. Besides, SE1022D can be used for current measurement with gains of 106 or 108 V/A. Two line filters (50/60 Hz and 100/120 Hz) are designed to eliminate power frequency interference. A programmable gain amplifier is used to adjust the dynamic reserve, so that SE1022D can keep a high dynamic reserve of 100 dB. The high-precision 24-bit ADC has a sampling rate of 312.5 kSPS, and the excellent anti-aliasing filter in front of the ADC can effectively prevent signal aliasing.

Reference Channel

Two independent reference channels can work in external mode or internal mode. In internal mode, a precise and stable internal oscillator generates sine wave as an internal reference that is multiplied by the input signal. This internal signal is without any phase noise. With the digital phase-shifting technique, the phase resolution of the reference signal is 0.01°. SE1022D can work at any fixed frequency from 1 mHz to 102 kHz in this mode. In external mode, the reference signal can be a sine wave or a TTL pulse or a square wave. The rising or falling edge of the external reference signal triggers the Phase Lock Loop (PLL) to lock the external signal. Based on the frequency of the reference signal, the SE1022D can detect the harmonics of the input signal. The maximum harmonic signal frequency can reach 32767 times the fundamental frequency, and the maximum harmonic frequency cannot exceed the maximum operating frequency of the instrument by 102 kHz. In addition, the SE1022D has a single-channel reference mode, in which two independent input channels are locked and measured using the same external reference channel (REF IN A). This mode can further meet a need for higher synchronization requirements.

Digital Demodulator and Output Filter

The key component of the SE1022D is the digital demodulator. Compared to traditional analog lock-in amplifiers, the SE1022D's internal digital demodulator effectively rejects the measurement errors caused by DC drift and offset. In addition, by optimizing the multiplication of the internal coherent signal of the digital demodulator, the calculation error is minimized so that the instrument can accurately detect the input weak signal. Time constants of the output low-pass filter from 10 μs to 3 ks can be selected with a choice of 6, 12, 18 or 24dB/oct rolloff. This low-pass digital filter is implemented using an high performance digital filter with a sample rate of 312.5 kHz.The digital demodulation and the low-pass filter used in SE1022D guarantees a high dynamic reserve (>100dB), accurate phase (absolute phase error <1°). Moreover, when the frequency of the input signal is lower than 200 Hz, A synchronous filter can be used to eliminate the harmonic influence of the reference signal, ensuring that SE1022D can detect a low-frequency signal quickly and effectively.

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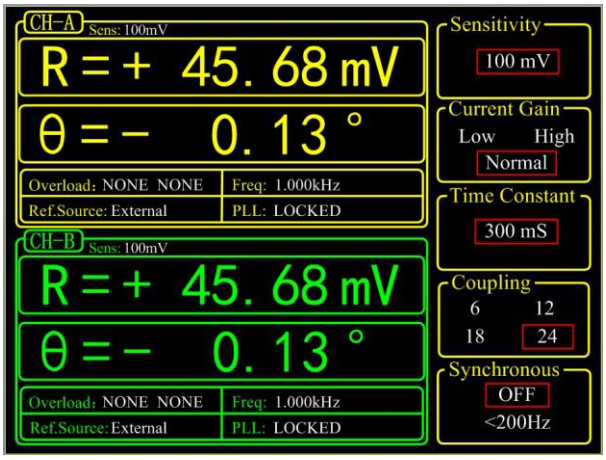
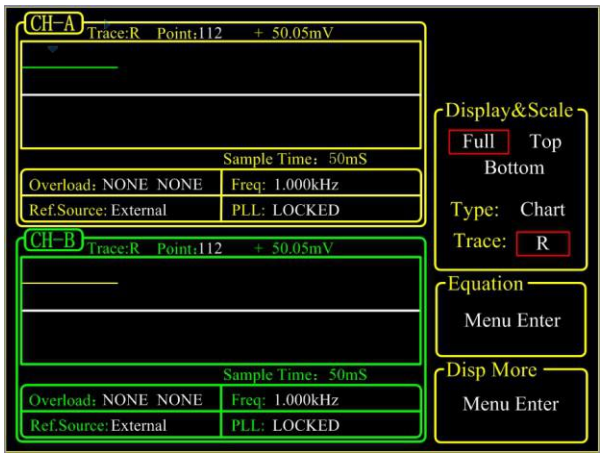
Display

SE1022D has a 5.6-inch 640 x 480 color TFT-LCD. The measurement results of SE1022D, such as X, Y, R, and θ, are shown in numerical form, bar graph, X-Y chart on the display.



