

MODEL OE1022

DSP Lock-In Amplifier



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Revision 4.2

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1. SPECIFICATIONS

1.1 Signal Channel

Voltage Inputs	Single-ended (A) or differential (A-B).
Full Scale Sensitivity	1 nV to 1 V in a 1-2-5 sequence.
Current Input	10^6 or 10^8 V/A.
Input Impedance	
Voltage	10 M Ω //25 pF, AC or DC coupled.
Current	1 k Ω to virtual ground.
CMRR	> 100 dB to 10 kHz, decreasing by 6 dB/oct.
Dynamic Reserve	> 100 dB.
Gain Accuracy	0.2% typ, 1% max.
Noise	
Voltage	10 nV/Hz at 1 kHz.
Current	0.13 pA/Hz at 1 kHz. 0.013 pA/Hz at 100 Hz.
Line Filter	50/60 Hz and 100/120 Hz.
Grounding	BNC shields can be grounded or floated via 1 k Ω to ground.
Stability	<5 ppm/ $^{\circ}$ C

1.2 Reference Channel

Input	
Frequency Range	1 mHz to 102 kHz.
Reference Input	TTL or Sine.
Impedance	1 M Ω //25pF.
Phase	
Resolution	0.01 $^{\circ}$
Absolute Phase Error	< 1 $^{\circ}$
Relative Phase Error	< 0.01 $^{\circ}$
Orthogonality	90 $^{\circ}$ \pm 0.001 $^{\circ}$
Phase Noise	
Internal ref.	Synthesized, < 0.0001 $^{\circ}$ rms at 1kHz.
External ref.	0.005 $^{\circ}$ rms at 1kHz (100 ms time constant, 12 dB/oct).
Drift	< 0.01 $^{\circ}$ / $^{\circ}$ C below 10 kHz. < 0.1 $^{\circ}$ / $^{\circ}$ C above 10 kHz.
Harmonic Detection	2F, 3F, ...nF to 120 kHz (n<32,767).
Acquisition Time	
Internal Ref.	Instantaneous acquisition.
External Ref.	(2 cycles + 5 ms) or 40 ms, whichever is greater.

1.3 Demodulator

Stability	
Digital Outputs	No zero drift on all settings.
Displays	No zero drift on all settings.
Analog Outputs	< 5 ppm/°C for all dynamic reserves.
Harmonic Rejection	-90 dB
Time Constants	10 μ s to 3ks (<200Hz); 10 μ s to 30s (>200Hz) (6, 12, 18, 24 dB/oct rolloff).
Synchronous Filter	Available below 200 Hz and 18,24 dB/oct.

1.4 Internal Oscillator

Frequency	
Range	1 mHz to 102 kHz
Accuracy	25 ppm + 30 μ Hz
Resolution	0.1 mHz
Distortion	-80 dBc (f < 10 kHz), -70 dBc (f > 10 kHz)
Amplitude	0.001 to 5 Vrms with 1 mVrms resolution
Error	1%
Temperature Stability	50 ppm/°C
Outputs	Sine, output impedance is 50 Ω .

1.5 Displays

Screen	5.6 inch, 640 \times 480 TFT color LCD
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.

1.6 Outputs

CH1 and CH2 Outputs	
Function	X, Y, R, θ , harmonic
Amplitude	\pm 10 V
Impedance	100 Ω
AUX Inputs	
Function	Four channels for input.
Amplitude	\pm 10V
Impedance	1M Ω

AUX Outputs	
Function	Four channels for output.
Amplitude	±10V.
Trigger Input	
Function	TTL external trigger for data storage
Monitor Output	
Function	Analog output of signal amplifiers.

1.7 Interface

RS-232 to USB	All instrument functions can be controlled and read through the USB interface.
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1.8 General

Power Requirements	
Voltage	110/240 VAC
Frequency	50/60 Hz
Power	40 W
Weight	26.235 lb. (11.9kg)
Dimensions	
Width	18.6 " (473mm)
Depth	19.3 "(490mm)
Height	
With feet	6.3 "(160mm)
Without feet	5.8 "(147mm)

2. LOCK-IN AMPLIFIER BASICS

2.1 Introduction

The Lock-in amplifier is a device used to detect very small signals, which are always obscured by noise sources many thousands of times larger. The lock-in amplifier can extract these small signals from noises and measure their values accurately.

The lock-in amplifier is a weak signal detection method based on the coherence. Lock-in amplifiers use a key technique known as phase-sensitive detection (PSD) to single out the required component of the signal. This component has the same frequency with the reference signal and also has a fixed phase differences with the reference signal. Noise signals at other frequencies are rejected and do not affect the measurement.

The basic processing of small signals is amplification. Traditional amplifiers will amplify both the noise signals and the required signals. If there is no band limiting or filtering, amplification will decrease the signal to noise ratio (SNR). Therefore, filtering is needed to purify the signal and increase the SNR in order to measure the weak signal accurately.

PSD can be seen as a band-pass filter with a very narrow bandwidth. The basic modules of PSD include a multiplier module and a low-pass filter (LPF) module, as shown in Fig.1. Sometimes PSD is described as a multiplier module without a LPF.

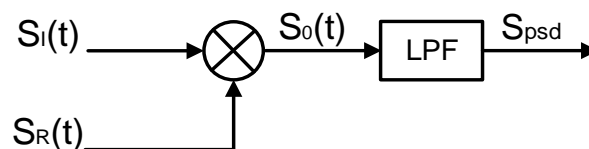


Fig.1 PSD diagram.

In Fig.1, $S_I(t)$ is the input signal plus noise in time region, $S_R(t)$ is the reference signal which has a fixed frequency with the test signal.

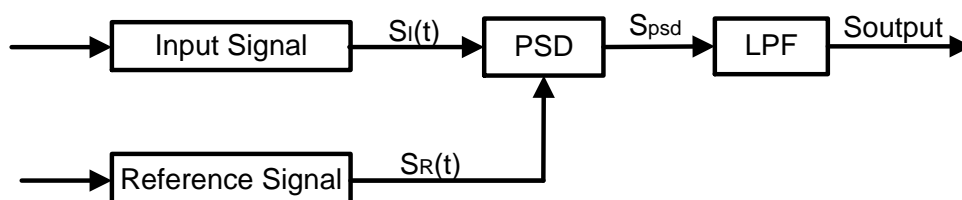


Fig.2 Single-phase amplifier diagram.

In Fig.2, the input signal $S_I(t)$ is defined as: $S_I(t) = A_I \sin(\omega t + \varphi) + B(t)$, where ω is the frequency of input signal, $A_I \sin(\omega t + \varphi)$ is the test signal, $B(t)$ is the total noise.

The reference signal $S_R(t)$ is defined as: $S_R(t) = A_R \sin(\omega t + \delta)$.

These two signals enter the PSD module for multiplication simultaneously, and the output of the PSD is defined as:

$$S_{psd} = S_I(t)S_R(t) = A_I A_R \sin(\omega t + \varphi) \sin(\omega t + \delta) + B(t)A_R \sin(\omega t + \delta)$$

$$= \frac{1}{2} A_I A_R \cos(\varphi - \delta) - \frac{1}{2} A_I A_R \cos(2\omega t + \varphi + \delta) + B(t)A_R \sin(\omega t + \delta)$$

In time region, the output of the PSD is made up of three parts:

The first part is a DC signal. If A_I , A_R and the phase difference $(\varphi - \delta)$ between the input signal and the reference signal are constants, this part is a DC signal.

The second part is the frequency-doubled reference AC signal.

The third part is the result of multiplication between the noise signal and the reference signal. Because the sine signal is periodic and there is no relevance between the noise signal and the reference signal. The integral of this part is zero.

In frequency region, we can redraw these three parts:

The first part is at 0Hz, which is known as the DC component of one signal.

The second part is at $2f_{ref}$ Hz.

The third part is a random signal at all the frequencies, such as white noise. The frequency spectrum of white noise does not change after any frequency drifts.

To sum up, the LPF output is defined as: $S_{Output} = \frac{1}{2} A_I A_R \cos(\varphi - \delta)$.

Although we can determine the amplitude of the input signal through adjusting the phase difference $(\varphi - \delta)$, the accuracy is unsteady and insecure. In order to solve this problem, the dual phase lock-in amplifier was invented, see Fig.3.

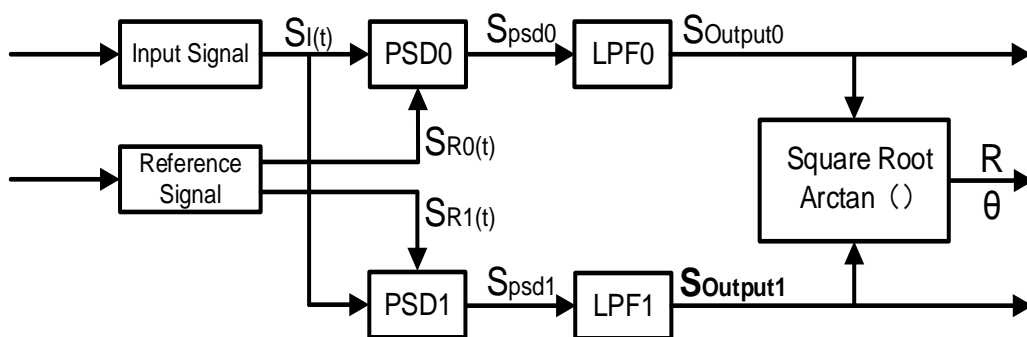


Fig.3 Dual Phase Lock-in Amplifier diagram.

Now, we define the phase difference $\theta = \varphi - \delta$, the LPF0 output $X = S_{Output0}$ and the LPF1 output $Y = S_{Output1}$. Then we calculate the amplitude R which is independent of θ :

$$R = \frac{A_I}{\sqrt{2}} = \frac{\sqrt{2(X^2 + Y^2)}}{A_R}$$

The phase difference is defined as: $\theta = \tan^{-1}(Y/X)$.

2.2 Functional Diagram

The functional block diagram of the OE1022 DSP Lock-In Amplifier is shown in Fig.4. On the whole, the OE1022 includes signal conditioners, reference signal generators, an algorithm module and a system control module and so on.

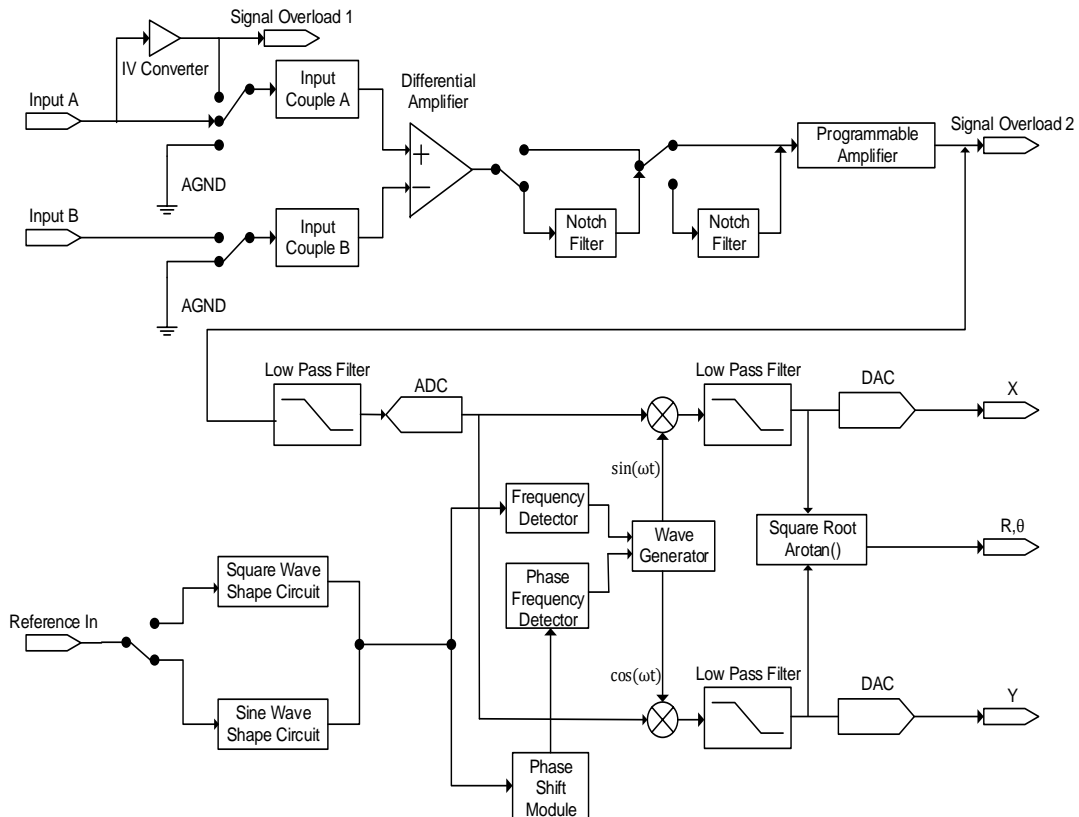


Fig.4 Functional Block Diagram of OE1022

2.3 Reference Channel

The reference channel is used to provide control signal which is associated with the detected signal. The OE1022 reference input can trigger on an analog signal such as a sine wave or a TTL logic signal. The input is AC coupled and the input impedance is $1M\Omega$.

Generally, both the sine wave and TTL signal can be used as the reference signal. However, the generator's sine output has a small and varying amplitude. Meanwhile, many function generators provide a stable TTL SYNC output which can be used as the reference. Therefore, for frequencies below 1Hz, a TTL reference signal is required.

The OE1022 lock-in amplifier has two reference signal modes: internal reference mode and external reference mode.

In internal reference mode, the internal oscillator generates a digitally synthesized sine wave which is used to multiply with the input signal. The phase-locked-loop (PLL) is not used since the lock-in reference provides the excitation. The phase noise will not affect the internal reference signal. The phase noise is extremely low. This mode can work normally from 1mHz to 102kHz.

In external reference mode, an external sine wave or TTL logic signal can be used as the external reference signal. PLL will be used in this mode, but it will generate a little phase jitter which may cause measurement errors.

The phase jitter means that average phase shift is zero but the instantaneous phase shift has a few milli-degrees of noise. The phase jitter makes the reference signal plus noise at different frequencies. According to the coherence principle of PSD, the output is not a single frequency, but a distribution of frequencies about the true reference frequency.

In fact, phase noise in the OE1022 is very low and generally has no effect. In applications that requiring no phase jitter, the internal reference mode should be chose. Since there is no PLL in internal mode. The internal oscillator and the reference sine waves are directly linked and there is no jitter in the measured phase.

2.4 Phase Sensitive Detectors

The PSD in the OE1022 acts as a digital multiplier as is shown in Fig.5. The input

signal amplified and filtered is converted to digital signal by a 24-bits A/D converter and then goes into the PSD. The reference sine wave is computed to 24 bit of accuracy, and the accuracy of the whole PSD is 48 bit.

The PSD module in lock-in amplifier is mainly used to implement the coherent modulation of the input signal and reference signal. Generally, there are two kinds of phase-sensitive detectors (PSD's): digital PSD's and analog PSD's. Traditional PSD's use an analog multiplier to multiply the input signal with the reference signal. There are many problems associated with these, including harmonic rejection, output offsets, limited dynamic reserve and gain error. It will limit the accuracy of PSD's and bring in various noises.

The digital PSD multiplies the digitized signal with a digitally computed reference sine wave. Because the reference sine wave is computed to 24 bit of accuracy, the harmonics have -90 dB roll off. That is to say, the harmonics do not affect the products of PSD.

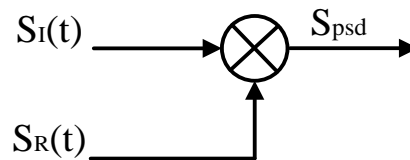


Fig.5 PSD diagram.

Because the PSD based on analog method has temperature drift, there are always some deviation between the output and actual result that is the uncertain system error. While the PSD based on digital method has a precise amplitude and never change, so it will not generate any system errors. This eliminates a major source of gain error in a linear analog lock-in. Considering that the inputs of analog multiplier are analog quantity, the reference signal will be affected by temperature drift. This will cause errors in the reference and greater errors in the results of coherent modulation.

The dynamic reserve of an analog PSD's is limited to about 60 dB, because there are always many background noises. When there is a large noise signal present, 1000 times or 60dB greater than the full-scale signal, the analog PSD measures the signal with an error. Because the lock-in amplifier is mainly used to detect weak signals, when the amplitude of background noise is similar to or larger than the signal amplitude, the results of coherent modulation will be wrong.

To the digital PSD's, the dynamic reserve is limited by the quality of the A/D conversion. Once the input signal is digitized, no further errors are introduced. Practically, the dynamic reserve of OE1022 can exceed 100dB.

The performance of a lock-in amplifier is largely determined by the performance of its PSD's. Almost in all respects, the digital PSD outperforms the analog one.

Besides, the digital PSD is also more convenient to modify.

2.5 Time Constants and DC Gain

The output signal of the PSD contains many signals of various frequency, such as the sum or difference between the input signal frequency and the reference frequency. Only the signal whose frequency is exactly equal to the reference frequency will result in a DC output.

The low pass filter (LPF) at the PSD output removes all the AC signals that unwanted, including the 2F (sum of the signal and the reference) and the noise signals. This filter is what makes the lock-in such a narrow band detector.

