

# Digital Lock-In Amplifiers

OE1201-DSP Lock-In Amplifier



## Features

- 50 mHz to 120 kHz frequency range
- Low-noise current and voltage inputs
- 1 nV to 1 V full-scale sensitivity
- Time constants extending from 10  $\mu$ s to 3 ks
- Up to 120 dB dynamic reserve
- Up to 100dB CMRR

## Overview

OE1201 Small-sized DSP Lock-in Amplifier provides a superb performance within its bandwidth from 50 mHz to 120 kHz. With the high-speed 4-core architecture, high-precision ADC and excellent analog performance, OE1201 can easily detect the phase and the magnitude of weak signals overwhelmed by various large noise. The performance of OE1201 is as good as other lock-in amplifiers all over the world, even better than them in some certain parameters, such as measurement accuracy, operating bandwidth, which meets the needs of scientific research and industrial application well.

## Input Channel

OE1201 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 9 nV/  $\sqrt{\text{Hz}}$ @997 Hz. The input impedance is 10 M $\Omega$  and the full-scale input voltage sensitivity ranges from 1 nV to 1 V. Besides, OE1201 can be used for current measurement with gains of 10<sup>6</sup> or 10<sup>8</sup> 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 OE1201 can keep a high dynamic reserve of 120 dB.

## 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 deg. OE1201 can work at any fixed frequency from 50 mHz to 120 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 OE1201 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 120 kHz.

## Digital Demodulator and Output Filter

The key component of the OE1201 is the digital demodulator. Compared to traditional analog lock-in amplifiers, the OE1201'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  $\mu$ s 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 a high performance digital filter with a sample rate of 485 kHz. The digital demodulation and the low-pass filter used in OE1201 guarantees a high dynamic reserve (>120dB), accurate phase (absolute phase error <1 deg). Moreover, when the frequency of the input signal is lower than 20 Hz, A synchronous filter can be used to eliminate the harmonic influence of the reference signal, ensuring that OE1201 can detect a low-frequency signal quickly and effectively.

## Display

Oe1201 has a 3.5-inch 320 x 240 color TFT-LCD. The measurement results of OE1201, such as X, Y, R, and  $\theta$ , are shown in numerical form.

*OE1201-DSP Lock-In Amplifier*

|                         |                  |                  |                |
|-------------------------|------------------|------------------|----------------|
| Sens: 100mV             | Filter: 24dB/oct | Notch: NONE      | Input Filter   |
| TC: 300mS               | DR: Normal       | Sync: OFF        | Ref Phase      |
| R = 45.456mV            |                  |                  | Gain TC        |
| $\theta = -0.456^\circ$ |                  |                  | Disp           |
| X = 45.456mV            |                  |                  |                |
| Y = 0.456mV             |                  |                  | Channel Output |
| Overload: NONE NONE     |                  | Freq: 1000.000Hz | Utility        |
| Ref. Source: External   |                  | PLL: LOCKED      |                |

## Internal Oscillator

The internal oscillator of OE1201 generates a low distortion (–80 dBc) sine reference signal varying from 50 mHz to 120 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 OE1201 or communication interface. When OE1201 is set in the external reference mode, the internal reference signal is phase-locked with the external reference signal.

|                       |           |                  |           |                |
|-----------------------|-----------|------------------|-----------|----------------|
| R =                   | 12.456 mV | θ =              | 0.46°     | Input Filter   |
| X =                   | 12.456 mV | Y =              | -0.456 mV | Ref Phase      |
| Phase: + 0.00°        |           |                  |           | Gain TC        |
| Ref. Source: External |           |                  |           | Disp           |
| Freq: 1000.000Hz      |           |                  |           | Channel Output |
| Slope: TTL            |           |                  |           | Utility        |
| Harmonic: 1           |           |                  |           |                |
| Overload: NONE NONE   |           | Freq: 1000.000Hz |           |                |
| Ref. Source: External |           | PLL: LOCKED      |           |                |

## Signal Generator

OE1201 uses a high precision digital-to-analog converter (DAC) to output a sine wave signal at the same frequency as the internal reference signal. The amplitude and phase of the output sine wave can be set through the OE1201's display, where the maximum amplitude of the sine wave is 1 Vrms.

## Manual Operation

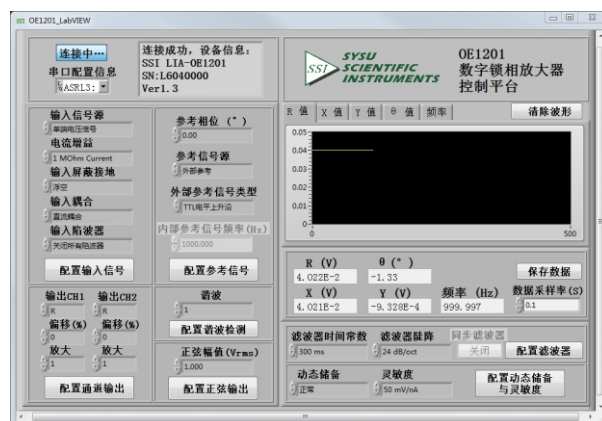
The parameters are convenient to be adjusted by the soft keys besides the display and the numeric keypad on the front panel, such as the internal oscillator frequency and the SINE OUT amplitude.

## Interface

OE1201 uses 9-pin RS-232 and RS-232 to USB interfaces as standard. Through communication interfaces, all instrument functions can be controlled and all data can be read in real-time. Meanwhile, all interfaces of OE1201 are distributed on the front panel and the rear panel.