In X-Y chart, SE1022D shows the trend of measurement results over time, and check the value by using knob control cursor.



Internal Oscillator

The internal oscillator of SE1022D generates a low distortion (−80 dBc) sine reference signal varying from 1 mHz to 102 kHz, which has a high frequency resolution of 1 mHz. The frequency and amplitude of the reference signal can be set by using the front panel of SE1022D or communication interface. When SE1022D is set in the external reference mode, the internal reference signal is phase-locked with the external reference signal.

Signal Generator

SE1022D uses two high precision digital-to-analog converters (DACs) to output two sine wave signals at the same frequency as their corresponding internal oscillators. The amplitude and phase of the output sine wave can be set through the SE1022D's display, where the maximum amplitude of the sine wave is 5 Vrms.

Simultaneous Multiple-harmonic Measurement

In the traditional lock-in amplifiers, only the fundamental frequency signal or a certain harmonic signal can be measured at one time, so it can not meet the requirement of multiple-harmonic measurement in some occasions. On the contrary, SE1022D uses a flexible digital framework combined FPGA and ARM, which make it practicable and efficient to measure 3 harmonic components simultaneously for each input channel, which means that each input channel is equivalent to three traditional lock-in

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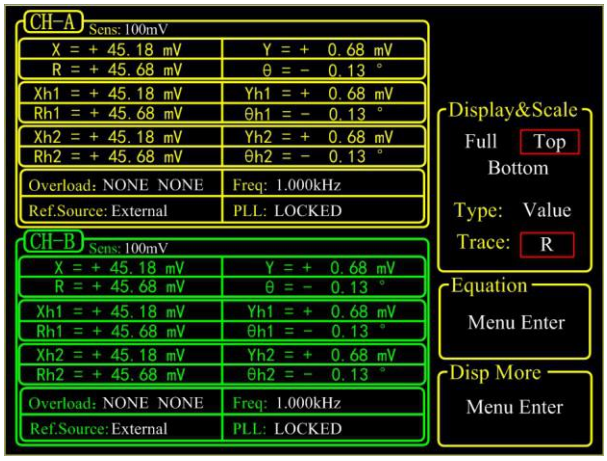
amplifiers. Because of two independent input channels in SE1022D, SE1022D can detect 6 harmonics (2 fundamentals and 4 harmonics) at one time. The maximum harmonic signal frequency can reach 32,767 times the fundamental frequency, but the maximum harmonic frequency cannot exceed the maximum operating frequency of the instrument by 102 kHz.



Manual Operation

The parameters are convenient to be adjusted by the soft keys besides the display and the numeric keypad on the front panel, such as the internal oscillator frequency and the SINE OUT amplitude.

Auto Function

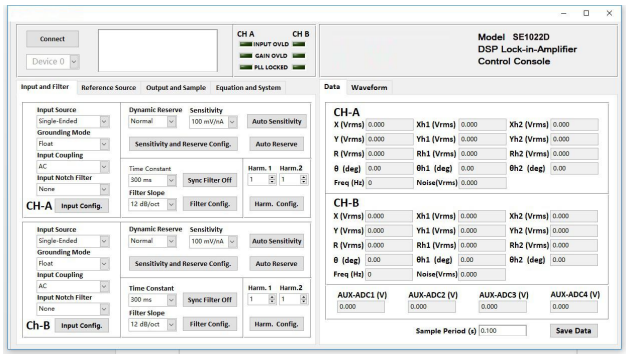
SE1022D can automatically adjust itself into different optimal operating modes for different input signals, such as Auto Gain mode, Auto Reserve mode and Auto Phase mode. This makes it easier for users to measure signals more efficiently.