Time Constants

The bandwidth setting of the low pass filter is the same as the conventional low pass filter. They are both determined by the time constants. The calculation of the time constant is defined as:

$$TC = \frac{1}{2\pi f}$$

Here f is the -3dB frequency of the low-pass filter. For example, to a one-order low pass filter of RC type, a 1s time constant means its -3dB point occurs at 0.16Hz.

In fact, where there is an input noise, there is an output noise. By increasing the time constant, the output becomes more stable and measurement becomes more reliable. The time constant reflects not only the stability of the system and the accuracy, but also the respond time of the output.

The time constant also determines the equivalent noise bandwidth (ENBW). The ENBW isn't the filter -3dB pole, it is the effective bandwidth for Gaussian noise.

Digital Filters vs Analog Filters

Analog filters have many limitations in performance. The temperature drift and non-linearity are two important problems that limit the rolloff performance of an analog filter. A two-stage analog filter provides about a maximum rolloff of 12 dB/oct at high frequency points.

Space and expense are also limitations. Each filter needs to have many different time constant settings. These different settings require different components and switches to select. Each setting is costly and space consuming. A large quantity of analog devices also bring quite complexity to the device debugging.

Considering these limitations, we choose a 47 bits digital filter to accomplish

narrow band filtering. The DC amplitude is exactly 0 dB and the equivalent value of Q exceeds 145dB.

Synchronous Filters

Another advantage of digital filtering is to do synchronous filtering. Even if the input signal has no noise, the PSD output always contains a component at $2F$ (sum frequency of the signal and the reference) whose amplitude may exceed the difference frequency component that we want. At low frequencies, increasing the time constant can attenuate the $2F$ component.

In OE1022, synchronous filters are available at detection frequencies below 20 Hz. At higher frequencies, the filters are not required because the $2F$ component is easily removed without using long time constants. The output of the synchronous filter is followed by two more stages of normal filters. This combination of filters can eliminate the harmonics of the reference signal and attenuate other noise signals.

Long Time Constants

Time constants above 100s are difficult to accomplish by using analog filters. This is simply because the capacitors required for the RC filters are prohibitively large in value and size. Why would you use such a long time constant? Sometimes you have no choice. If the reference is below 1 Hz with a lot of noise at low frequency, the PSD output will contain many low frequency components. But the synchronous filter only filter out the harmonic component of the reference frequency, and the noise is filtered by the followed filters.

The OE1022 provides time constants as long as 3000s when the reference frequency is below 200 Hz, which can satisfy most requirements of measurements.

DC Output Gain

How big is the DC output from the PSD? It depends on the dynamic reserve. With a 60 dB dynamic reserve, a noise signal can be 1000 times (60 dB) greater than a full scale signal. At the PSD, the noise cannot exceed the input range of PSD. For example, in an analog lock-in, the PSD input range might be 5 V. With 60 dB dynamic reserves, the signal will be only 5 mV at the PSD input. The PSD typically has no gain so the DC output from the PSD will only be a few millivolts. Even if the PSD had no DC output errors, amplifying this millivolt signal up to 10 V is error prone. An offset as small as 1 mV will appear as 1 V at the output. This is one of the reasons why analog lock-in does not perform well at high dynamic reserve.

The digital lock-in does not have an analog DC amplifier, and has no DC output

offset. Likewise, the digital DC amplifier has no input offset. The output of digital DC amplifier is simply the products of multiplying the input signal by the gain. This allows the OE1022 to operate with 100 dB of dynamic reserve without any output offset or zero drift.

2.6 DC Outputs and Scaling

The OE1022 has Channel 1 and Channel 2 outputs (CH1 and CH2) on the front panel.

CH1 and CH2 Outputs and Display

The output range of CH1 and CH2 is from -10V to 10V.

The output signal is proportional to the value of the test signal and the setting scale. Otherwise, the OE1022 shows the value of CH1 and CH2 on the front panel, including the value of X, Y, R, θ of the test signal. The display interface of OE1022 is shown in Fig.6.

OE1022 can display the value of CH1 and CH2 through bars in addition to numbers. To discover the changes of data, you can observe the data in time region.

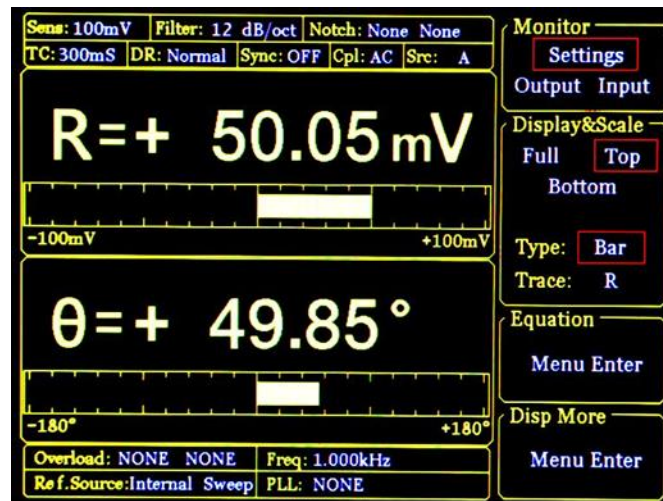


Fig.6 Display Interface of OE1022

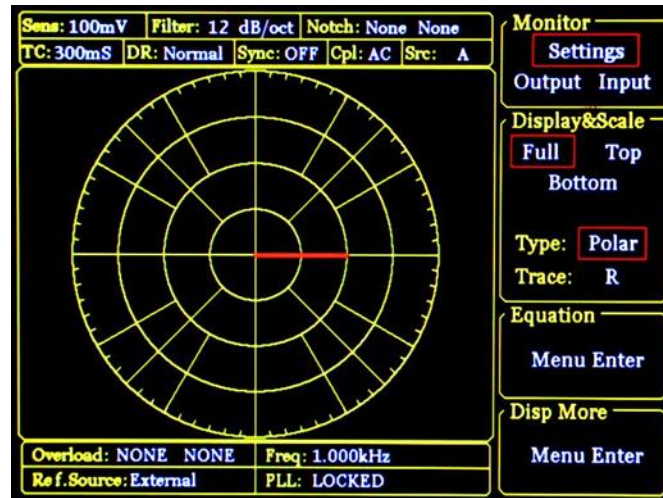


Fig.7 Polar Display Mode

Otherwise, OE1022 can use polar coordinates to display the vector combined with the co-phase and quadrature component of test signal. The polar display interface is shown in Fig.7. All display modes can simply adjust the display ratio by hand operation. The auto-adjust function can optimize the display mode rapidly.

X, Y and R Output Offset and Expand

The OE1022 has the ability to offset the X, Y and R outputs, which is useful when measuring deviations in the signal around some nominal value. The output can be offset to zero by setting the offset. Then changes in the output can be read directly from the display or output voltages. The offset is specified as a percentage of full scale. Offsets can be set up to 100% of full scale. When the sensitivity is changed, the percentage does not change.

The X, Y and R outputs can be expanded. It's realized by multiplying the output with an expansion factor. Thus, a signal which is only 10% of full scale can be expanded to provide 10 V rather than 1 V. The general use for expansion is to increase the measurement resolution around some value which is not zero.

When the output does not exceed full scale, the OE1022 can expand the output by multiplying the expansion factor from 1 to 256. The output with offset and expand is:

$$\text{Output} = \left(\frac{\text{Signal}}{\text{Sens}} + \text{Offset} \right) \times \text{Expand} \times 10(\text{V})$$

where <Offset> can be set $\pm 100\%$ by the digital keyboard and the minus step is 0.01%. <Expand> can be set from +1 to +256 by the digital keyboard and the minus step is 1. Related display interface is shown in Fig.8.

For example, there is:

$$\text{Output} = \left(\frac{0.1\text{mV}}{1\text{mV}} + 0.2 \right) \times 2 \times 10(\text{V}) = 6(\text{V})$$

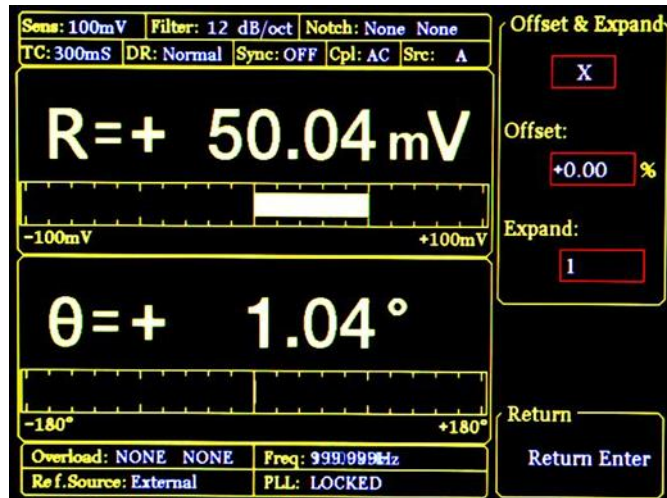


Fig.8 Output Offset and Expand

2.7 Dynamic Reserve

The traditional definition of dynamic reserve is the ratio of the largest tolerable noise signal to the full scale signal, expressed in dB. The dynamic reserve can be defined as:

$$\text{Dynamic reserve} = 20(\text{OVL}/\text{FS})(\text{dB})$$

where OVL is the total dynamic range of the input signal, FS is the dynamic range of the output signal. If the dynamic reserve is 100 dB, the tolerable noise can be 10^5 times the input.

The 'tolerable' means that the noise at the dynamic reserve limit should not cause an overload anywhere in the instrument. Overload might appear at the input of pre-amplifier and the output of DC amplifier. We can adjust the distribution of the gain to achieve high dynamic reserve. This means that the input signal gain at the pre-amplifier should be set very low so the noise is not likely to overload. The low pass filter then removes the large noise component from the PSD output which allows the remaining DC components to be amplified (a lot) to reach 10 V full scale.

Before PSD processing, the input signal is amplified by an AC gain. After the PSD, the output signal is amplified by a DC gain. The total gain is defined by multiplying the AC gain and the DC gain, the input noise is easy to overload after the AC gain. Suppose that the total gain is steady. If the AC gain increases and the DC gain decreases, the input noise is easy to overload after AC gain. Thus, the dynamic reserve and the DC drifts decrease. In contrast, if the AC gain decreases and the DC gain increases, the dynamic reserve increases. In this case, the output stability will decrease and the accuracy of measurement will lower.

The noise frequencies and amplitudes affect the accuracy of the DC output signal.

The noise signal with the same frequency as the reference signal and large amplitude become part of the DC output after the PSD processing. This enlarges the output error of the lock-in amplifier

The dynamic reserve is relative to noise frequency. The dynamic reserve increases from zero when the signal frequency is far from the reference frequency. The dynamic reserve can reach the maximum value when the frequency is low enough or high enough. The dynamic reserve near the reference frequency is important to noise tolerance of the instrument. Adding the stages of low pass filters can improve the performance of the filters and increase the dynamic reserve near the reference frequency. The dynamic reserve far from reference frequency is generally big but has little influence.

The OE1022 dynamic reserve is greater than 100 dB. High dynamic reserves will cause output noise and drift. When the dynamic reserve is high, output noise will be increased due to the A/D converter. There is background noise at any signal source and when the signal is amplified by PSD, the output signal will contain noises. If the noise is very high, it will result in large output noise. Otherwise, if the external noise is very low, the output is mainly affected by the noise of OE1022. And reducing dynamic reserve and DC gain can decrease the error. Therefore, low dynamic reserve should be chosen in actual application.

In fact, the minimum reserve changes with the sensitivity (gain) of the instrument. At high gain, the minimum dynamic reserve increases with the increase of the sensitivity. For analog lock-in amplifiers, low dynamic reserve means low output error and drift. In OE1022, high dynamic increases output noise, but not increases output error and drift. However, if the gain of analog amplifier is large enough, the amplified intrinsic noise will be greater than the noise generated by the A/D converter. In this case, increasing analog gain cannot decrease the output noise. At high sensitivity, decreasing the gain can increase the dynamic reserve.

2.8 Signal Input Amplifier and Filters

A lock-in amplifier can measure signal as small as a few nanovolts. The gain of the low noise signal amplifier should be large enough so that the output signal can be digitized by A/D converter without degrading the signal to noise (SNR). The analog gain in the OE1022 ranges from roughly 7 to 1000 times. Higher gains do not improve SNR.

The overall gain (AC and DC) is determined by the sensitivity. The distribution of the gain (AC versus DC) is set by the dynamic reserve.

Input Noise

In OE1022, the input noise is about $10 \text{ nV}_{\text{rms}}/\sqrt{\text{Hz}}$. If an amplifier has $10 \text{ nV}_{\text{rms}}/\sqrt{\text{Hz}}$ of input noise and a gain of 1000, the output will have $10 \text{ } \mu\text{V}_{\text{rms}}/\sqrt{\text{Hz}}$ of noise. Suppose the output of the amplifier is low-pass filtered by a single RC filter (6 dB/oct rolloff) with 100 ms time constant.

Input noise of lock-in amplifier and Johnson noise of resistor are both Gaussian in nature. That is to say, the amplitude of noise is proportional to the square root of the noise bandwidth. A single-stage RC filter has ENBW of $1/4T$ where T is the time constant (RxC). This means that Gaussian noise at the filter input is filtered with an effective bandwidth equal to ENBW. In this case, the filter sees $10 \text{ } \mu\text{V}_{\text{rms}}/\sqrt{\text{Hz}}$ of input noise and ENBW of $1/(4 \times 100 \text{ ms})$ or 2.5 Hz. The voltage noise at the filter output will be $10 \text{ } \mu\text{V}_{\text{rms}}/\sqrt{\text{Hz}} \times \sqrt{2.5 \text{ Hz}}$ or $15.8 \text{ } \mu\text{V}_{\text{rms}}$.

For Gaussian noise, the peak-peak noise is about 5 times the rms noise. Thus, the output noise will be about $79 \text{ } \mu\text{V}_{\text{rms}}$. Input noise works as the same way. For sensitivities below $5 \text{ } \mu\text{V}$ full scale, input noise will determine output noise.

ENBW depends on time constant and rolloff. For example, suppose the OE1022 is set to $<5 \text{ } \mu\text{V}>$ full scale, $<100 \text{ ms}>$ time constant and $<6 \text{ dB/oct}>$ rolloff. Thus, ENBW is 2.5 Hz. This brings $7.9 \text{ nV}_{\text{rms}}$ input noise. At the output, this causes about 0.16% full scale ($7.9 \text{ nV}/5 \text{ } \mu\text{V}$). The peak to peak noise will be about 0.8% full scale.

Assume that the signal input is being driven from a low impedance source. The Johnson noise of resistors equals to $0.13x\sqrt{R}$. Take a 100Ω resistor for example, its noise is almost $1.3 \text{ nV}_{\text{rms}}/\sqrt{\text{Hz}}$. When the impedance of the resistor is $2 \text{ k}\Omega$, the signal Johnson noise is greater than the OE1022 input noise. The overall noise of multiple noise sources is determined by the square root of the sum of the squares of the individual noise figures. For example, if a $1 \text{ k}\Omega$ source impedance is used, the Johnson noise will be $4.11 \text{ nV}_{\text{rms}}/\sqrt{\text{Hz}}$.

At lower gains (sensitivities above $50\mu\text{V}$), there is not enough gain at high reserve to amplify the input noise to a level greater than the noise of the A/D converter. In these cases, the output noise is determined by the A/D noise. Fortunately, at these sensitivities, the DC gain is low and the noise at the output is negligible.

Notch Filter

The OE1022 has two notch filters in the signal amplifier chain. These are pre-tuned to the line frequency and twice the line frequency. In circumstances where the largest noise signals are at the power line frequencies, these filters can be engaged to remove noise signals at these frequencies. Removing the largest noise signals before the final gain stage can reduce the amount of dynamic reserve required to perform a measurement.

To the extent that these filters reduce the required reserve to either 60 dB or minimum reserve (whichever is higher), then some improvement might be gained. If the required reserve without these notch filters is below 60 dB or if the minimum reserve is sufficient, then these filters do not significantly improve the measurement.

Using either of these filters precludes making measurement in the vicinity of the notch frequencies. These filters have a finite range of attenuation, generally 10 Hz or so. Thus, if the lock-in is measuring at 70Hz, do not use the 60 Hz notch filter. The signal will be attenuated and the measurement will be in error. When measuring phase shifts, these filters can affect phase measurements up to an octave away.

Anti-aliasing filter

After all of the signal filtering and amplification, there is an anti-aliasing filter. This filter is required by the signal digitization process. According to the Nyquist criterion, signals must be sampled at a sampling frequency at least twice the highest signal frequency. For example, the highest frequency is 100 kHz and the sampling frequency is 312.5 kHz so things are OK. However, no signals above 156 kHz can be allowed to reach the A/D converter. These signals would violate the Nyquist criterion and be under-sampled. The result of this under-sampling is to make these higher frequency signals appear as lower frequencies in the digital data stream. This would be a problem.

To avoid this under-sampling, the analog signal is filtered to remove any signals above 154 kHz. This filter has a flat pass bandwidth from DC to 120 kHz so as not to affect measurements in the operation range of the lock-in. The filter rolls off from 120 kHz to 154 kHz and achieves an attenuation above 154 kHz of at least 100 dB.

Input Impedance

The input impedance of the OE1022 is 10 M Ω . If higher input impedance is desired, the OE1022 remote preamplifier can be used so that the OE1022 has the maximum input impedance of 100 M Ω .

