Digital Lock-In Amplifiers

SE2031-DSP Lock-In Amplifier

1 mHz to 3 MHz

Features

- *1 mHz to 3 MHz frequency range*
- *1 nV to 1 V full-scale sensitivity*
- *Time constants from 10 μs to 3 ks*
- *>120 dB dynamic reserve*
- *Automatic adjustment*
- *Multiple-harmonic measurement*
- *5.6 inch color TFT-LCD screen*

Overview

SE2031 Digital Lock-in Amplifier provides an excellent performance within its bandwidth from 1 mHz to 3 MHz. With the advantage of the latest digital signal processing technology and high-speed 16-bit ADC, SE2031 can easily detect the phase and the magnitude of weak signals overwhelmed by various large noise. The performance of SE2031 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. Otherwise, SE2031 integrates some special functions like multiple harmonic measurement, which meets the needs of scientific research and industrial application well.

Input Channel

SE2031 detects an input signal in a single-ended mode or a differential voltage mode. With an ultra low-noise pre- amplifier, the input noise is as low as 3 nV/√Hz@997 Hz. The input impedance is 10 MΩ and the full-scale input voltage sensitivity ranges from 1 nV to 1 V. Besides, SE2031 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 of the system, so that SE2031 can keep a high dynamic reserve of 120 dB. The high-precision 16-bit ADC has a sampling rate of 10 MSPS, and the excellent anti-aliasing filter in front of the ADC can effectively prevent signal aliasing.

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Reference Channel

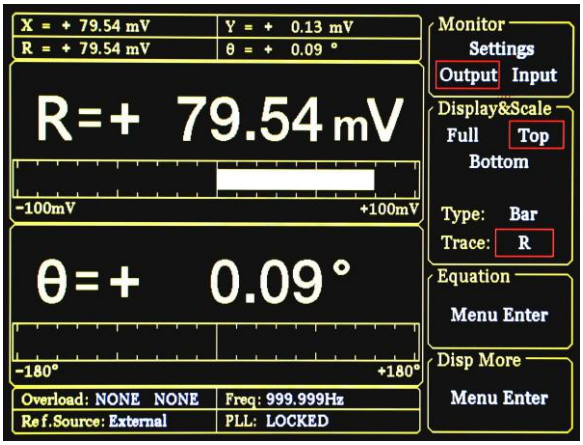
The reference signal can work in external mode or internal mode. In internal mode, a precise and stable internal oscillator generates sine wave as an internal reference that is multiplied by the input signal. This internal signal is without any phase noise. With the digital phase-shifting technique, the phase resolution of the reference signal is 0.01°. SE2031 can work at any fixed frequency from 1 mHz to 3 MHz in this mode. In external mode, the reference signal can be a sine wave or a TTL pulse or 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 SE2031 can detect the harmonics of the input signal. The maximum harmonic signal frequency can reach 32,767 times the fundamental frequency, and the maximum harmonic frequency cannot exceed the maximum operating frequency of the instrument by 3 MHz.

Digital Demodulator and Output Filter

The key component of the SE2031 is the digital demodulator. Compared to traditional analog lock-in amplifiers, the SE2031'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 24 dB/oct rolloff. This low-pass digital filter is implemented using a high performance digital filter with a sample rate of 10 MHz. The digital demodulation and the low-pass filter used in SE2031 guarantees a high dynamic reserve (>120dB), 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 SE2031 can detect a low-frequency signal quickly and effectively.

Display

SE2031 has a 5.6-inch 640 x 480 color TFT-LCD. The measurement results of SE2031, such as X, Y, R, and θ, are shown in numerical form, bar graph, X-Y chart and polar coordinates on the display.



In X-Y chart, SE2031 shows the trend of measurement results over time, and check the value by using knob control cursor.

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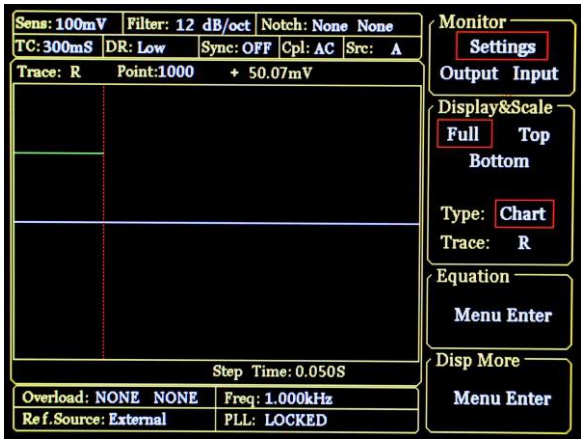
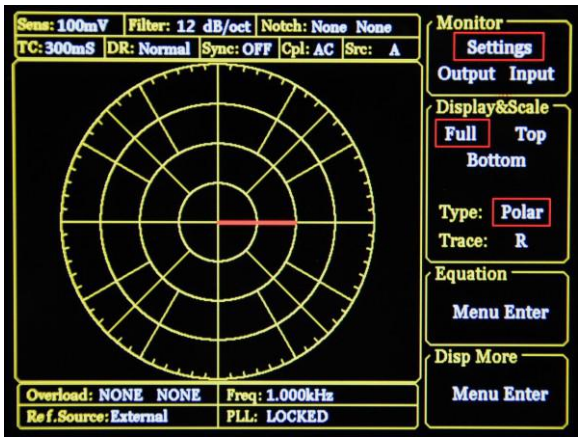
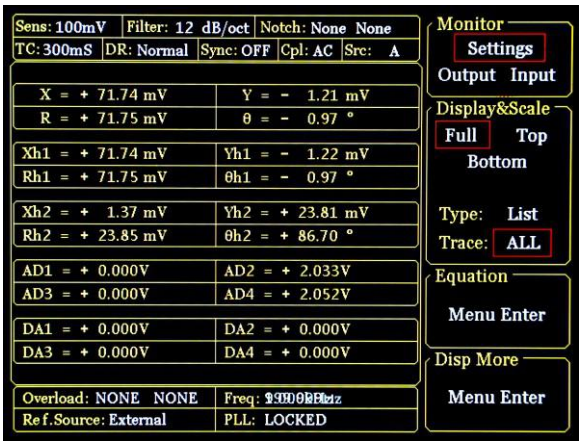