Interface

SE1022D uses RS-232 and USB 2.0 as standard interfaces. Through communication interfaces, all instrument functions can be controlled and all data can be read in real-time. Meanwhile, all interfaces of SE1022D are distributed on the front panel and the rear panel.

Remote Operation

Users can use PC to control SE1022D through communication interfaces, including setting the parameters and reading the measurement data. SE1022D is equipped with a free LabVIEW program, which makes it easy to use in complex scientific experiments.



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Technical Specifications

➢ Two Signal Channels

Voltage Input Mode	Single-ended or Differential
Full-scale Sensitivity	1 nV to 1 V in a 1-2-5 sequence 1 fA to 1 μA
Current Input	10^6 or 10^8 V/A
Impedance	
Voltage	10 MΩ // 25 pF, AC or DC coupled
Current	1 kΩ to virtual ground
C.M.R.R	>100 dB to 10 kHz, decreasing by 6 dB/oct
Dynamic Reserve	>100 dB
Gain Accuracy	0.2% typ, 1% max
Voltage Noise	6 nV/√Hz at 997 Hz
Current Noise	15 fA/√Hz at 97 Hz 13 fA/√Hz at 997 Hz
Line Filters	50/60 Hz and 100/120 Hz
Gounding	BNC shield can be grounded or floated via 10 kΩ to ground

➢ Two Reference Channels

Input	
Frequency range	1 mHz to 102 kHz
Reference input	TTL or Sine
Input impedance	1 MΩ//25 pF
Phase	
Resolution	0.01°
Absolute phase error	<1°
Relative phase error	<0.01°
Orthogonality	90°±0.001°
Phase noise	
Internal ref.	Synthesized, <0.0001°rms at 1 kHz
External ref.	0.001°rms at 1 kHz (100 ms time constant, 12 dB/oct)
Drift	<0.01°/℃ below 10 kHz <0.1°/℃ above 10 kHz
Harmonic Detection	2F, 3F, …nF to 102 kHz (n<32767)
Acquisition Time	
Internal ref.	Instantaneous acquisition
External ref.	(2 cycles + 5 ms) or 40 ms, whichever is larger

➢ Demodulator

Stability	
Digital output	no zero drift on all setting
Display	no zero drift on all setting
Analog output	<5 ppm/℃ for all dynamic reserve settings
Harmonic Rejection	-90 dB
Time Constant	10 μs to 3 ks (<200 Hz) 10 μs to 30 s (>200 Hz) (6, 12, 18, 24 dB/oct rolloff)
Synchronous Filters	Available below 200 Hz (18, 24 dB/oct rolloff)

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➢ Internal Oscillator

Frequency	
Range	1 mHz to 102 kHz
Accuracy	2 ppm + 10 μHz
Resolution	1 mHz
Distortion	-80 dBc (f<10 kHz), -70 dBc (f>10 kHz)
Amplitude	0.001 to 5 Vrms
Accuracy	1%
Stability	50 ppm/℃
Output	Sine output on rear panel TTL sync output on rear panel

➢ Interfaces

USB2.0 and RS232 interfaces

➢ Display

Screen	5.6 inch, 640×480 TFT
Screen Format	Single or dual display
Display Quantities	Each display shows one trace, traces can be defined as X,Y,R,θ
Display Types	Numerical form, bar graph and strip chart

➢ Two Outputs

CH1 and CH2 Outputs

Function	Output X, Y, R, θ
Output voltage	±10 V full scale, 30 mA max output current

➢ General

Power Requirement	
Voltage	220 - 240 VAC, 100 - 120 VAC (optional)
Frequency	50/60 Hz
Power	50 W
Dimension	473 (W)×160 (H)×490 (D) mm (with feet) 473 (W)×147 (H)×490 (D) mm (without feet)
Weight	11kg

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