2.9 Input Connections

Noises exist in every part of the lock-in. Even if the signal is not very low, the existing of noises will decrease the accuracy. There are lots of methods to lower noise. Considering the noises when designing the system can increase the accuracy of the measurement. Besides, the effect of noise sources in the laboratory and the problem of the differential grounds between the detector and the lock-in can be minimized by careful input connection.

There are two basic methods for connecting a voltage signal to the lock-in - the single-ended connection is more convenient while the differential connection eliminates spurious pick-up more effectively.

Single-Ended Connection (A)

In the first method, the lock-in uses the A input in a single-ended mode. The lock-in detects the signal as the voltage between the center and outer conductors of the A input only. However, this mode has two disadvantages.

First, the low voltage is the 0 V constant. However, the ground voltage of different devices is always different. When the ground of input signal is connected with the ground of the detector, differing ground potentials will bring about a large current and this is ground loop. Thus, connecting a resistor between the experiment and the lock-in can avoid ground loop problems. Generally, float uses 10 k Ω and ground uses 10 Ω .

Second, this mode is not sensitive to the change of noise. The signal cable is just like wire. The lock-in lets the shield 'quasi-float' in order to sense the experiment ground and pick up the activities of the electronic in environment. In this case, the noise came up. But the single-ended connection mode cannot distinguish the noise and actual signal.

Differential Connection (A-B)

The second method of connection is differential mode. This mode has two signals which are connected to signal source. There are two high impedance power amplifiers in the instrument. The lock-in measures the voltage difference between

the center conductors of the A and B inputs. And this can avoid common voltage problems.

When using two input cables, it is important that both cables travel the same path between the experiment and the lock-in. Specifically, there should not be a large loop area enclosed by the two cables. Large loop areas are susceptible to magnetic pickup.

2.10 Intrinsic Noise Sources

Noise is defined as any negative factors which will affect the result of measurement. It is random, unpredictable and temporary. Good experimental design can reduce this noise stability and accurate.

There are a variety of intrinsic noise sources which are present in all electronic signals. These sources are physical in origin. Some of them are unavoidable which only can be decreased by a narrower or even bandwidth, such as the wave fluctuations of measurement. Others can be decreased by filtering and perfect chip structures and layout, such as the RF cross and ground loop. Low noise technology can be used to decrease the intrinsic noise of the lock-in amplifier.

Johnson Noise

Every resistor generates a noise voltage across its terminals due to thermal fluctuations in the electron density within the resistor itself. And this is Johnson noise. The spectrum of the Johnson noise is flat, so the noise power is same in every frequency band (it is sure that there is a limit in frequency). The noise will be called white noise if the spectrum is very flat. The fluctuations give rise to an open-circuit noise voltage,

The open-circuit noise voltage is defined as:

$$V=(4KTRB)^{1/2}$$

where k is the Boltzmann's constant of $1.38 \times 10^{-23} \text{J}/^\circ\text{K}$, T is the temperature in $^\circ\text{Kelvin}$ which can be transformed to $^\circ\text{Celsius}$ of $^\circ\text{Kelvin}$ minus 273.16, R is the resistance in Ohms, and B is the bandwidth of the measurement in Hz.

Then, Nyquist describes the features of Johnson noise in math, and found that the power spectrum function of Johnson noise is:

$$St(f) = 4KTR(V^2/\text{Hz})$$

At 300°K , a resistor of $10 \text{ K}\Omega$ is connected to the input of the amplifier. The voltmeter is connected to the output of the amplifier. The open-circuit effective voltage of the filter which has a 10 kHz bandwidth is $1.3 \mu\text{V}$.

The amplitude of Johnson noise is unpredictable in normal case. But it follows the Gaussian distribution. Johnson noise is the minimum value of the noise voltage of any devices including detectors, signal sources and amplifiers with resistors. Johnson noise is a typical case of wave dissipation.

Shot Noise

Electric current has noise due to the finite nature of the charge carriers. There is always some non-uniformity in the electron flow which generates noise in the current. This noise is called shot noise. This can appear as voltage noise when current is passed through a resistor, or as noise in a current measurement.

If ignore the effect between the charge, the shot noise or current noise is given by:

$$I=(2qI_{dc}B)^{1/2}$$

where q is the electron charge of 1.6×10^{-19} Coulomb, I_{dc} is the DC current and B is the bandwidth. If I_{dc} is 1 A DC current and B is 10 kHz, then, I is 57 nA which is about 0.000006% of I_{dc} . At a smaller current, the fluctuation is larger. For example, if I_{dc} is 1 μ A and B is still, then, I is about 0.006% or -85 dB. If I_{dc} is 1 pA and B is still, then, I is about 5.6% or 56 fA.

In fact, shot noise is also one kind of white noise. Its power spectrum density is given by:

$$S_{sl}(f)=2qId(A^2/Hz)$$

This function is used only when no effect exists between the charge, such as the diffusion current in the junction diode. However, for general metal, this function cannot be used because the cross effect between the charge cannot be ignored.

Flicker Noise of 1/f Noise

In 1925, Johnson found that there is $1/f$ noise in valves. The power spectrum function of this kind of noise is proportional to $1/f$. So, it is also called low frequency noise. Microscopically, this noise is caused by the random contact resistance between two conductors. The amplitude of $1/f$ noise follows the Gaussian distribution, and the power spectrum density is proportional to $1/f$ which is given by:

$$S(f) = \frac{KI_d^2}{f} (V^2/Hz)$$

This noise is also called flicker noise due to the random fluctuation of the power spectrum density in active devices. It broadens the bandwidth near the center frequency and reduces the value of Q of oscillators. $1/f$ noise must be considered near the center frequency.

Total Noise

Johnson noise and shot noise are all unreducible. Any resistors with the same resistance have the same Johnson noise. Shot noise relies on the special manufacture of resistors, including its material and package technology and so on. For example, among winding resistor, metal film, carbon resistor and pure carbon, the winding resistor has the minimum resistance. The metal film resistor and carbon resistor have larger resistances. The pure carbon resistor has the maximum resistance of these four.

All of these noises are incoherent. The total random noise is the square root of the sum of the squares of all the incoherent noise sources.

2.11 External Noise Sources

In addition to the intrinsic noise sources discussed previously, there are a variety of external noise sources within the laboratory. Most of these noise sources are asynchronous. They are not related to the reference and do not occur at the reference frequency or its harmonics. These noise sources affect the measurement by increasing the required dynamic reserve or lengthening the time constant. Another kind of noise sources, however, are related to the reference and, if picked up in the signal, will add or subtract from the actual signal and cause errors in the measurement.

Many of these noise sources can be minimized with good laboratory practice and experiment design. There are several ways in which noise sources are coupled in the signal path.

Capacitive Coupling

The mutual capacity between wires is often called stray capacity C_{stray} . An AC voltage from a nearby piece of apparatus can couple to a detector via C_{stray} . Although C_{stray} may be very small, the coupled noise may still be larger than a weak experimental signal and cause severe unstable for the detector. The noise current is given by:

$$I = \omega C_{\text{stray}} V_{\text{noise}}$$

where ω is 2π times the noise frequency, V_{noise} is the noise amplitude, and C_{stray} is the stray capacitance.

When the frequency of the noise source, the coupling noise will be amplified. If the noise frequency is equal to the reference frequency, the noise will be quite large. The lock-in rejects noise at other frequencies, but pick-up at the reference frequency appears as signal.

Cures for capacitive noise coupling include:

- 1) Remove or turn the noise source off.
- 2) Design the experiment to measure voltages with low impedance for most of low frequency noise sources.
- 3) Install capacitive shield by placing both the experiment and detector in one metal box.

Inductive Coupling

An AC current in a nearby piece of apparatus can couple to the experiment via a magnetic field. A changing AC current gives rise to a changing magnetic field which induces voltage. The larger the change frequency is, the larger the induced voltage is, the larger the measurement error is.

Cures for inductively coupled noise include:

- 1) Remove or turn the interfering noise source off.
- 2) Reduce the area of the pick-up loop by using twisted pairs or coaxial cables.
- 3) Use magnetic shield to prevent magnetic field from crossing the area of measurement.

Resistive Coupling or Ground Loops

The ground loop is an interference source which can generate noise voltage between the grounds. If the noise voltage is large enough, this will cause measurement errors. Ground loop is a physic loop, which generates from many ground methods. These grounding methods can act as a big loop wire. They pick up noises from the environment and generate voltages in the grounding system. The 50 Hz magnetic field of the AC power is normal noise source that the ground loop always pickup. For distributed grounding systems, the ground voltage can cause the ground current flow in the ground loop. The ground is with low impedance; thus, noise current is always very high.

Cures for ground loop problems include:

- 1) Ground everything to the same physical point.
- 2) Use a heavy ground bus to reduce the resistance of ground connections.
- 3) Remove sources of large ground currents from the ground bus used for small signals.

Microphonic

Not all noise sources are electrical in origin. Mechanical noise can be transformed into electrical noise by microphonic effect. Physical changes in the device or cables (such as due to vibrations) can result in electrical noise over the overall

bandwidth of the lock-in.

Solutions to minimize microphonic signals:

- 1) eliminate mechanical vibrations near the experiment.
- 2) Tie down cables carrying sensitive signals so they do not move.
- 3) Use a low noise cable that is designed to reduce microphonic effects.

Thermocouple effects

When two dissimilar metals connect, there will be potential difference between them. The reason of generating contact potential difference is: (1) dissimilar metals has different electronic work function. (2) the electron concentration in the two metals is different.

Suppose that metal A and metal B have work functions V_a and V_b respectively. The emf between A and B is:

$$V_{ab} = V_a - V_b + \frac{kT}{q} \times \ln\left(\frac{N_a}{N_b}\right)$$

Where K is Boltzmann's constant of $1.38 \times 10^{-23} \text{J/K}$, T is the temperature of °Kelvin, q is the charge of $1.60 \times 10^{-19} \text{Coulomb}$. From the formula, the contact potential depends on the nature of metal and the temperature of the contact surface.

If two dissimilar metals connect, the electromotive force at the contact point will increase a millivolt level on the basis of the original level. This kind of noise is sensitive to temperature. This source of noise is typically at very low frequency since the temperature of the detector and experiment generally changes slowly. This effect is large on the scale of many detector outputs and can be a problem for low frequency measurements, especially in the mHz range.

Solutions to minimize thermocouple effects are:

- 1) Hold the temperature of the experiment or detector constant.
- 2) Use a compensation junction, i.e. a second junction in reverse polarity which generates an emf to cancel the thermal potential of the first junction. This second junction should be held at the same temperature as the first junction.

2.12 Aux In/Out

There are four 16-bit high-precision AUX-ADC input channels in OE1022. The input voltage ranges from - 10 V to + 10 V and the minimum resolution is 0.3 mV. This 4 ADC channels can clamp the input signal and amplify the internal differential signal. The input impedance is 1 MΩ. At the same time, they can pick up signals to measure slow analog signal or DC signals (the signals come from temperature sensor and pressure sensor). This is useful to proportional operate and transfer the data to the computer.

Because of the internal special structure of the 4 AUX-ADC channels, the measurement result is about 2.048 when the input is floating.

There are also four 16-bit high-precision AUX-ADC output channels in OE1022. The output voltage ranges from - 10 V to + 10 V and the minimum resolution is 0.3 mV.

The AUX IN and AUX OUT ports use standard BNC connect on the rear panel. The number display setting for AUX ADC/DAC can be made in the [display] / [AUX OUTPUT] sub-menu.

2.13 Sweep Frequency and Amplitude of Signal Generator

The OE1022 adds some new functions which are frequency and amplitude scanning. Signal generator can scan on the output amplitude and frequency. Users can scan on the frequency they interested in and analyze the characteristics of the signal better. The output of amplitude scanning is sine and this will increase the scope of application.

The basic way of Frequency and amplitude scan is setting the value of the start and end point, increasing the value by step and then the scan is end. See details in the sections related to frequency and amplitude scan.

2.14 FFT Spectral Analysis

FFT is Fast Fourier transformation. It is an algorithm that extracts the frequency domain information of the signal. Generally, it is hard to analyze the signal's features in time domain. But it is easy to the component of the signal at each frequency if the signal is in frequency domain. This is beneficial to evaluate the signals in all aspects.

FFT comes from the improvement of DFT. The result is proportional to the size of N if calculate DFT directly. If N is great like 1024, the DFT requires to calculate 1048576 times. Therefore, it is impossible to analyze spectrum and process the signal in real time.

The FFT algorithm rapidly computes such transformations by factorizing the DFT matrix into a product of sparse factors and reduce the complexity of the computing the DFT by using periodicity and symmetry. For example, divide the N-sequence into two N/2-sequence. The DFT compute needs $(N/2)^2$ times' calculation for every N/2 point. Then the DFT transformation of two N/2 points can combine into one N point after N times' compute. After this transformation, the total compute times will be $N+2*(N/2)^2=N+N^2/2$. Thus, when $N=1024$, the total times are 525312 and this reduces the number of calculations by about 50%.

OE1022 develops and integrates the function of FFT high accuracy spectrum analysis. This instrument can do the frequency domain analysis from 1 kHz to 100 kHz. And OE1022 can display the spectrum distribution of the signal in real time.

2.15 Harmonic Wave Measurement

Harmonics represent these waves at multiple frequencies. Any periodic function can be described as the linear combination of one constant and many sine or cosine functions with the base frequency and the multiple frequencies. The constant is the DC component. The base frequency component is the base wave. The multiple frequencies are harmonics.

The OE1022 only measures one base wave or one component of harmonics at one time. The setting is at <Harmonic> in [REF/PHASE].

3. INTERFACES

3.1 Front Panel

The front panel of OE1022 is shown in Fig.9.



Fig.9 The OE1022 Front Panel

Display

The OE1022 uses 5.6 inches TFT-LCD for data display and interactive control. The resolution of the display screen. And the display screen has 8 levels background brightness which can set in the [SYSTEM] sub-menu. The large area in left screen is used for displaying the measurement results of input signal. It can provide single or double area for display. Otherwise, each area can display number, XY coordinates and polar coordinates. The right area is used for choosing and modifying the measurement control conditions.

Soft Keys

There are 5 soft keys on the right side of the display screen. The soft keys' functions vary with the current menu. In general, these soft keys have two main functions, one is to choose different setting options, the other one is highlight some parameters and input with soft keys or spin knob. For all the functions, the soft keys can only act on the parameters which are connected with soft keys.

Spin Knob

The knob is used to adjust parameters which are highlighted in the reference display. Most parameters can be adjusted by the spin knob.

Keyboard

Keyboard is made up of three sets keys. The [ENTRY] area is used to input the parameters which are highlighted as data forms. The [MENU] area is used for changing the parameter list at the right side of the display. And it can provide 10 different function menus. The [CONTROL] area provides ancillary functions for display, like [CURSOR].

BNC Connectors

REF IN	The reference input can be a sine wave or a TTL pulse. When the input is a sine wave, the input impedance is $1\text{M}\Omega$ and AC coupled. For low frequencies ($<1\text{Hz}$), it is necessary to use a TTL reference signal.
SINE OUT	The signal generator can provide programmable voltage which is up to 5 V. The output impedance is $50\ \Omega$. If using the external reference signal, the signal generator can lock the phase of the input signal through PLL.
CH1&CH2	The output range of CH1&CH2 OUTPUT is from -10 V to +10 V. According to ratio of the current measurement result and current setting measurement range, the input is proportional to output.
SIGNAL IN	There are two signal input methods, single input A and differential input A, B. The input A can input current signal. When measuring voltage, the input impedance of A and B are both $10\ \text{M}\Omega//25\text{pF}$. When measuring current, the input is connected to the ground with a $1\text{k}\Omega$ resistor.

3.2 Rear Panel

The rear panel is shown in Fig.10. It includes cooling fan, power connector and power switch.

USB connector and extension functional connectors which include AUX IN, AUX OUT, TRIG IN, TTL OUT, and MONITOR.



Fig.10 The OE1022 Rear Panel

Power Connector Power connector is used to provide power for the instrument. This power connector with a build-in fuse receives 220 V, 50 Hz AC power. And it can filter high frequency noise.

USB The OE1022 lock-in amplifier communicates with PC through USB connector. PC can control the OE1022 and read data.

AUX IN AUX_ADC input 1-4(A/D Inputs). These are auxiliary analog inputs which can be digitized. The range is -10V to +10V.

AUX OUT AUX_DAC output 1-4(D/A Outputs). These are auxiliary analog outputs. The range is -10V to +10V.

TRIG IN TRIG IN receives a TTL signal input used to trigger data sampling and start to get data. The rise edge is effective for TRIG IN. The maximum sampling speed is 500 Hz.

TTL OUT TTL OUT and Sine Output are synchronous. When the amplitude of the output sine wave, the TTL OUT can be used for sync lock.

MONITOR The main display is divided into 4 parts, including Status bars, Function bars, Monitoring bars and Menu bars.

3.3 Main Display

The main display is divided into 4 parts, including Status bars, Function bars, Monitoring bars and Menu bars.

3.3.1 Status Bars

As is shown in Fig.11, Fig.12, the Status bars shows the current settings of the experiment and the result of measurement.

If [Display] is lighted, see the Status 1. If another menu bar is lighted, see the Status 2.

