



## Overview

The OE2031/OE2041 is a high-frequency phase-locked amplifier offering exceptional measurement capabilities for both weak signals and wide bandwidths, with a bandwidth measurement range of DC to 10MHz (OE2031) / 80MHz (OE2041). With the advantage of the latest digital signal processing technology and high-speed 250MSPS 14-bit ADC, OE2031/OE2041 can easily detect the phase and the magnitude of weak signals overwhelmed by various large noise. The performance of OE2031/OE2041 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, which meets the needs of scientific research and industrial application well.

## Reference Signal 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 0.001deg. OE2031/OE2041 can work at any fixed frequency from DC to 10MHz/80MHz 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, can demodulate multiple harmonics and arbitrarily frequency input signal. The maximum harmonic signal

## Key Features

- DC - 10 MHz/80 MHz frequency range
- 1 nV to 2 Vrms full-scale sensitivity
- Input noise: as low as  $3 \text{ nV}/\sqrt{\text{Hz}}$
- Time constants from 100 ns to 3 ks
- >120 dB dynamic reserve
- 6 demodulators and 2 PLLs
- Oscilloscope, Spectrum Analysis, Sweeper, 4 PID Controllers, AM/FM/PM-MOD

## Input Signal Channel

OE2031/OE2041 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  $3 \text{ nV}/\sqrt{\text{Hz}}@1\text{MHz}$ . The input impedance is 50Ω or 10MΩ and the full-scale input voltage sensitivity ranges from 1nV to 2 Vrms. Besides, designed to eliminate power frequency interference. A programmable gain amplifier is used to adjust the dynamic reserve of the system, so that OE2031/OE2041 can keep a high dynamic reserve of 120 dB. The high-precision 14-bit ADC has a sampling rate of 250 MSPS, and the excellent anti-aliasing filter (Blocking Attenuation >100dB) in front of the ADC can effectively prevent signal aliasing.

## Digital Demodulator and Output Filter

The key component of the OE2031/OE2041 is the digital demodulator. Compared to traditional analog lock-in amplifiers, OE2031/OE2041'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. OE2031/OE2041 features 6 dual-phase demodulators. Time constants of the output low-pass filter from 100ns to 3ks (50μHz to 1.6MHz) can be selected with a choice of 6, 12, 18, 24, 30, 36, 42 and 48 dB/oct rolloff (1st to 8th order). This low-pass digital filter is implemented using a high performance digital filter with a sample rate of 250 MHz. The digital demodulation

# Digital Lock-In Amplifier

OE2031/OE2041 -DSP Lock-in Amplifier

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frequency can reach 10000 times the fundamental frequency, and the maximum harmonic frequency cannot exceed the maximum operating frequency of the instrument by 10MHz/80MHz.

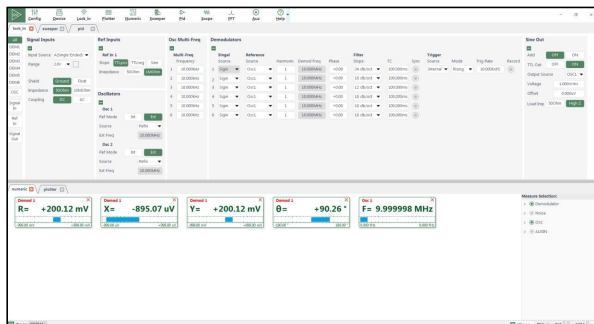
## Auxiliary IO

The OE2031/OE2041 features arbitrary auxiliary input and output interfaces. The AUX-IN port can measure voltages below 10V at a sampling rate of 312.5kSPS. The AUX-OUT/CH-OUT port operates at a refresh rate of 1 Msps, capable of outputting X, Y, R and  $\theta$ -values, and arbitrary DC voltages. Additionally, the OE2031/OE2041 incorporates CLK-IN, CLK-OUT, TRIG IN, TRIG OUT, and analogue mirror output ports.