In addition, SE2031 can also uses polar coordinates to display the in-phase component and quadrature component of the input signal. All of these display modes can be easily adjusted by manual or automatic operations.



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 need of the multiple-harmonic measurement in some occasions. On the contrary, SE2031 uses a flexible digital framework combined FPGA and ARM, which make it practicable and efficient to measure 3 harmonic components simultaneously, which means that one SE2031 is equivalent to three traditional lock-in amplifiers. 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 3 MHz.



Internal Oscillator

The internal oscillator of SE2031 generates a low distortion (–80 dBc) sine reference signal varying from 1 mHz to 3 MHz, 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 SE2031 or communication interface. When SE2031 is set in the external reference mode, the internal reference signal is phase-locked with the external reference signal.

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Signal Generator

SE2031 uses a high precision digital-to-analog converter (DAC) to output a sine wave signal at the same frequency as the internal reference signal from 1 mHz to 3MHz. The amplitude and phase of the output sine wave can be set through the SE2031's display, where the maximum amplitude of the sine wave is 10 Vpp.

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

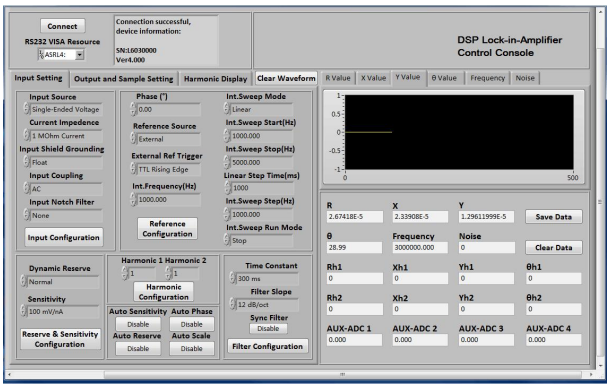
SE2031 can automatically adjust itself into different optimal operating modes for different input signals, such as Auto Gain mode, Auto Reserve mode and Auto Phase mode. This function makes it easier for users to measure signals more efficiently.

Interface

SE2031 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 SE2031 are distributed on the front panel and the rear panel.

Remote Operation

Users can use PC to control SE2031 through communication interfaces, including setting the parameters and reading the measurement data. SE2031 is equipped with a free LabVIEW program, which makes it easy to use in complex scientific experiments.



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Technical Specifications

➢ Signal Channel

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	>120 dB
Gain Accuracy	0.2% typ, 1% max
Voltage Noise	3 nV/√Hz at 997 Hz
Current Noise	7 fA/√Hz at 97 Hz 10 fA/√Hz at 997 Hz
Line Filters	50/60 Hz and 100/120 Hz
Gounding	BNC shield can be grounded or floated via 1 kΩ to ground

➢ Two Reference Channels

Input	
Frequency range	1 mHz to 3 MHz
Reference input	TTL or Sine
Input impedance	1 MΩ//25 pF
Phase	
Resolution	1 μdeg
Absolute phase error	<1 deg
Relative phase error	< 1 mdeg
Orthogonality	90°±0.001°
Phase noise	
Internal ref.	Synthesized, <0.0001°rms at 1 kHz
External ref.	0.005°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 3 MHz (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)

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➢ Internal Oscillator

Frequency	
Range	1 mHz to 3 MHz
Accuracy	2 ppm + 10 μHz
Resolution	1 mHz
Distortion	-80 dBc (f<10 kHz), -70 dBc (f>10 kHz)
Amplitude	0.001 to 10 Vpp
Accuracy	1%
Stability	50 ppm/℃
Output	Sine output on front panel TTL sync output on rear panel

➢ Interfaces

USB2.0 and RS-232 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	Large numeric readout, bar graph, polar plot and strip chart

➢ 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	40 W
Dimension	473 (W)×160 (H)×490 (D) mm (with feet) 473 (W)×147 (H)×490 (D) mm (without feet)
Weight	12kg

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