Specifications at the Status bars:

<Sens>	The value of the sensitivity
<Filter>	The value of the roll-off.
<Notch>	The status of the notch filter.
<TC>	The value of the time constant.
<DR>	The status of the dynamic reserve.
<Sync>	The status of the synchronous filter.
<Cpl>	The couple mode.
<Src>	The input mode.
<X>	The value of the input X signal.
<Y>	The value of the input Y signal.
<R>	The value of the input R signal.
< θ >	The value of the input θ signal.

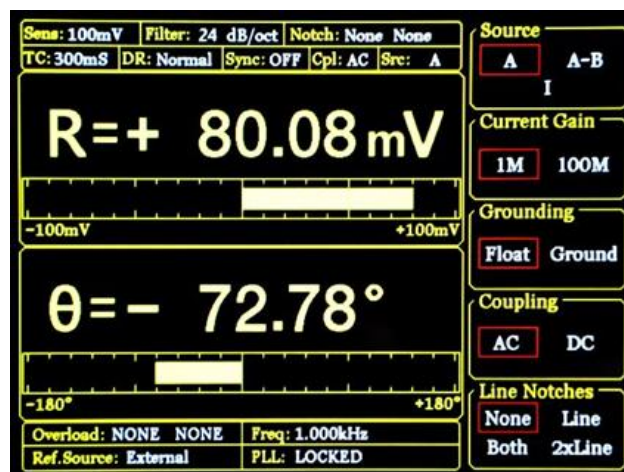


Fig.11 Main Interface: Status Bar 1

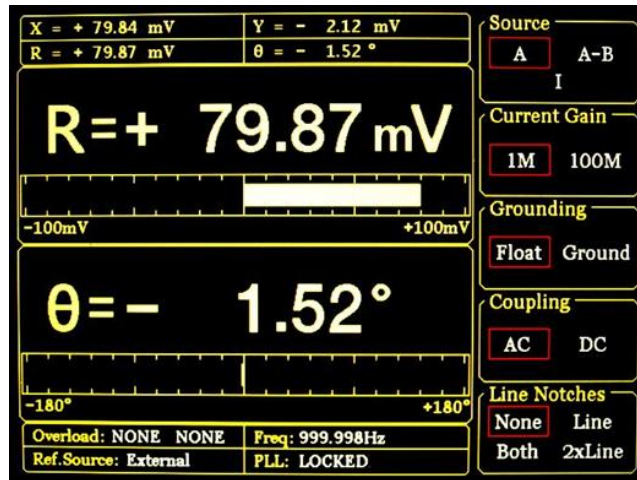


Fig.12 Main Interface: Status Bar 2

3.3.2 Data Bars

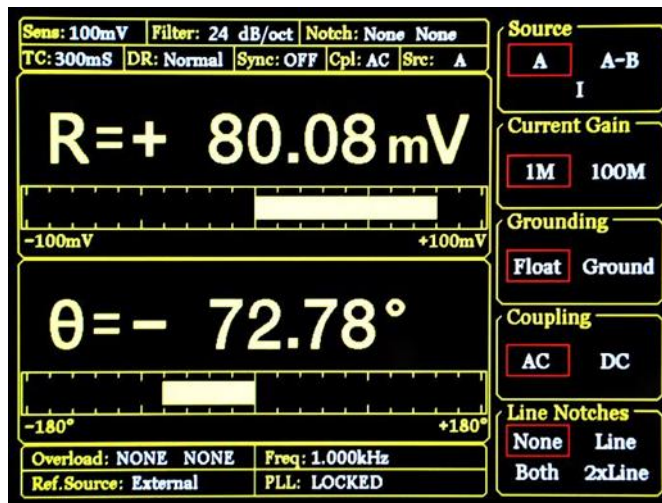


Fig.13 Main Interface: Data Bar

Users can choose to display the data of <X>, <Y>, <R>, < θ > in [DISPLAY] submenu, as is shown in Fig.13. The display methods can be number chart, bar chart, XY coordinate graph and pole coordinate graph. The setting way is in [DISPLAY] submenu.

3.3.3 Monitoring Bar

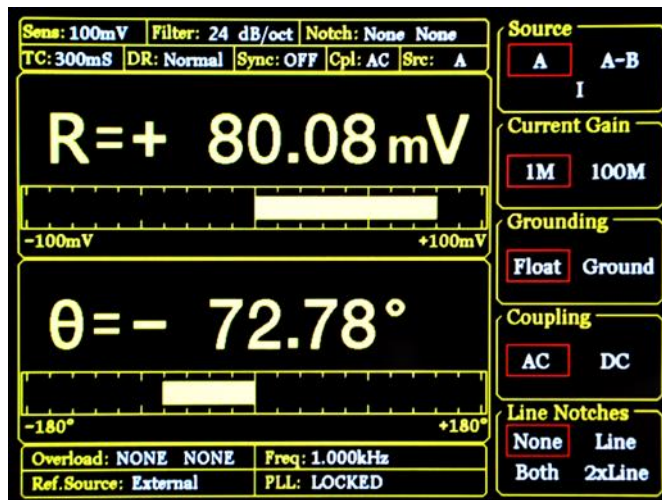


Fig.14 Main Interface: Monitoring Bar

The Monitoring bars is on the bottom part of the display as is shown in Fig.14:

<Overload>

A signal on overload for the input and output of the preamplifier.

If no overload, show <Overload: NONE NONE>;

if the input of the preamplifier is overload, show <Overload: INPUT NONE>;

if the output is overload, show <Overload: NONE GAIN>;

if the input and the output are overload at the same time, show

<Overload: INPUT GAIN>. For this case, it is necessary to turn down the input signal in case of over-voltage damage.

<Freq> The value of the input frequency.

<Ref. Source> The mode of the reference signal: Internal or External.

<PLL> The status of PLL.

If the internal reference signal is used, show <PLL: UNLOCK>.

If the external reference signal is used, show <PLL: LOCKED>.

If <Harmonic> is greater than 1, show <PLL: LOCKED HARM>.

3.3.4 Function Bar

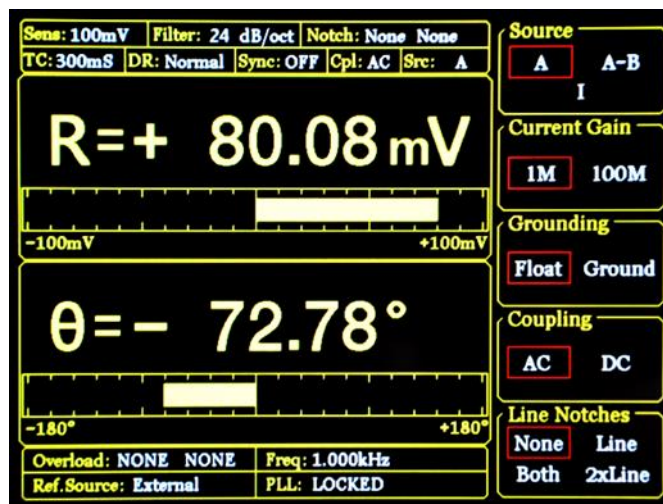


Fig.15 Main Interface: Function Bar

As is shown in Fig.15, there are many functions to choose in function setting box. They are corresponding to the 5 soft keys which are make different sense in different submenu. This is the main way to control the system.

4. MENU

The MENUs are made up of ten parts: [INPUT/FILTERS], [REF/PHASE], [GAIN/TC], [DISPLAY], [SAVE/LOAD], [CHANNEL OUTPUT], [SAMPLE], [AUX OUTPUT], [SYSTEM] and [AUTO SET]. Press one button and then the interface will switch to the corresponding sub menu display.

4.1 [INPUT/FILTERS]

You can enter this submenu by choosing the [INPUT/FILTERS] in menus of front panel, as is shown in Fig.16.

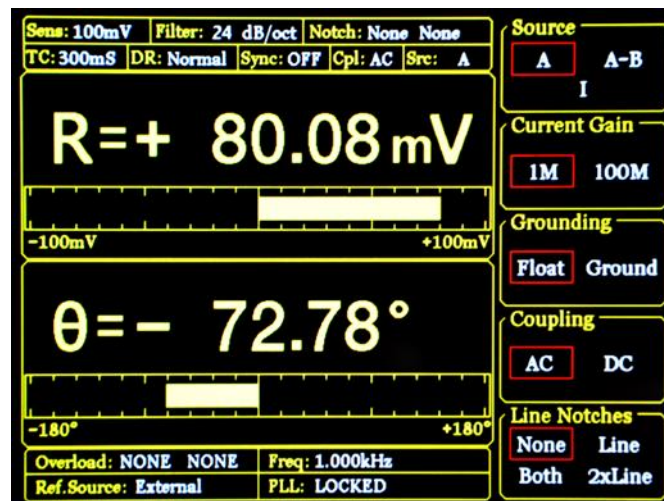


Fig16. [INPUT/OUTPUT] submenu

4.1.1 <Source>: Setting the Input Signal Mode

- <A> The single-ended voltage input mode.
- <A-B> The differential voltage input mode.
- <I> The current input mode.

Note that when use <A> and <A-B>, the amplitude of the input signal must be less than 1 Vrms.

4.1.2 < Current Gain >: Setting the Current Gain

- <1M> The current input is amplified by the gain of 10^6 V/A.
- <100M> The current input is amplified by the gain of 10^8 V/A.

4.1.3 < Grounding >: Setting the Ground Mode

- <Float> The shields of the input connectors are connected by 10 kΩ to the chassis ground.
- <Ground> The shields are connected by 10 Ω to ground (connected to the earth).

In general, if the current of the input signal is not large, it can be ground and short the signal ground and system. This method can avoid signal drift caused by the float signal ground. When

there is large potential difference between the signal and instrument ground and the input current ability of the signal ground is strong, it is necessary to use <Float> and make the signal ground float. This can also limit current to protect the system circuit.

4.1.4 < Coupling >: Setting the Coupling Input Mode

- | | |
|------|--|
| <AC> | AC coupling input mode. In this mode, the DC component of the input signal will be eliminated. If the input frequency is greater than 200 Hz, <AC> should be used. |
| <DC> | DC coupling input mode. In this mode, the AC component of the input signal will be eliminated. If the input frequency is less than 200 Hz, <DC> should be used. |

4.1.5 <Line Notches>: Setting the Status of the Notch Filters

- | | |
|----------|--|
| <None> | Turn all notch filters off. |
| <Line> | Turn the 50 Hz notch filter on to suppress the power line interference. |
| <2xLine> | Turn the 100 Hz notch filter on to suppress the basic and the second harmonic power line interference. |
| <Both> | Turn on the 50 Hz and the 100 Hz notch filter. |

Generally, if the input frequency is greater than 200Hz, choose <Both>, <Line> or <2xLine>. If not, choose <None> to avoid the amplitude damage due to small slope of the notch filter.

4.2 [REF/PHASE]

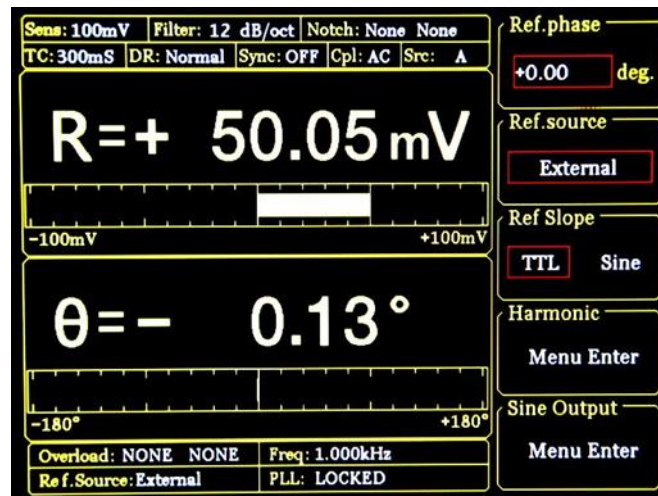


Fig.17 [REF/PHASE] Submenu-<External>.

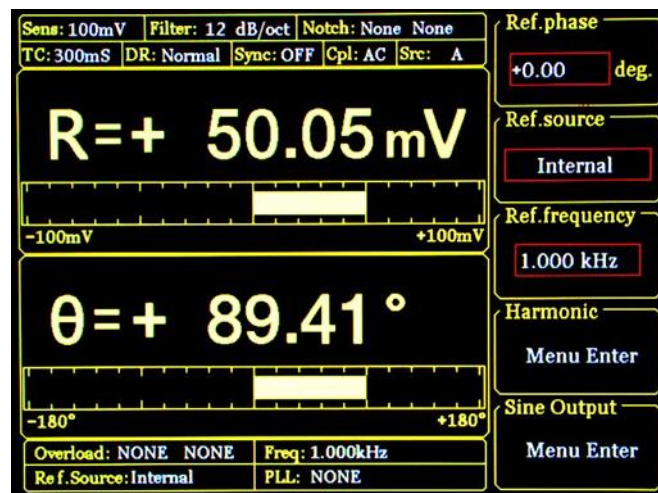


Fig.18 [REF/PHASE] Submenu-<Internal>

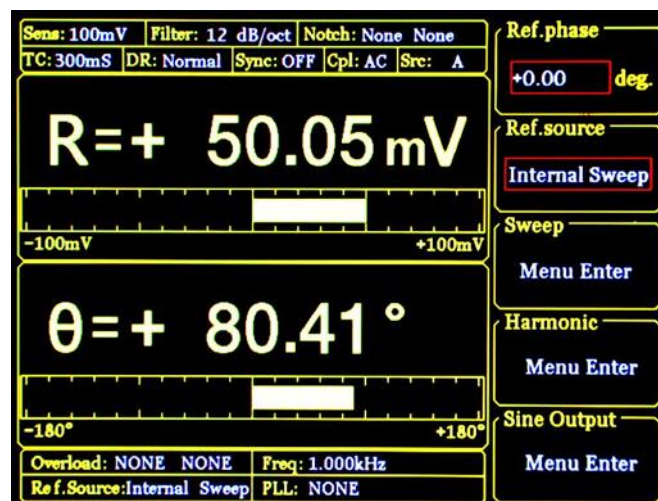


Fig.19 [REF/PHASE] Submenu-<Internal Sweep>

4.2.1 < Ref. phase >: Setting the Reference Phase

Spinning the knob or press the two buttons under the knob to set the phase difference between two orthogonal reference signals. The accuracy of phase is 0.01° . The phase range is from -180° to $+180^\circ$.

After the accuracy PLL lock the phase of the reference signal REF IN, the signal will be the phase standard and that is default in this system. Other phase values are relative to this signal phase.

4.2.2 < Ref. source>: Setting the Reference Signal Mode

<External>	The external reference signal, as is shown in Fig.17. It can set <Ref.slope>.
<Internal>	The internal reference signal. In this mode, the experiment uses the reference signal from the internal oscillator. The [REF IN] signal is useless. As is shown in Fig.18, it can set <Ref.frequency>.
<Internal Sweep>	The internal reference signal sweep. In this mode, the signal generator will do internal sweep according to the parameters set by users. As is shown in Fig.19, it can set <Sweep>.

4.2.3 < Ref. slope>: Setting the External Signal Mode

When <Ref. source> is in <External>, this setting can access. Choose the corresponding signal type according to the external reference signal type.

<TTL>	Choose this when the external reference signal is a square wave.
<Sine>	Choose this when the external reference signal is a sine wave.

If the input reference signal is TTL wave, choose TTL to trigger. Pay attention to that if the electronic level is not high enough to reach the TTL logic high or low level threshold, there will be unstable trigger even the input REF is square wave. Thus, it is beneficial to choose SINE to trigger. Moreover, the reference signal should be TTL signal if the frequency is very low ($<1\text{Hz}$).

If the input reference signal is sine wave, choose SINE to trigger. In this mode, the instrument will do precision truing for the REF IN input and then detect the frequency and phase information.

Otherwise, the system has no requirement on the signal duty cycle no matter what the trigger way is. It is kind to use common 50% duty cycle.

4.2.4 < Ref. frequency>: Setting the Internal Reference Frequency

When <Ref. source> is in <Internal>, this setting can access. The frequency range is from 1mHz to 100 kHz and 1.000 kHz in default. Frequency settings can input from keyboard. The minimum frequency resolution is 1mHz.

4.2.5 < Sweep>: Setting the External Reference Signal Types

When <Ref. source> is in <Internal Sweep >, this setting can access. Press the <Sweep> in choose interface can access the submenu. In the submenu, users can set the function of <Sweep Type>, <Sweep Set> and <Sweep Run>, as is shown in Fig.20.

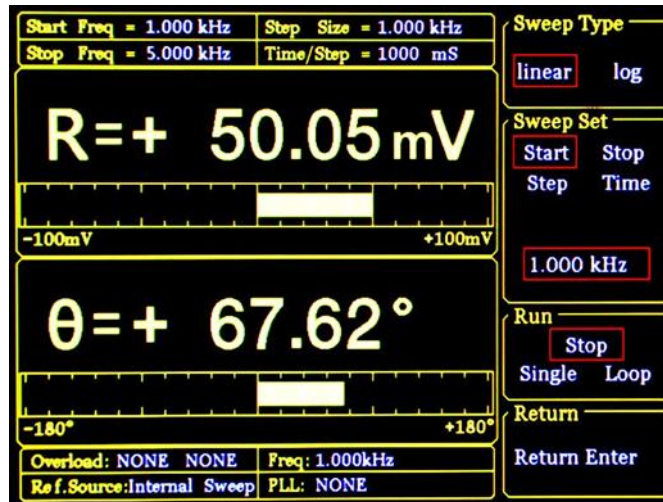


Fig.20. <Sweep> Secondary Submenu

<Sweep Type> Setting frequency sweep type.