## Remote Operation

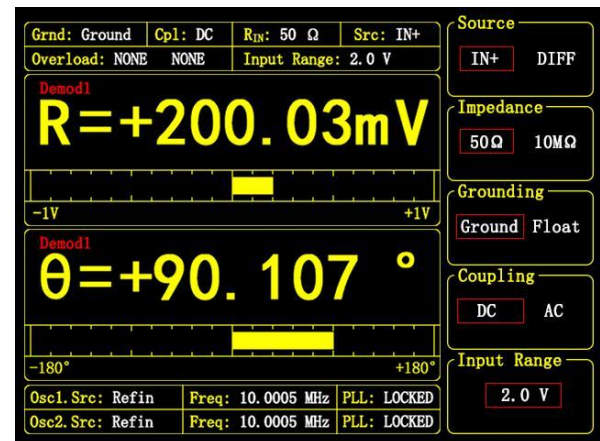
The OE2031/OE2041 is equipped with graphical upper computer software. With quick graphic buttons and rich graphic operation functions, in addition, this software has a clear numerical value display and waveform display function, real-time display of measurement data, measurement results can be saved 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).



and the low-pass filter used in OE2031/OE2041 guarantees a high dynamic reserve ( $>120\text{dB}$ ), accurate phase (absolute phase error  $< 1\text{deg}$ ). Moreover, when the frequency of the input signal is lower than 1MHz, A synchronous filter can be used to eliminate the harmonic influence of the reference signal, ensuring that OE2031/OE2041 can detect a low-frequency signal quickly and effectively.

## Display

The OE2031/OE2041 is equipped with a 5.6-inch TFT-LCD colour display serving as the primary interface for the instrument, enabling comprehensive independent control via the keyboard. Data detectable by the instrument, such as signal X, Y, R and  $\theta$ -values, can be displayed through numerical graphs, bar charts, and full data presentation modes.



## Communication Interface

The OE2031/OE2041 has USB2.0, Gigabit Ethernet port and standard 9-pin RS232 serial port. Through these interfaces, users can effectively utilize all testing functions of the OE2031/OE2041 on a controlling computer, setting reasonable control parameters and reading the data measured by the instrument.

## Signal Generator

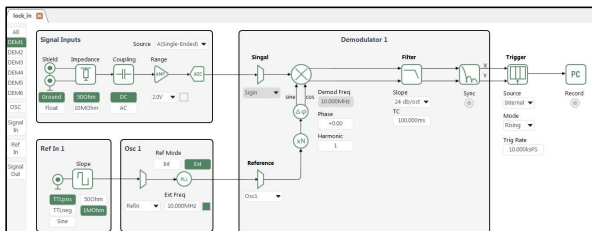
The OE2031/OE2041 utilises a 16-bit high-precision digital-to-analogue converter (DAC) to output a sinusoidal signal matching the internal reference frequency. This sinusoidal wave features a maximum amplitude of 2V<sub>rms</sub>, an accuracy of 0.1 $\mu$ V<sub>rms</sub>, and a frequency range spanning DC to 10MHz/80MHz. The amplitude and phase of the output sine wave can be configured via the OE2031/OE2041 display.

## Auto Function

The OE2031/OE2041 can automatically adjust to different optimal operating states based on the input signal, such as automatic range adjustment, automatic filter parameter setting, automatic phase compensation adjustment, and automatic output bias adjustment.

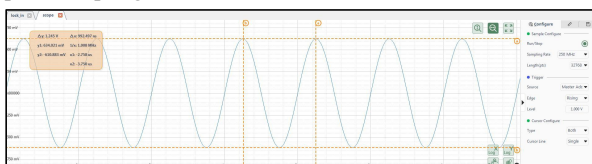
## Flowchart Operation Interface

The OE2031/OE2041 host computer may optionally display the phase-locked amplifier configuration in flowchart mode. This flowchart provides users with a diagram of the instrument's internal hardware and algorithmic structure, facilitating understanding of each parameter's function.