## Remote Operation

Users can use PC to control OE1201 through communication interfaces, including setting the parameters and reading the measurement data. OE1201 is equipped with a free LabVIEW program, which makes it easy to use in complex scientific experiments.



## OE1201 Specifications

### Signal Channel

|                        |                                                                                                                     |
|------------------------|---------------------------------------------------------------------------------------------------------------------|
| Voltage input Mode     | Single-ended or Differential                                                                                        |
| Full-scale Sensitivity | 1 nV to 1 V in a 1-2-5 sequence<br>1 fA to 1 $\mu$ A                                                                |
| Current input          | $10^6$ or $10^8$ V/A                                                                                                |
| Impedance              |                                                                                                                     |
| Voltage                | 10 M $\Omega$ // 25 pF,<br>AC or DC coupled                                                                         |
| Current                | 1 k $\Omega$ to virtual ground                                                                                      |
| C.M.R.R<br>by 6 dB/oct | >100 dB to 10 kHz, decreasing                                                                                       |
| Dynamic reserve        | >120 dB                                                                                                             |
| Gain accuracy          | 0.2% typ, 1% max                                                                                                    |
| Noise                  | 9 nV/ $\sqrt{\text{Hz}}$ at 997 Hz<br>0.14 pA/ $\sqrt{\text{Hz}}$ at 997 Hz<br>0.13 pA/ $\sqrt{\text{Hz}}$ at 97 Hz |
| Line filters           | 50/60 Hz and 100/120 Hz                                                                                             |
| Grounding              | BNC shield can be grounded<br>or floated via 1 k $\Omega$ to ground                                                 |

### Reference Channel

|                                 |                                                                                        |
|---------------------------------|----------------------------------------------------------------------------------------|
| Input                           |                                                                                        |
| Frequency range                 | 50 mHz to 120 kHz                                                                      |
| Reference input                 | TTL or Sine                                                                            |
| Input impedance                 | 1 M $\Omega$ /25 pF                                                                    |
| Phase                           |                                                                                        |
| Resolution                      | 1 $\mu$ deg                                                                            |
| Absolute phase error            | <1 deg                                                                                 |
| Relative phase error            | <1 mdeg                                                                                |
| Phase noise                     |                                                                                        |
| Internal ref.                   | Synthesized, <0.0001 deg at<br>1 kHz                                                   |
| External ref.                   | 0.005 deg at 1 kHz (100 ms<br>time constant, 12 dB/oct)                                |
| Drift                           | <0.1 deg/ $^{\circ}\text{C}$ below 10 kHz<br><0.5 deg/ $^{\circ}\text{C}$ above 10 kHz |
| Harmonic detection<br>(n<32767) | 2F, 3F, ...nF to 120 kHz                                                               |
| Acquisition time                |                                                                                        |
| Internal Ref.                   | Instantaneous acquisition                                                              |
| External Ref.                   | (2 cycles + 5 ms) or 40 ms,<br>whichever is larger                                     |

### Demodulator

|                                    |                                                                                                  |
|------------------------------------|--------------------------------------------------------------------------------------------------|
| Stability                          |                                                                                                  |
| Digital outputs                    | no zero drift on all setting                                                                     |
| Display                            | no zero drift on all setting                                                                     |
| Analog outputs<br>reserve settings | <5 ppm/ $^{\circ}\text{C}$ for all dynamic                                                       |
| Harmonic rejection                 | -90 dB                                                                                           |
| Time constants                     | 10 $\mu$ s to 3 ks (< 200 Hz)<br>10 $\mu$ s to 30 s (> 200 Hz)<br>(6, 12, 18, 24 dB/oct rolloff) |

|                     |                       |
|---------------------|-----------------------|
| Synchronous filters | Available below 20 Hz |
|---------------------|-----------------------|

### Internal Oscillator

|            |                                                            |
|------------|------------------------------------------------------------|
| Frequency  |                                                            |
| Range      | 50 mHz to 120 kHz                                          |
| Accuracy   | 2 ppm + 10 $\mu$ Hz                                        |
| Resolution | 1 mHz                                                      |
| Distortion | -80 dBc (f<10 kHz),<br>-70 dBc (f>10 kHz)                  |
| Amplitude  | 0.10 Vrms to 1 Vrms                                        |
| Accuracy   | 1%                                                         |
| Stability  | 100 ppm/ $^{\circ}\text{C}$                                |
| Outputs    | Sine output on rear panel<br>TTL sync output on rear panel |

### Display

|                    |                                                     |
|--------------------|-----------------------------------------------------|
| Screen             | 3.5 inch, 320 $\times$ 240 TFT                      |
| Display quantities | 4 channels of data to display<br>X,Y,R and $\theta$ |
| Display types      | Numerical form                                      |

### Outputs

|                     |                                                   |
|---------------------|---------------------------------------------------|
| CH1 and CH2 Outputs |                                                   |
| Function            | X, Y, R, $\theta$                                 |
| Output Voltage      | $\pm 5$ V full scale.<br>30 mA max output current |

### Interfaces

RS-232 and RS-232 to USB interfaces.

### General

|                    |                              |
|--------------------|------------------------------|
| Power requirements |                              |
| Voltage            | 220/240 V AC<br>100/120 V AC |
| Frequency          | 50/60 Hz                     |
| Power              | 20 W                         |
| Dimensions         |                              |
| Width              | 259 mm                       |
| Depth              | 320 mm                       |
| Height             |                              |
| With feet          | 115 mm                       |
| Without feet       | 102 mm                       |
| Weight             | 3.2 kg                       |