- <Linear> linear sweep type
- <Log> logarithm sweep type

In the <Linear> mode, the step type is frequency by adding the frequency with the setting step frequency. In the <Log> mode, the step type is percentage of frequency.

For example, in the <Log> sweep mode, the sweep step is 10% of the frequency, the start frequency is 1 kHz and the cutoff frequency is 2kHz. The process of frequency change in sweep frequency is:

1000.000 Hz
 1100.000 Hz
 1210.000 Hz
 1331.000 Hz
 1464.000 Hz
 1610.510 Hz
 1771.561 Hz
 1948.717 Hz
 2000.000 Hz

<Sweep Set> Setting frequency sweep parameter.

- <Start> the start frequency of the sweep
- <Stop> the cutoff frequency of the sweep
- <Step> in the <Linear> mode, the <Step> is the step frequency of the sweep; in the <Log> mode, the <Step> is 100 percent frequency.

<Time> The step time interval of the sweep.

Combine the keyboard and the soft keys to set the start frequency, cutoff frequency, step frequency and time. The range of start frequency and cutoff frequency is from 1mHz to 102kHz. <Start> frequency is 1.000kHz in default and <Stop> frequency is 5.000kHz in default. The minimum resolution of the frequency is 1mHz. In the <Log> mode, the minimum resolution of the step is 0.001% of the frequency; and the minimum/maximum resolution of the step time is 1mS/100S.

<Sweep Run> Setting frequency sweep run mode

<Stop> stop sweep

<Single> single sweep

<Loop> loop sweep

When start from <Single> sweep, OE1022 do an internal frequency sweep according to the settings of the users. After that, the state switched to <Stop> automatically.

When start from <Loop > sweep, OE1022 do constant loop sweep until users switch the state to <Stop> manually.

4.2.6 <Harmonic>: Setting the Harmonic Detection

The harmonic setting interface is shown in Fig.21.

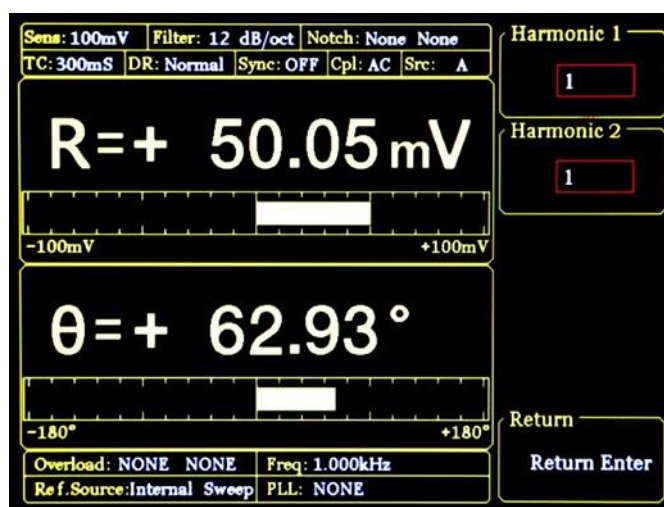


Fig.21 <Harmonic> Secondary Submenu

<Harmonic 1> Setting harmonic 1. The minimum value is 1 and the maximum value is 32767.

<Harmonic 2> Setting harmonic 2. The minimum value is 1 and the maximum value is 32767.

Input the order of the harmonic from keyboard. The display is 1 in default and this means detecting 1 order harmonic (fundamental wave). The limitation of the harmonic setting is (Harmonic * Freq) < 100kHz, where Freq means the reference frequency. Once beyond the

limit, system will reduce the order of harmonic automatically to meet the conditions. At the same time, when the order is set to 0, the system set the order to 1 automatically

For example, the input signal is 1kHz square wave. Suppose that the signal's amplitude is A. Set the harmonic value to 1, 2, 3, 4, 5, 6..., the R will be 0.45A, 0.015A, 0.09A, 0... This sequence is A times higher the coefficient sequence of the square wave Fourier Series.

It is necessary to set <List> in the <Full> option of the <Display> submenu during detecting the double harmonic.

4.2.7 <Sine Output>: Setting the Sine Signal Output

OE1022 can output sine wave whose amplitude range is from 0V to 5V through the "Sine Out" BNC connector in front panel. <Fixed> fixed amplitude output, <Linear> linear sweep amplitude output or <Log> logarithm sweep amplitude output can be set in submenu. There are <Sweep Type> <Voltage> <Sweep Set> and <Sweep Run> in the submenu. When choosing different <Sweep Type>, the display is different as is shown in Fig.22 and Fig.23.

When using the <External> reference, <Sine Output> provides a sine signal which can lock phase with external reference signal. When using the <Internal> reference, the reference signal is generated by the oscillator in OE1022. The BNC connector of the "TTL OUT" in rear panel will output TTL signal which is synchronous with the <Sine Output>.

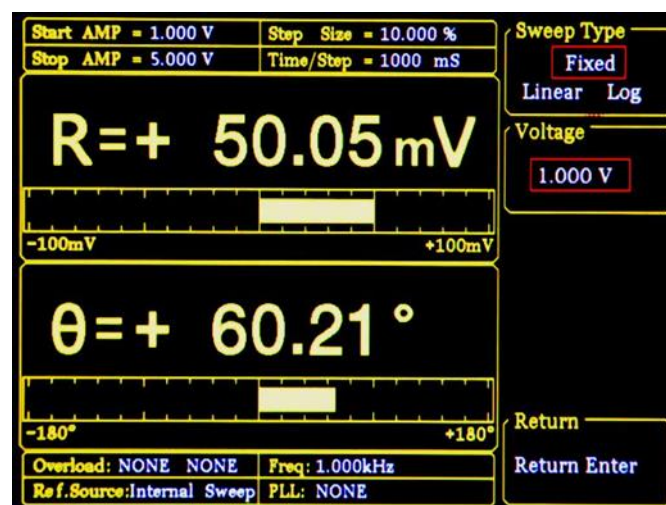


Fig.22 <Sine Output> Secondary Submenu-<Fixed>

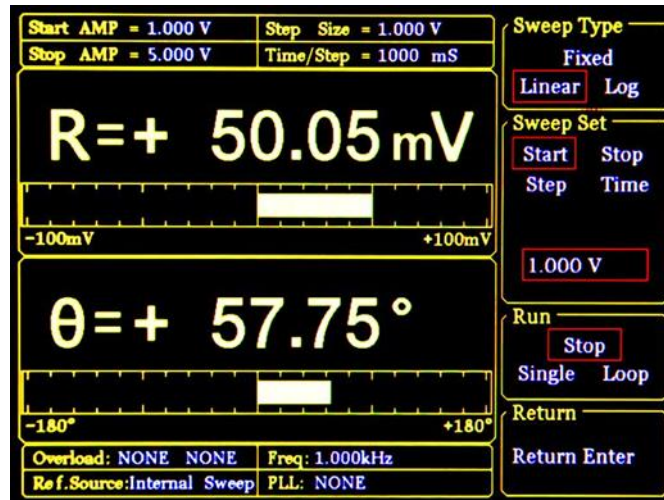


Fig.23 <Sine Output> Secondary Submenu-<Linear & Log>

- <Sweep Type>** Setting frequency sweep type.
- <Fixed> fixed sweep type(default)
 - <Linear> linear sweep type
 - <Log> logarithm sweep type

In the <Fixed> mode, <Sine Output> output the input amplitude that users set. In the <Linear> or <Log> mode, the output amplitude is set by <Sweep Set> and <Sweep Run>

- <Voltage>** Setting the sine signal output amplitude.

In the <Fixed> mode, the settings of sine signal amplitude is input from the keyboard. The range of the sine signal amplitude is from 0.001 Vrms to 5 Vrms. The minimum resolution is 0.001Vrms.

- <Sweep Set>** Setting frequency sweep parameter.
- <Start> the start frequency of the sweep
 - <Stop> the cutoff frequency of the sweep
 - <Step> in the <Linear> mode, the <Step> is the step frequency of the sweep; in the <Log> mode, the <Step> is 100 percent frequency.
 - <Time> the step time interval of the sweep.

Combine the keyboard and the soft keys to set the start frequency, cutoff frequency, step Frequency and time. The range of amplitude is from 0.001 Vrms to 5 Vrms. <Start> amplitude is 1.0 Vrms. in default and <Stop> amplitude is 5.000 Vrms in default. The minimum resolution of the amplitude is 0.001 Vrms. In the <Log> mode, the minimum resolution of the step is 0.001% of the frequency; and the minimum/maximum resolution of the step time is 1ms/100,000ms.

<Sweep Run> Setting frequency sweep run mode

<Stop> stop sweep

<Single> single sweep

<Loop> loop sweep

When start from <Single> sweep, OE1022 do an internal frequency sweep according to the setting of the users. After that, the state switched to <Stop> automatically.

When start from <Loop > sweep, OE1022 do constant loop sweep until users switch the state to <Stop> manually.

4.3 [GAIN/TC]

You can choose [GAIN/TC] submenu in menus bar to enter this interface, as is shown in Fig.24.

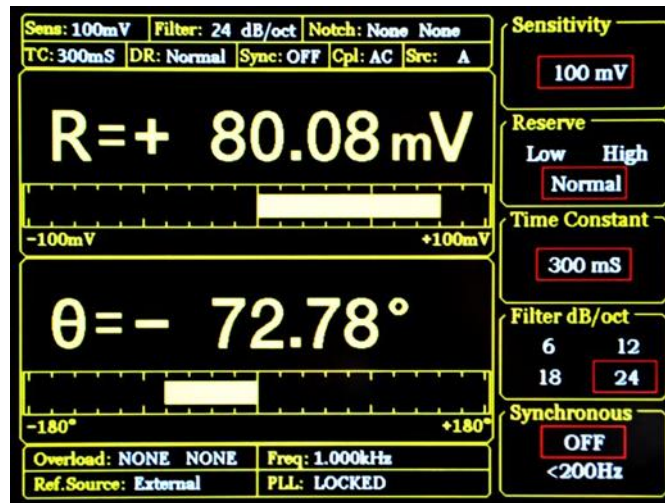


Fig.24 [GAIN/TC] Submenu

4.3.1 <Sensitivity>: Setting the Full Scale Sensitivity

Choose appropriate full-scale sensitivity according to the amplitude of the input signal. Adjust the value by press the soft keys or spin knob.

1 nV/fA	200 nV/fA	50 μV/pA	10 mV/nA
2 nV/fA	500 nV/fA	100 μV/pA	20 mV/nA
5 nV/fA	1 μV/pA	200 μV/pA	50 mV/nA
10 nV/fA	2 μV/pA	500 μV/pA	100 mV/nA
20 nV/fA	5 μV/pA	1 mV/nA	200 mV/nA
50 nV/fA	10 μV/pA	2 mV/nA	500 mV/nA
100 nV/fA	20 μV/pA	5 mV/nA	1 V/μA

The change of <Sensitivity> can change the dynamic range of the system. Also, it will affect the output of CH1&CH2. If the measure signal is current, the full scale is corresponding current unit, <100mV/nA> in default.

When using the <AUTO GAIN> which can set sensitivity automatically, the system will automatically adjust sensitivity according to the R of input signal. If the current time constant is very large, the system will need more time to adjust.

4.3.2 <Reserve>: Setting the Dynamic Reserve Mode

- <Low> Low dynamic reserve mode
- <High> High dynamic reserve mode.

<Normal> Normal dynamic reserve mode. Generally, we use this mode

When using the <AUTO RESERVE>, the system will automatically adjust the minimum dynamic range according to the R value of the input signal.

4.3.3 < Time Constant >: Setting the Time Constants

The range of time constant setting is from 10 us to 3000 s. Press the soft keys or spin knob to adjust value.

10 μ s	3 ms	1 s	300 s
30 μ s	10 ms	3 s	1000 s
100 μ s	30 ms	10 s	3000 s
300 μ s	100 ms	30 s	
1 ms	300 ms	100 s	

The greater the time constant is, the smaller the ENBW is, the longer the system response is and the higher the measurement accuracy.

4.3.4 < Filter dB/oct >: Setting the Roll off Slope of the Low Pass Filter

<6dB/oct> The roll off slope is 6 dB/oct.
 <12dB/oct> The roll off slope is 12 dB/oct.
 <18dB/oct> The roll off slope is 18 dB/oct.
 <24dB/oct> The roll off slope is 24 dB/oct.

If the measure accuracy is same, the greater the roll of slope of filter is, the smaller the time constant is. And this will cause faster response.

4.3.5 < Synchronous >: Setting the Status of the Synchronous Filter

<OFF> Close the synchronous filter.
 <200Hz> Open the synchronous filter. Only useful at a low reference frequency (< 200 Hz). If the input signal frequency is very low, the low pass filter can't get stable results or needs long time. This can be improved by synchronous filter.

Note that if the synchronous filter is open, <Filter dB/oct> must be <18 dB/oct> or <24 dB/oct >.

4.4 [DISPLAY]

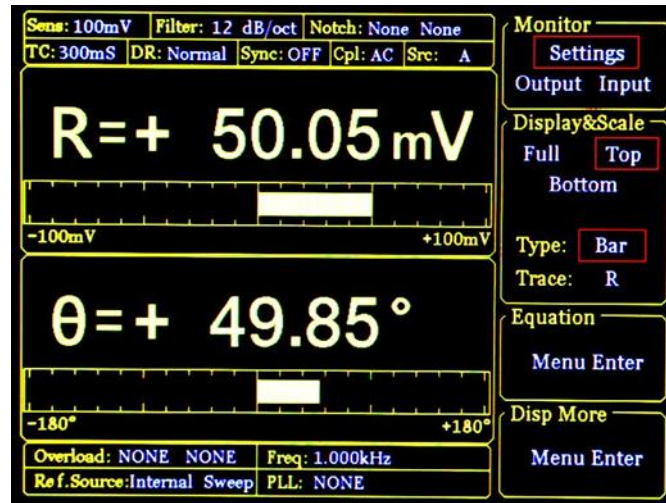


Fig.25 [DISPLAY] Submenu

[DISPLAY] contains 4 submenus: <Monitor> <Display & Scale> <Equation> <Disp More>, the interface is shown in Fig.25. And they can be set by the soft keys beside the submenu.

4.4.1 < Monitor >: Setting Status Bar Display

- <Setting> there are current parameters and status, including<Sensitivity>, <Filter>, at the top left status bar of the LCD.
- <Output> there are real time value of <R>, <X>, <Y> and <θ> at the top left status bar of the LCD.
- <Input> there are real time value of <AD1>, <AD2>, <AD3> and <AD4> of the current real panel AUX_ADC.

4.4.2 < Display & Scale >: Setting the Dynamic Area Display

- <Area> Setting display area.

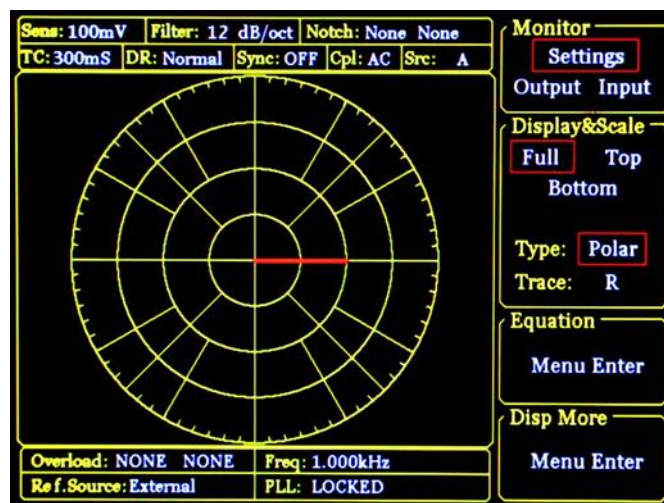


Fig.26 <Full>-<Polar> Display

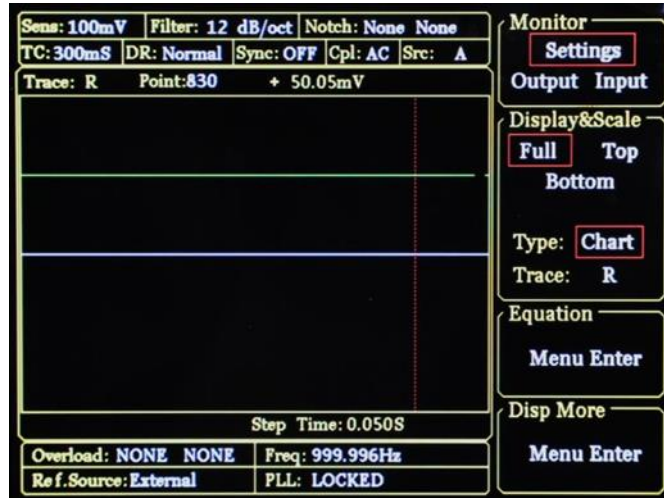


Fig.27 <Full>-<Chart> Display

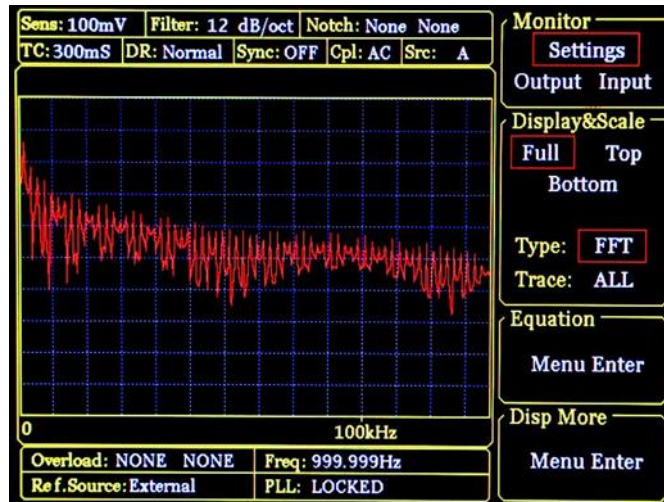


Fig.28 <Full>-<FFT> Display

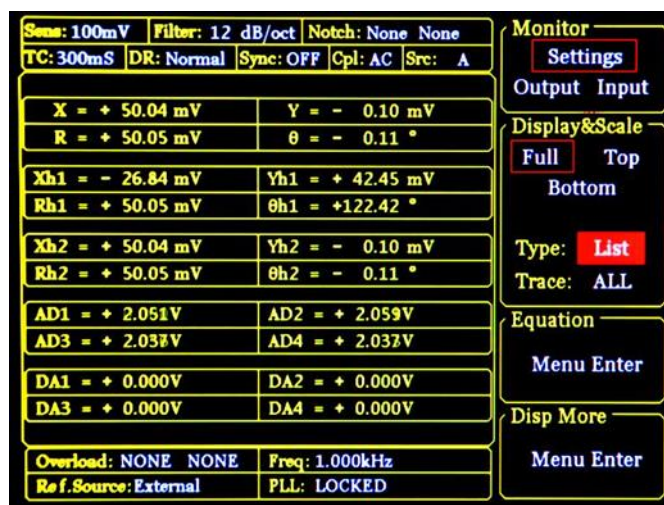


Fig.29 <Full>-<List> Display

<Full> Full bar display mode. This has 4 display modes, including <Polar>,

<Chart>, <FFT> and <List>.