## Oscilloscope Functionality

The oscilloscope functionality features one signal channel, supporting selectable signal inputs, reference inputs, signal outputs, auxiliary inputs and outputs, among other signals. It incorporates multiple trigger modes to display time-domain signals in real time for the user. Each channel offers a maximum sampling depth of 262,144 samples and a peak sampling rate of 250 MSPS.



## Internal Oscillator

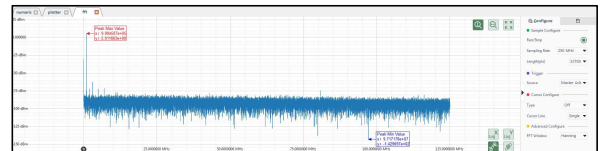
The two internal oscillators of the OE2031/OE2041 generate low-distortion (-75dBFS) sine reference signals from DC to 10 MHz/80 MHz, with frequency resolution up to 1 nHz. The frequency and amplitude of the reference signal can be set via the OE2031/OE2041 front panel or communication interface. When the OE2031/OE2041 is configured in external reference mode, the internal reference signal locks to the external reference signal.

## Manual Operation

The OE2031/OE2041 can use the softkeys on the front panel, together with the knobs, to realize convenient and quick parameter adjustments, such as adjusting the frequency and phase of the internal reference signal.

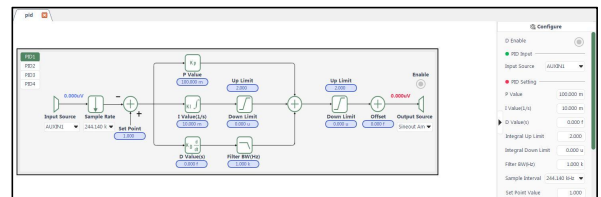
## FFT Spectrum Analysis

The FFT spectrum analysis function analyses the frequency-domain information of signals based on waveforms captured by the oscilloscope. Depending on the sampling rate and sampling depth, the frequency resolution of the spectrum analysis ranges from approximately 0.01Hz to 950Hz.



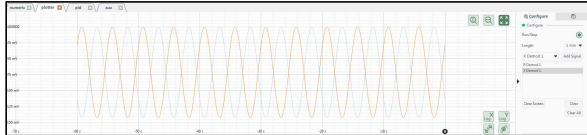
## PID Controller

The OE2031/OE2041 incorporates an independent dual-channel digital PID controller with a sampling rate up to 3.9 MSPS. The PID controller interfaces seamlessly with the phase-locked amplifier, enabling precise regulation of output signal amplitude, phase, frequency and other parameters based on demodulator measurements. This facilitates accurate control of multiple controlled variables.



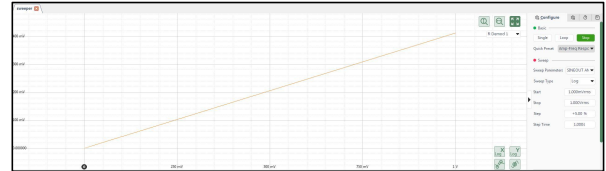
## Plotter

The plotter function enables scrolling display of time-domain data variations, flexible scaling of horizontal and vertical axes, addition of different measurement values, switching between linear and logarithmic coordinates, and display of maximum and minimum values for the current waveform, among other extensive capabilities.



## Parameter Scanner

The Parameter Scanner provides users with convenient rapid scanning, enabling instant graphical representation of frequency response, amplitude response and other curves. It offers both single-shot and cyclic scanning modes.



## Input Signal Channel

|                        |  |
|------------------------|--|
| Voltage input mode     | Single-ended or Differential   |
| Full-scale sensitivity | 1 nV to 2 Vrms   |
| Input impedance        | 50Ω // 10pF or 10 MΩ // 10pF   |
| Input coupling         | AC or DC coupled   |
| C.M.R.R                | >80 dB(<100 kHz)<br>>70 dB(@1 MHz)                                     |
| Dynamic reserve        | >120 dB  |
| Gain accuracy          | 0.5% typ.(< 1 MHz), 3% max   |
| Noise                  | 3.5 nV/ $\sqrt{\text{Hz}}$ @100 kHz<br>3 nV/ $\sqrt{\text{Hz}}$ @1 MHz |
| Grounding              | BNC (IN+, IN-) shield can be grounded or floated via 1 kΩ to ground    |