1) <Polar>: polar coordinates map.

The graphical pointer can change its length according to the actual <R> value and draw, as is shown in Fig.26.

its angle according to the < θ > value.

2) <Chart>: XY coordinates map.

It displays the curve map of the measure value. Users can control <Cursor> to see the value of the sampling points by spin knob. <Chart> always pick up the measure data cooperating with [SAMPLE] submenu and [CONTROL] area, as is shown in Fig.27.

3) <FFT>: spectrum map.

Compute the spectrum information of the input signal by FFT and display, as is shown in Fig.28.

4) <List>: display the value of the fundamental wave and two harmonics of the input signal and AUX_ADC, AUX_DAC in rear panel at the same time. The interface is shown in Fig.29.

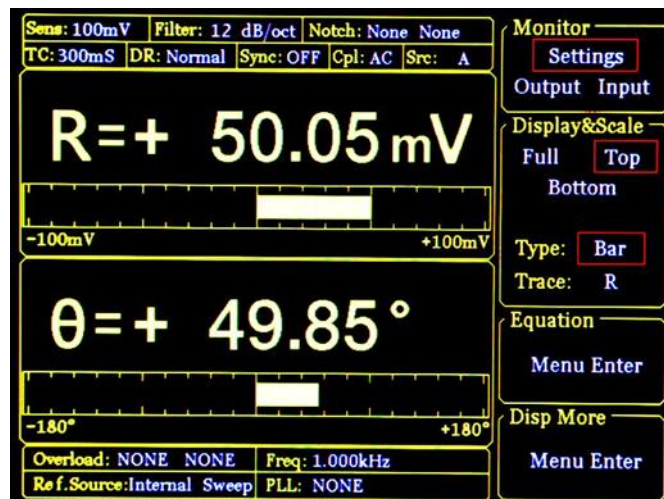


Fig.30 <Top>-<Bar> Display

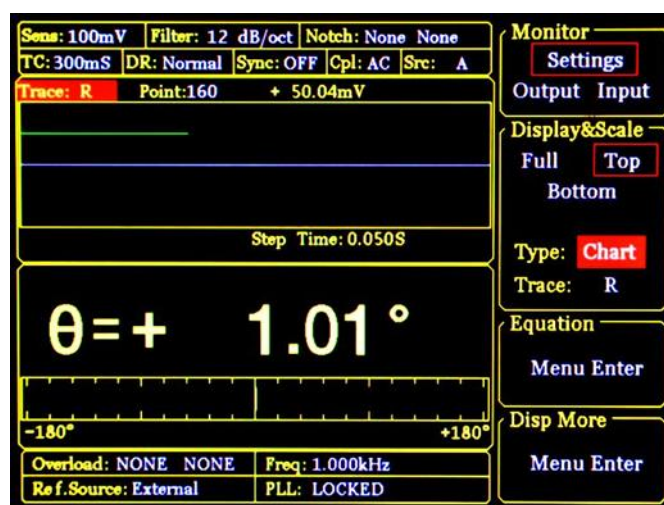


Fig.31 <Top>-<Chart> Display

<Top>	Choose the top area to display. When switching to <Type> or <Trace>, this area will change, as is shown in Fig.30 and Fig.31. There are two choices in <Type>, including <Bar> and <Chart>. If the <Type> is <Bar>, <Traces> provides many options, including fundamental wave, harmonic, and Equation. If the <Type> is <Chart>, <Trace> only have 4 options: <Buffer1>, < Buffer2>, < Buffer3> and < Buffer4>. The <Buffer> is set by <Select> submenu of <SAMPLE>.
<Bottom>	Choose the bottom area to display. When switching to <Type> or <Trace>, it changes just like the <Top>.
<Type/Trace>	The display types. There are many options, including harmonic wave, fundamental wave and Equation.
<X>	The X value of fundamental wave of the input signal.
<Y>	The Y value of fundamental wave of the input signal.
<R>	The R value of fundamental wave of the input signal.
< θ >	The θ value of fundamental wave of the input signal.
<Xh1>	The X value of 1 th channel harmonic of the input signal.
<Yh1>	The Y value of 1 th channel harmonic of the input signal.
<Rh1>	The R value of 1 th channel harmonic of the input signal.
< θ h1>	The θ value of 1 th channel harmonic of the input signal.
<Xh2>	The X value of 2 th channel harmonic of the input signal.
<Yh2>	The Y value of 2 th channel harmonic of the input signal.
<Rh2>	The R value of 2 th channel harmonic of the input signal.
< θ h2>	The θ value of 2 th channel harmonic of the input signal.
<E1>	The 1 th Equation value.
<E2>	The 2 th Equation value.
<E3>	The 3 th Equation value.
<E4>	The 4 th Equation value.

4.4.3 <Equation>: Setting the Equation.

The function of <Equations> is to do basic proportional calculation with the instrument measure value. The results are output through CH1/CH2 2 BNC in front panel. The fixed equation is:

$$\text{Equation} = \frac{A \times B}{C}$$

Where A, B and C can be set in <Equation> secondary submenu. There are 4 groups <Equation> in [DISPLAY] submenu.

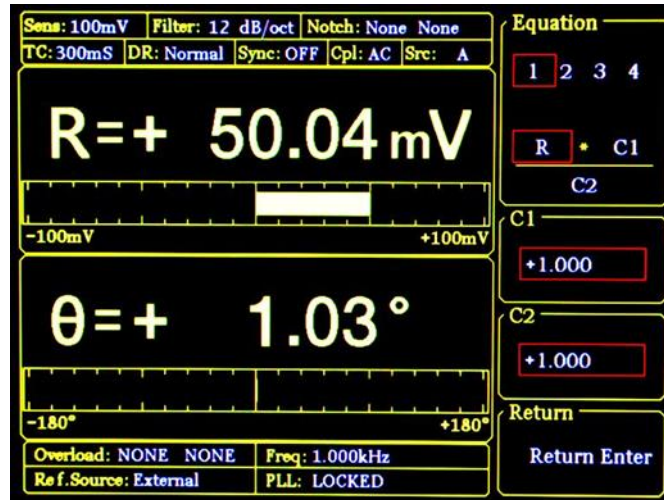


Fig.32 <Equation> Secondary Submenu

<Equation>

Setting equation parameters.

The Equation1~4=A*B/C can change the value of A, B and C through soft keys. There are 4 numeric options, including fundamental wave, harmonic wave, frequency and constant parameter, as is shown in Fig.32 For example, when A is R=50mV, B is θ=130°, C is Freq=1 kHz, then

$$\text{Equation} = \frac{A \times B}{C} = \frac{0.05 \times 130}{1000} = 0.0065$$

When the <Trace> options in [DISPLY] submenu switch to <E1>, the display result is the calculate result of the Equation 1. In <Bar> display mode, the display range is from 0.000001 to 9999999 without unit and progress bar.

When the <Source> options in [CHANNEL OUPUT] submenu switch to <E1>, the display result is the output of the Equation 1 result.

<C1>

Setting constant parameter 1.

Constant parameter <C1> setting, range: -10~+10.

<C2>

Setting constant parameter 2.

Constant parameter <C2> setting, range: -10~+10.

4.4.4 < Disp More >: More Display Settings

<Disp More> secondary submenu adds two settings, including <Range> and <Curve Point>, as is shown in Fig.33.

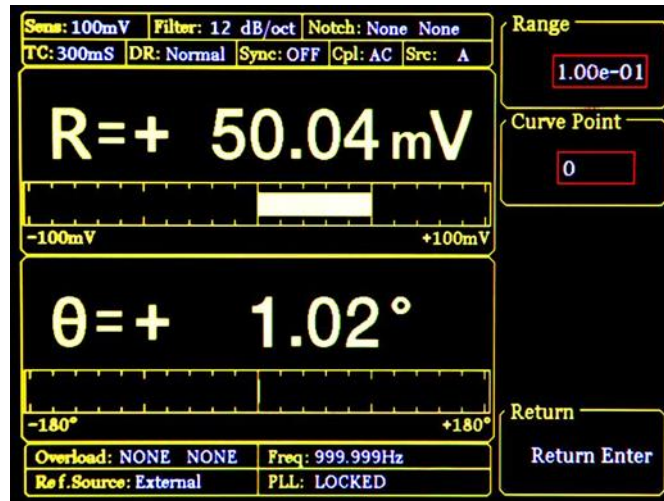


Fig.33 <Disp More> Secondary Submenu

<Range>

Setting display range

<Range> is used to set the maximum axis of <Bar>, <Chart> and <Polar> map.

The input range of <Range> is from 1 nV to 1 V. This range will change in sync with the change of <Sensitivity>. Also, this range can set by input from numeric keyboard. For example, 1.00e-01 means $1.00 \times 10^{-2} \text{V} = 100 \text{mV}$.

The <Sensitivity> remains unchanged and change the value of <Range>. Make the <Range> is 1.00e-03=1mV, then the display range is from -1mV to +1mV.

<Curve Point>

Setting the position of sampling curve

In this <Curve Point> mode, the <Cursor> under the mode of <Chart> map can rapidly locate position and see the measure value of this point. The setting range of <Curve Point> is 1~16384.

When <Chart> is in reset mode (can't store data), the <Curve Point> makes no sense and keeps 0. When acquainting data, this option will be hidden (can't use), and it will display after pause.

Before using <Curve Point>, users should call out <Cursor> by pressing [CURSOR] key in CONTROL area.

4.5 [SAVE/RECALL]

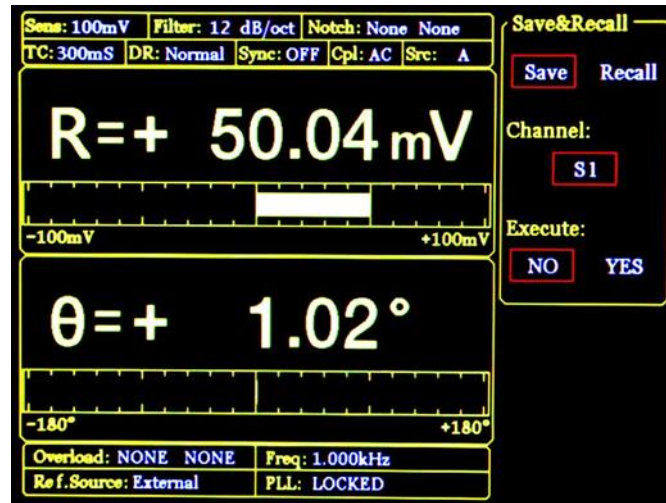


Fig.34 [SAVE/RECALL] Submenu

[SAVE/RECALL] menu is mainly used for saving and recalling the set parameters and status. Users can choose <S1>, <S2>, <S3> and <S4> to save according to their individual favorites. As is shown in Fig.34, choose <Save>, <Channel> chooses <S1> and then choose <YES> in option <Execute>. In this case, the current parameters and status can be save in <S1>. Choose <Recall>, <Channel> chooses <S1> and then choose <YES> in option <Execute>. In this case, the data in <S1> can be recalled.

4.6 [CHANNEL OUTPUT]

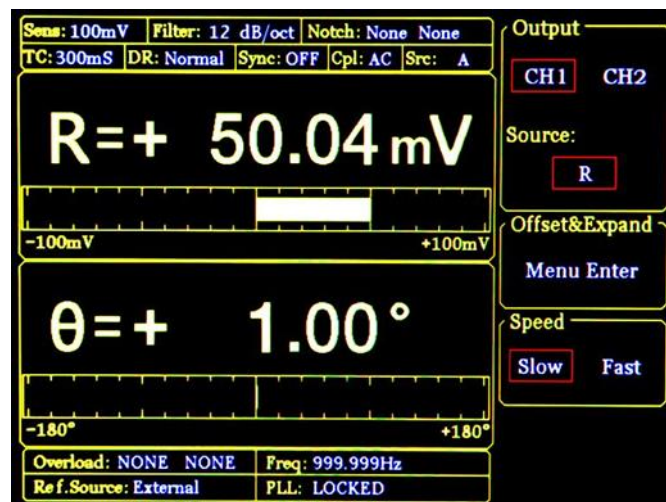


Fig.35 [CHANNEL OUTPUT] Submenu

The [CHANNEL OUTPUT] display interface is shown in Fig.35, the two BNC channels which is in the [CHANNEL OUTPUT] submenu control front panel can output the value of X, Y, R and θ . The

<Offset & Expand> can set the output of the bias and gain. <Speed> option bar can set the output rate for any channel.

The calculation equation is:

1. The chosen signal is <R>, <X>, <Y>, <Rh1>, <Xh1>, <Yh1>, <Rh2>, <Xh2>, <Yh2>, <Noise>:

$$\text{output} = \left(\frac{\text{Signal}}{\text{Sens}} + \text{offset} \right) \times \text{Expand} \times 10V$$

2. The chosen signal is <θ>, <θh1>, <θh2>

$$\text{output} = \frac{\text{Signal}}{180^\circ} \times 10V$$

3. The chosen signal is <E1>~<E4>(Equation), there are other options as below:

- a) AUX_IN1~AUX_IN4: the output voltage is equal to the input voltage.
- b) constant coefficient: directly correspond. 10 corresponding to 10V, -5 corresponding to -5V.
- c): frequency Freq:

Every step of the frequency is 5V-10V. For example,

- 1000Hz = 5 V
- 1200Hz = 6 V
- 1600Hz = 8 V
- 1800Hz = 9 V
- 1990Hz = 9.95 V
- 2000Hz = 5 V (next step)

The step is defined as:

- 62.5 Hz – 125 Hz
- 125 Hz – 200 Hz
- 250 Hz – 500 Hz
- 500 Hz – 1000 Hz
- 1 kHz – 2 kHz
- 4 kHz – 8 kHz
- 8 kHz – 16 kHz

...

When the Equation calculates, the parameter needs conversion according to the above equations. Then calculate according to the Equation itself and get the result. The range of result is from -10 V to +10 V.

4.6.1 < Output Source >: Setting Output Source Channel

<X>:	the analog level corresponding to the value of the channel output X
<Y>:	the analog level corresponding to the value of the channel output Y
<R>:	the analog level corresponding to the value of the channel output R
< θ >:	the analog level corresponding to the value of the channel output θ
<Xh1>:	the analog level corresponding to the value of the channel output Xh1
<Yh1>:	the analog level corresponding to the value of the channel output Yh1
<Rh1>:	the analog level corresponding to the value of the channel output Rh1
< θ h1>:	the analog level corresponding to the value of the channel output θ h1
<Xh2>:	the analog level corresponding to the value of the channel output Xh2
<Yh2>:	the analog level corresponding to the value of the channel output Yh2
<Rh2>:	the analog level corresponding to the value of the channel output Rh2
< θ h2>:	the analog level corresponding to the value of the channel output θ h2
<E1>:	the analog level corresponding to the value of the channel output E1
<E2>:	the analog level corresponding to the value of the channel output E2
<E3>:	the analog level corresponding to the value of the channel output E3
<E4>:	the analog level corresponding to the value of the channel output E4
<Noise>:	the analog level corresponding to the value of the channel output Noise

4.6.2 < Offset&Expand >: Setting the Bias and Amplify of the Parameters

Choose the <Offset &Expand> option to the secondary submenu, as is shown in Fig.36.

<Offset> bias setting:

Input from the numerical keyboard. The adjustable range of bias is -100%~+100%. The minimum step is 0.01% and 0.00% in default. Every option value is corresponding to a bias value.

<Expand> amplify setting:

Input from the numerical keyboard. The adjustable range is 1~256 and 1 in default. If the setting of Expand causes the calculation result more than 10V, the output result will be seriously affected. Every option value is corresponding to an amplify value.

The settings of <Offset> and <Expand> will not affect the data display in dynamic area data box.

4.7 [SAMPLE]

[SAMPLE] submenu is used to control the sampling store for measure object. There are 5 options in the <SAMPLE> submenu, including <Step Time>, <Length>, <Select>, <Trigger Mode> and <Sample Mode>, as is shown in Fig.37.

The setting of [SAMPLE] menu should cooperate with the keys in CONTROL area. In this case, the [SAMPLE] can control the sample to start, pause and reset.

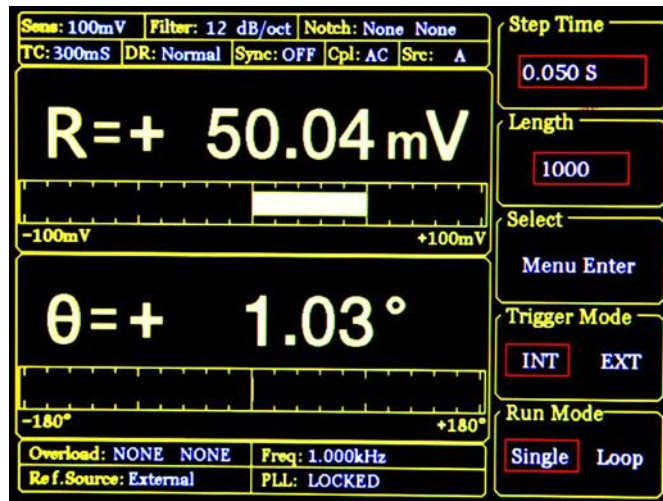


Fig.37 [SAMPLE] Submenu

4.7.1 < Step Time >: Setting the Sampling Interval

Setting the sampling time interval, range: 1ms~ 100,000ms, collect one data at every time interval.

4.7.2 < Length >: Setting the Sampling Length

Setting the sampling data length, range: 1~16384

When the data sampling is being executed, and the <Length> value is set to less than the length of the current sampling point, the sampling will be stop immediate at single sampling mode. But in the loop sampling mode, the sampling will start from the first point.

4.7.3 < Select >: Setting the Sampling Object

The <Select> interface is shown in Fig.38.

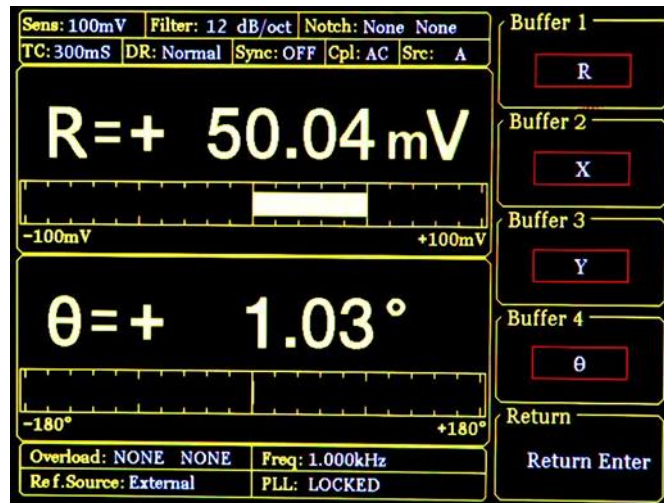


Fig.38 <Select> Secondary Submenu

<Buffer1~4>

Setting the choice for 4 sampling buffers

There are 4 internal <Buffer> in OE1022. Every buffer can store 16384 34-bit data. And every buffer can measure anyone of these parameter, including <R>, <X>, <Y>, <θ>, <R>, <X>, <Y>, <θ>, <R>, <X>, <Y>, <θ>, <Noise>, <E1>, <E2>, <E3>, <E4>, <A1>, <A2>, <A3>, <A4> and <Freq>.

Only when the sampling restart, the setting of <buffer> will be effective. The choice of <buffer> will affect the <Trace> options in <Chart> display mode. And in the <Chart> display mode, the <Trace> can only choose the measure option in the settings in <Buffer>.

4.7.4 < Trigger Mode >: Setting Trigger Mode

<INT> internal trigger mode
<EXT> external trigger mode

In the <INT> mode, the sampling time interval is generated by the internal of instrument and set by <Sampling Time> option.

In the <EXT> mode, the sampling pulse is input from BNC TRIG_IN in the rear panel. Each sampling pulse is sampled once and the sampling rate is no more than 500 Hz.

Internal trigger mode and external trigger mode both control start, stop and reset sampling through the button in the CONTROL area.

4.7.5 < Sample Mode >: Setting Sampling Mode

- <Single> single sampling mode
- <Loop> loop sampling mode

In the <Single> mode, the system will stop after completing a data collection and wait for the next start. In the <Loop> mode, the system will loop sampling automatically and cover the original sampling results.

Single and loop sampling mode both control start, stop and reset sampling through the button In CONTROL area.

4.8 [AUX OUTPUT]

There are 4 options in this [AUX OUTPUT] submenu, including <DA1 Output>, <DA2 Output>, <DA3 Output> and <DA4 Output>. These 4 options are corresponding to the 4 AUX_DAC output. The output range is ±10V and the output is 0.000V in default. The interface is shown in Fig.39.

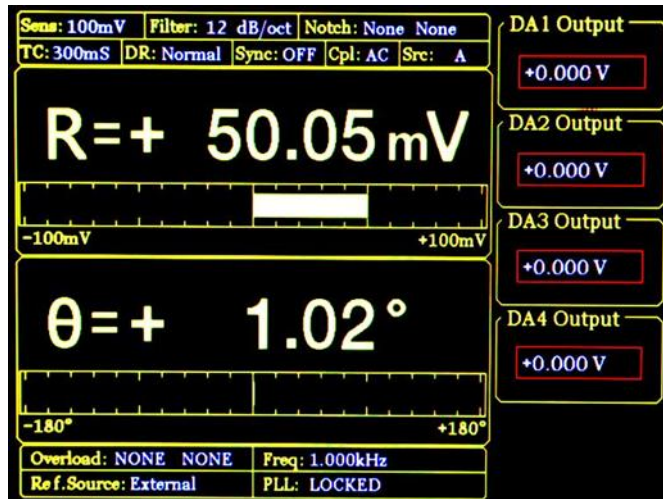


Fig.39 [AUX OUTPUT] Submenu

- <DA1 Output> the first channel output of AUX DAC, corresponding to the AUX_DAC1 in rear panel.
- <DA2 Output> the second channel output of AUX DAC, corresponding to the AUX_DAC2 in rear panel.
- <DA3 Output> the third channel output of AUX DAC, corresponding to the AUX_DAC3 in rear panel.
- <DA4 Output> the forth channel output of AUX DAC, corresponding to the AUX_DAC4 in rear panel.

4.9 [SYSTEM]

The [SYSTEM] submenu includes the system information and settings of the OE1022, like instrument information, the brightness of the screen and the settings of RS232 communications, as is shown in Fig.40.

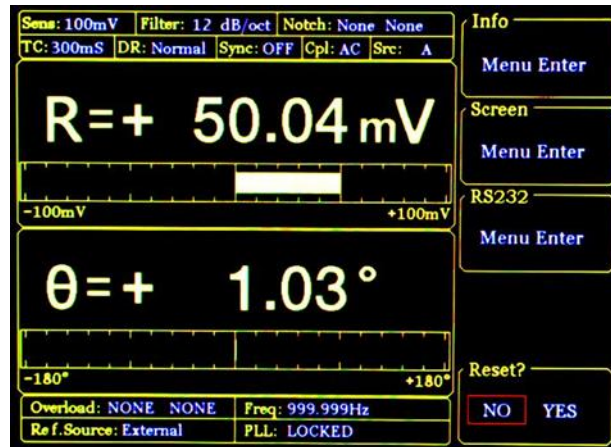


Fig.40 [SYSTEM] Submenu

4.9.1 < Info >: Setting the Parity Mode

Choose the <Info> to this interface shown in the Fig.41 and the interface displays the information of research unit.



Fig.41 <INFO>-Research Unit

Press corresponding operation button and the interface displays the version of the OE1022, as is shown in Fig.42.

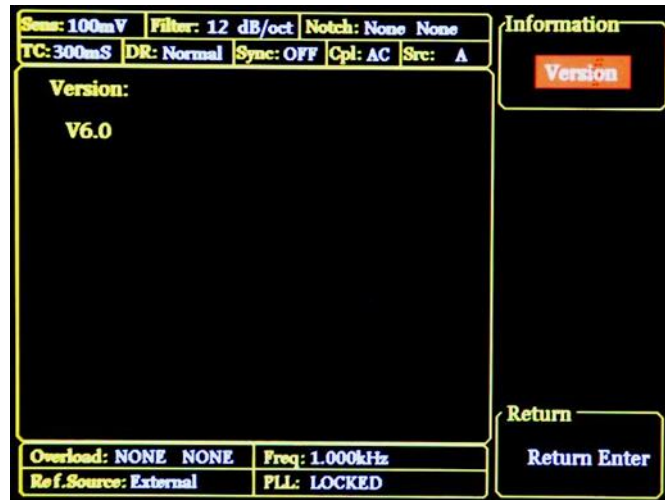


Fig.42 <INFO>-Version

Then press the button again, the interface displays the contact information as is shown in Fig.43.

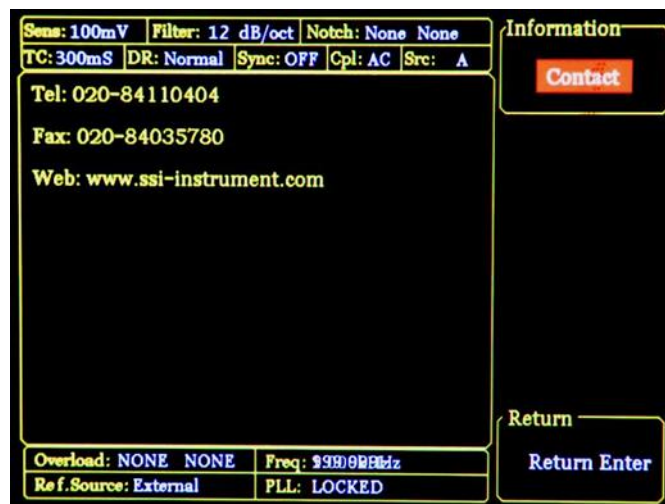


Fig.43 <INFO>-Contact Information

4.9.2 < Screen > Submenu

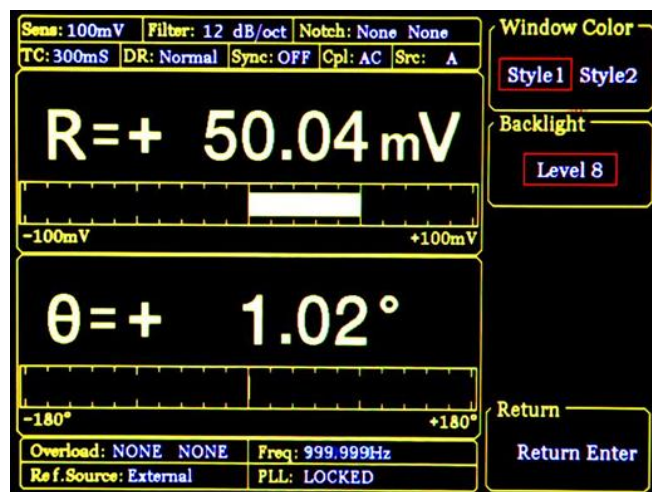


Fig.44 <Screen> Submenu-<Style 1>

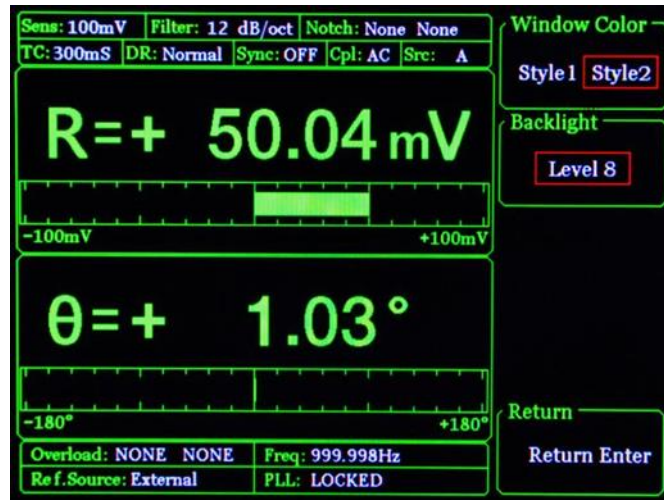


Fig.45 <Screen> Submenu-<Style 2>

Choose <Screen> to enter this interface, as is shown in Fig.44 and Fig.45.

This submenu includes two function settings, <Window Color> and <Backlight>.

- <Window Color> setting the window color
 - <Style 1> the window main color is yellow
 - <Style 2> the window main color is green
- <Backlight> setting the brightness of the backlight
 - Spin knob and the bright levels can vary from <Level 1> to <Level 8>

4.9.3 < RS232 >: Setting the RS232 Mode

Choose the <RS232> secondary submenu to enter Fig.46

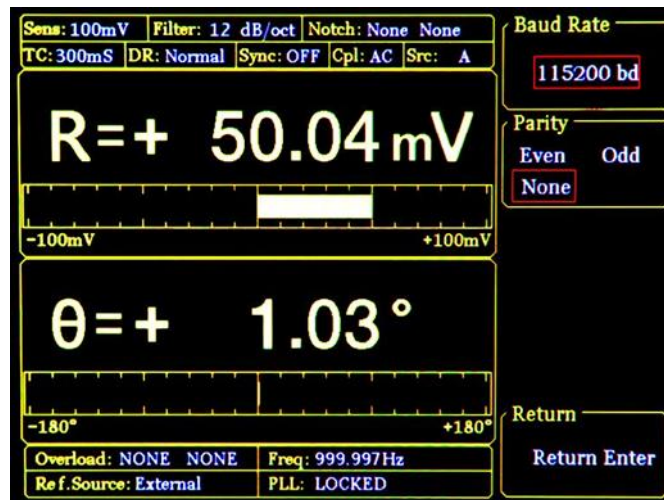


Fig.46 <RS232> Submenu

There are 3 function settings in submenu, including <Baud Rate>, <Word Length> and <Parity>.

- <Baud Rate> setting baud rate
 - Press the corresponding soft keys and spin knob to adjust the baud rate.

The value can be set as <600>, <1200>, <2400>, <9600>, <19200>, <38000>, <43000>, <56000>, <57600>, <115200>, <230400>, <380400>, <460800>, <921600>.

<Parity>	setting parity
<Even>	Even
<ODD>	Odd
<NONE>	nothing

Note that use <USB> and <RS232>, the local OE1022 can communicate with another OE1022 or the PC. More details are talked at '5 PROGRAMMING'.

4.9.4 <Reset? >: The Lock-in Reset

Press the corresponding soft keys and the system will be restarted.

4.10 [AUTO SET]

There are 4 settings in [AUTO SET] submenu, including <Auto Reserve>, < Auto Gain>, < Auto Phase >, < Auto Scale >, as is shown in Fig.47.

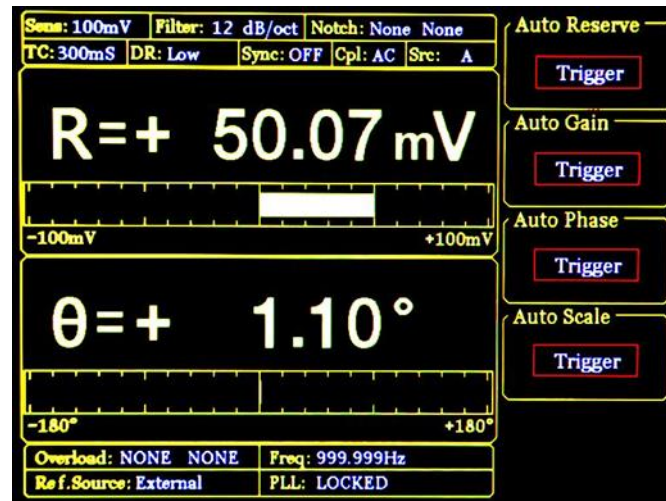


Fig.47 [AUTO SET] Submenu

4.10.1 < Auto Reserve >: Setting the Dynamic Reserve Function Automatically

Press the < Auto Reserve > button, the system will change the settings of <Reserve> according to the current signal. The system will choose the current measure signal as the setting of the minimum dynamic reserve.

4.10.2 < Auto Gain >: Setting the Sensitivity Function Automatically

Press the < Auto Gain> button, the system will change the setting of <Sensitivity> according to the current R. It is the principle that the systems should choose appropriate <Sensitivity> but no more than the maximum sensitivity. The < Auto Gain > function in OE1022 needs some response time (generally less than 5s). If the current R fluctuates a lot, the setting for < Auto Gain > might be fail. In this case, users should switch current menu to [GAIN/TC] submenu and set R manually.