## Reference Signal Channel

|                    |   |
|--------------------|---|
| Input              |   |
| Frequency range    | DC to 10 MHz/80 MHz                                   |
| Reference input    | TTL or Sine   |
| Input impedance    | 50 Ω // 10 pF or 1 MΩ // 10 pF                        |
| Phase              |   |
| Resolution         | 1 μdeg  |
| Phase error        | 1 deg typ.(< 1 MHz), 5deg max                         |
| Drift              | < 200 ppm/°C  |
| Harmonic detection | 1-10000 (OE2031: nF < 10 MHz;<br>OE2041: nF < 80 MHz) |
| Acquisition time   |   |
| Internal Ref.      | Instantaneous acquisition                             |
| External Ref.      | 100 cycles + 5 ms                                     |

## Demodulator

|                     |   |
|---------------------|---|
| Number              | 6 channel   |
| Bit width           | 64 bits   |
| Stability           |   |
| Digital outputs     | no zero drift on all setting                                |
| Display             | no zero drift on all setting                                |
| Analog outputs      | < 200 ppm/°C  |
| Time constants      | 100 ns to 3 ks (6,12,18,24,<br>30,36, 42,48 dB/oct rolloff) |
| Synchronous filters | Effective below 1MHz  |

## Internal Oscillator

|                       |  |
|-----------------------|--|
| Number                | 2 channel                                    |
| Accuracy              | 0.3 ppm                                      |
| Temperature stability | 0.5 ppm/°C                                   |
| Phase noise           | -145 dBc/Hz (@1kHz)                          |
| Frequency             |  |
| Range                 | DC to 10 MHz/80 MHz                          |
| Accuracy              | 2 ppm + 1 μHz                                |
| Distortion            | -75 dBFS (f=100 kHz),<br>-60 dBFS (f=1 MHz), |

## Output

|                  |                             |
|------------------|-----------------------------|
| Amplitude        | 1 μV to 2 Vrms              |
| Accuracy         | 0.5% typ.(f<1 MHz), 3%max   |
| Stability        | < 200 ppm/°C                |
| Drive capability | ±70 mA max                  |
| Impedance        | 50Ω                         |
| TTL sync output  | 3.3V TTL/CMOS level         |
| Add In interface | -10V to 10V voltage signals |

## Display

|                    |  |
|--------------------|--|
| Screen             | 5.6 inch, 640×480 TFT                                    |
| Screen format      | Dual-column animated chart<br>or full data display chart |
| Display quantities | X,Y,R,θ values can be<br>displayed for each channel      |
| Display types      | Numerical display chart,<br>Bar chart                    |

## AUX Inputs and Outputs

|               |                                      |
|---------------|--------------------------------------|
| AUX Inputs    |                                      |
| Function      | 4 channel inputs                     |
| Voltage       | ±10V full scale<br>0.3 mV resolution |
| Impedance     | 1 MΩ                                 |
| AUX Outputs   |                                      |
| Function      | 4 channel outputs                    |
| Voltage       | ±10V full scale<br>0.3 mV resolution |
| Drive current | ±30 mA max                           |

## Interfaces

|           |                             |
|-----------|-----------------------------|
| USB2.0    | USB2.0 high-speed interface |
| RS-232    | DB-9 female interface       |
| Enthernet | 1GbE interface              |

## General

|                    |                    |
|--------------------|--------------------|
| Power requirements |                    |
| Voltage            | 100-240 V AC       |
| Frequency          | 50/60 Hz           |
| Power              | 50 W typ., 70W max |
| PSRR               | 70dB@1MHz          |
| Dimensions         |                    |
| Width              | 448 mm             |
| Depth              |                    |
| With handle        | 513 mm             |
| Without handle     | 470                |
| Height             |                    |
| With feet          | 148 mm             |
| Without feet       | 133 mm             |
| Weight             | 10 kg              |