4.10.3 < Auto Phase >: Setting Phase Shift Automatically

Press the < Auto Phase > button and the system will adjust the phase shift of the reference signal to make the phase of the input signal 0. This < Auto Phase> function needs some response time (generally less than 10s). If the current θ fluctuates a lot, the setting for < Auto Phase > might be fail. In this case, users should switch current menu to [REF/PHASE] submenu and set θ manually.

4.10.4 < Auto Scale >: Setting Adjusting Scale Automatically

Press the <Auto Scale> button and the system will adjust the scale to make the display value large enough within the range. This < Auto Scale > function can only affect display; the input and output will not be affected. The scale can also be set through <Range> in the [DISPLAY] submenu.

4.11 [CONTROL]

There are 4 buttons in [CONTROL] area, including [START CONT], [PAUSE CLEAR], [CURSOR], [ACTIVE CHART]. The [CONTROL] menu, coordinate with [SAMPLE] menu and <CHART> map, control the start, pause, reset of the current data collection. Also, it controls to choose [CURSOR], <Chart> and display.

4.11.1 < START/CONT >: Start or Continue Sampling Data

The [START/CONT] button has two functions. One is to start new sampling [START], the other is to continue the paused sampling [CONTINUE].

Sampling is start and the measure data will be stored in internal Buffer according to the set baud rate in [SAMPLE] menu. If in the <Chart> status, the sampling data will display on <Chart> in sync. Otherwise, the system will store the data in the background.

In the single sampling mode, the sampling will stop if the number of sampling points is equal to the sampling length. If the system sampling pauses, press the [START] button and the system will start sampling form the first point and stop sampling at the endpoint.

Press the [PAUSE] button and the system will be paused when the sampling is executing. In this case, press this [START/CONT] button and the system will continue the paused sampling.

4.11.2 < PAUSE/CLEAR >: Pause Sampling or Clear Sampling Data

The [PAUSE/CLEAR] button has two functions. One is to pause sampling, the other is to clear sampling data.

Press this button to pause data sampling when the sampling is executing. The <Chart> will also pause if pressing this button. If press this button again when the system is paused, the sampling data will be empty and the system will stop. Also, the <Chart> will be empty if in the <Chart> status.

4.11.3 < CURSOR >: Display and Hide of the Cursor in <Chart> Map

The [CURSOR] button has two functions. One is to display the <Chart> or hide the <Cursor>, the other is to choose <Cursor> again in other status.

When there is no <Cursor> in <Chart>, this button can call out and pick on <Cursor>. And then spin knob to move <Cursor> and read data. If the <Cursor> has been paged out but not chosen (for example, the option <Sensitivity> parameter is set to highlight and then the spin knob is only used to set parameter), the <CURSOR> can pick on <Cursor> again. Press the [CURSOR] again when the <Cursor> is picked on, in this case, the <Cursor> will be hidden.

Spin knob to adjust <Cursor>. If the <Cursor> exceeds the edge of <Chart>, the <Chart> will change to next page. Also, it can locate directly through <Curve Point> in <Disp More> menu. The [CURSOR] can make sense when the data sampling is executing or pausing.

4.11.4 < ACTIVE CHART >: Choose the <Chart> as the Active Area

The [ACTIVE CHART] is used to choose <Top> or <Bottom> area of <Chart> as the current active area. When the <Chart> is chosen to active, the <Cursor> will make sense in that area. The chose active area will be highlight at the top-left corner of the <Chart>. The <Chart> in <Full> area is always active. This [ACTIVE CHART] button makes no sense to <Full> area.

5. REMOTE PROGRAMMING

5.1 OE1022 Command Syntax

The upper computer uses ASCII characters to communicate with OE1022. Commands must be UPPER case. A command to the OE1022 consists of a four-character command mnemonic, parameters if necessary, and a command terminator. The terminator must be a linefeed <lf> or carriage return <cr> on RS232 to USB. No command processing occurs until a command terminator is received. Commands may require one or more parameters. Multiple parameters are separated by commas (.).

Multiple commands may be sent on one command line by separating them with semicolons (;). The difference between sending several commands on the same line and sending several independent commands is that when a command line is parsed and executed, the entire line is executed before any other device action proceeds.

The OE1022 has a 256-character input buffer and processes commands in the order receive. If the buffer fills up, the new commands will cover the oldest and processed commands.

OE1022 allows users to read the current value of internal parameters through commands. The format of inquiring commands is appending a question mark “?” to the command mnemonic and omitting the desired parameter(s) from the command. Values returned by the OE1022 are sent as a string of ASCII characters terminated by a corresponding terminator. If multiply queries are sent on one command line (separated by semicolons), the answers will be returned one by one. Each is corresponding to a terminator.

Examples of Command Formats

FMOD1<cr>	Set reference source to internal
FREQ10E3<cr>	Set internal reference frequency to 10kHz
OUTP?1<cr>	Queries the output value of CH1

5.2 Detailed Command List

The parameters in each command sequence specify the command. Multiple parameters are separated by commas. Parameters shown in {} are optional. Commands that may be queries have a question mark in parentheses (?) after the mnemonic. Do not send () or {} as part of the command.

The variables are defined as follows.

i, j, k, l, m, n, o, p, q, r, s, t, u	integers
x	real numbers
f	frequency

Note that all numeric variables can be expressed in integer, floating point or exponential formats (i.e., the number five can be 5, 5.0, or .5E1). Strings are sent as a sequence of ASCII characters.

5.2.1 Reference and Phase Commands

PHAS(?) <i>{x}</i>	<p>The PHAS command sets or queries the reference phase shift. The parameter <i>i</i> selects the phase value (real number, unit: °). The PHAS <i>x</i> sets the current phase shift value to <i>x</i>°.</p> <p>The <i>x</i> value is rounded to 0.01°. The phase is limited from -180° to +180°. For example, send command “PHAS -179.0” and the phase shift value of OE1022 will be set to -179°. The PHAS? command is a query only command</p>
FMOD(?) <i>{i}</i>	<p>The FMOS command sets or queries the reference signal source. The parameter <i>i</i> selects external reference (<i>i</i>=0), internal reference (<i>i</i>=1) or internal sweeping frequency reference (<i>i</i>=2).</p>
FREQ(?) <i>{f}</i>	<p>The FREQ command sets or queries the frequency of internal reference signal. The FREQ? command will return the current reference signal frequency. (internal or external)</p>
RSLP(?) <i>{i}</i>	<p>The RSLP command sets or queries the current trigger way of reference signal when the system uses external reference source.</p> <p>The parameter <i>i</i> selects <TTL> rising edge (<i>i</i>=0) or <Sine> more than 0 detection (<i>i</i>=1) to trigger. When the frequency is less than 1 Hz, it is necessary to use <TTL> trigger.</p>
SWPT(?) <i>{f}</i>	<p>The SWPT command sets or queries the modes of internal sweeping frequency. The parameter <i>i</i> selects <Linear> (<i>i</i>=0) or <Log> (<i>i</i>=1).</p>
SLLM(?) <i>{f}</i>	<p>The SLLM command sets or queries <Start> frequency in internal sweeping frequency mode. The SLLM? command will return the start frequency. The range of <i>f</i> is 0-100kHz and the minimum resolution is 1mHz.</p>
SULM(?) <i>{f}</i>	<p>The SULM command sets or queries <Stop> cutoff frequency in internal sweeping frequency mode. The SULM? command will return the cutoff frequency. The range of <i>f</i> is 0-100kHz and the minimum resolution is 1mHz.</p>
SSLL(?) <i>{f}</i>	<p>The SSLL command sets or queries the step frequency in <Linear> internal sweeping frequency mode. The SSLL? command will return the step frequency. The range of <i>f</i> is 0-100kHz and the minimum resolution is 1mHz.</p>
SSLG(?) <i>{x}</i>	<p>The SSLG command sets or queries the percentage in <Log> internal sweeping frequency mode. The SSLG? command will return the percentage in <Log> sweep frequency mode. The range of <i>x</i> is 0-100 and the minimum resolution is 0.001. <i>x</i>=1 means that the percentage is 50%.</p>

- STLM(?)*{i}* The STLM command sets or queries the step time in internal sweeping frequency mode. The STLM? command the step time of internal sweep mode. The range of x is 1ms-100,000ms and the minimum resolution is 1ms.
- HARM(?)*{i,j}* The HARM command sets or queries harmonic detection. The parameter i selects harmonic 1(i=1) or harmonic 2 (i=2) and is required. The parameter j selects the integer between 1 and 32767. The HARM i,j command sets j harmonic of detecting input reference frequency. The parameter j should make $j*f \leq 100\text{kHz}$. If the value of j harmonic is more than 100kHz, then j will be set to the maximum value that meets this condition.
- SLVL(?)*{x}* The SLVL command sets or queries the amplitude of the output synchronous sine wave.
The parameter x selects the amplitude of voltage (real number, unit: V). The range of x is $0.000 \leq x \leq 10.000$ and x is rounded to 0.001V.
- SWVT(?)*{i}* The SWVT command sets or queries output type of <Sine Output>. The parameter i selects fixed amplitude output (i=0), linear sweeping amplitude output (i=1) or logarithm sweeping amplitude output (i=2).
- SVLL(?)*{i}* The SVLL command sets or queries <Start> amplitude in <Sine Output> sweep mode. The SVLL? command will return the start amplitude of sweeping amplitude. The range of x is $0.000 \leq x \leq 10.000$ and the minimum resolution is 0.001V.
- SVUL(?)*{x}* The SVUL command sets or queries <Stop> cutoff amplitude in <Sine Output> sweep mode. The SVUL? command will return the cutoff amplitude of sweeping amplitude. The range of x is $0.000 \leq x \leq 10.000$ and the minimum resolution is 0.001V.
- SVSL(?)*{x}* The SVSL command sets or queries <Step> amplitude in <Linear> <Sine Output> sweep mode. The SVSL? command will return the step amplitude of linear sweeping amplitude mode. The range of x is $0.000 \leq x \leq 10.000$ and the minimum resolution is 0.001V.
- SVSG(?)*{x}* The SVSG command sets or queries the percentage in <Log> <Sine Output> sweep mode. The SVSG? command will return the percentage in <Log> sweep amplitude mode. The range of x is 0-100 and the minimum resolution is 0.001. x=1 means that the percentage is 50%.
- SVTM(?)*{x}* The SVTM command sets or queries step <Time> in <Sine Output> sweep mode. The SVTM? command will return the step <Time> of logarithm sweeping amplitude. The range of x is 1ms-100,000ms and the minimum resolution is 1ms.

SVRM(?)*{x}* The SVRM command sets and queries the executing mode in <Sine Output> sweep mode. The parameter *i* selects <Stop> (*i*=0), <Single> (*i*=1) or <Loop> (*i*=2).

5.2.2 Equation Commands

EQCD(?)*i*{*j,k,l*} The EQCD *i* command sets or queries the parameter value of A, B and C in four <Equation>. The parameter *i* selects Equation1(*i*=1), Equation2(*i*=2), Equation3(*i*=3) or Equation4(*i*=4).

The parameter *j, k, l* are corresponding to A, B, C in <Equation> and selects the numbers below.

<i>j, k, l</i>	Parameter
0	R
1	X
2	Y
3	θ
4	Rh1
5	Xh1
6	Yh1
7	θ h1
8	Rh2
9	Xh2
10	Yh2
11	θ h2
12	Noise
13	A1
14	A2
15	A3
16	A4
17	Freq
18	C1
19	C2

For example, send command “EQCD 2.0,17” and then the Equation 2 is set: $E2=R*C1/Freq$.

The EQCD? *i* command queries the configuration parameter of Equation *i*. Values are returned as the serial number corresponding to A, B, C with the values separated by commas. For example, send command “EQCD? 2” and return string “0,18 17”. In this case, for the Equation2, A is the value of <R>, B is the value of <C1>, C is the value of <Freq>.

EQCS(?)i{x} The EQCS command sets or queries two coefficients <C1>, <C2>. The parameter i selects to set <C1> (i=1), <C2> (i=2) and is required when sending this command.

The parameter is used to set the value of coefficients and the range is $-10.000 \leq x \leq 10.000$.

For example, send command "EQCS 2,5.00" and this will set the value of <C2> to 5.00.

5.2.3 Input and Filter Commands

ISRC(?)i} The ISRC command sets or queries the input configuration. The parameter i selects A (single input mode) (i=0), A-B (differential input mode) (i=1), I (1 M Ω) (input current and the expand is $10^6 V/A$) (i=2) or I (100 M Ω) (input current and the expand is $10^8 V/A$) (i=3).

IGND(?)i} The IGND command sets or queries the input shield grounding. The parameter i selects Float (i=0) when the input ground is connected to the instrument ground with 10 k Ω resistor or Ground (i=1) when the input ground is connected to the instrument ground with 10 Ω resistor.

ICPL(?)i} The ICPL command sets and queries the input coupling. The parameter i selects AC (i=0) or DC (i=1).

ILIN(?)i} The ILIN command sets and queries the notch filter status. The parameter i selects to close notch filter (i=0), open 50Hz notch filter (i=1), open 50Hz and 100Hz notch filter at the same time (i=2) or open 100Hz notch filter (i=3).

5.2.4 Sensitivity and Time Constants Commands

SENS(?)*{i}* The SENS command sets or queries the sensitivity. The parameter *i* is to select the sensitivity below.

<i>i</i> sensitivity	<i>i</i> sensitivity
1: 1 nV/fA	15: 50 uV/pA
2: 2 nV/fA	16: 100 uV/pA
3: 5 nV/fA	17: 200 uV/pA
4: 10 nV/fA	18: 500 uV/pA
5: 20 nV/fA	19: 1 mV/nA
6: 50 nV/fA	20: 2 mV/nA
7: 100 nV/fA	21: 5 mV/nA
8: 200 nV/fA	22: 10 mV/nA
9: 500 nV/fA	23: 20 mV/nA
10: 1 uV/pA	24: 50 mV/nA
11: 2 uV/pA	25: 100 mV/nA
12: 5 uV/pA	26: 200 mV/nA
13: 10 uV/pA	27: 500 mV/nA
14: 20 uV/pA	28: 1 V/uA

RMOD(?)*{i}* The RMOD command sets or queries the reserve mode. The parameter *i* selects High Reserve (*i*=2), Normal (*i*=1) or Low Noise (minimum) (*i*=0).

OFLT(?)*{i}* The OFLT command sets or queries the time constant. The parameter *i* selects a time constant below.

<i>i</i> time constant	<i>i</i> time constant
1: 10 us	10: 300 ms
2: 30 us	11: 1 s
3: 100 us	12: 3 s
4: 300 us	13: 10 s
5: 1 ms	14: 30 s
6: 3 ms	15: 100 s
7: 10 ms	16: 300 s
8: 30 ms	17: 1000 s
9: 100 ms	18: 3000 s

OFSL(?)*{i}* The OFSL command sets or queries the low pass filter slope. The parameter *i* selects 6dB/oct (*i*=0), 12dB/oct (*i*=1), 18dB/oct (*i*=2) or 24dB/oct (*i*=3).

SYNC(?)*{i}* The SYNC command sets or queries the synchronous filter status. The parameter *i* selects Off (*i*=0) or On (*i*=1). The synchronous filtering is turned on only if the detection frequency (reference x harmonic number) is less than 20 Hz.

5.2.5 Display and Output Commands

FPOP(?)i{j} The FPOP command sets and queries the front panel output sources. The parameter i must be set when sending this command. The parameter i selects CH1 (i=1) or CH2 (i=2) and is required. The FPOP i, j command sets output i to quantity j where j is listed below.

CH1(i=1)		CH2(i=2)	
j	Input Type	j	Output Type
0	R	0	R
1	X	1	X
2	Y	2	Y
3	θ	3	θ
4	Rh1	4	Rh1
5	Xh1	5	Xh1
6	Yh1	6	Yh1
7	θh1	7	θh1
8	Rh2	8	Rh2
9	Xh2	9	Xh2
10	Yh2	10	Yh2
11	θh2	11	θh2
12	Noise	12	Noise
13	E1	13	E1
14	E2	14	E2
15	E3	15	E3
16	E4	16	E4

OEXP(?)i{x,j} The OEXP command sets or queries the output offsets and expands. The parameter i must be set when sending this command. The parameter i selects the type of parameters below.

i	Parameter
0	R
1	X
2	Y
3	Rh1
4	Xh1
5	Yh1
6	Rh2
7	Xh2
8	Yh2
9	Noise

The parameter x is the offset in percent (-100.00≤x≤100.00); the parameter j is used to set expand and the range of expand is 1≤x≤256. For example, send

command "OEXP 2,50.00,2" and then the offset parameter <Y> is 50%; the output expand is 2 times; the parameter x and j is required to send.

The OEXP? i command queries the offset and expand of quantity i. The returned string contains both the offset and expand separated by a comma. For example, if the OEXP? 2 command returns "50.00,1" then the Y offset is 50.00% and the Y expand is 10.

- OAUX (?)i{x} The OAUX? Command sets or queries the AUX_DAC output values. The parameter i must be set when sending this command. The parameter i selects an DAC channel and is used to set the voltage of DAC. The voltage range is $-10.000V \leq X \leq 10.000V$. For example, send command "OAUX 2, 5.00" and then the channel voltage of <DAC2> is set to 5.00V.
- SPED(?)i The SPED command sets or queries the executing mode of <Channel Output>. Choose <Slow> mode when i=0; choose <Fast> mode when i=1. In the <Fast> mode, the output is only the value of <R>, <X> and <Y>. If the current choice isn't the value of <R>, <X> and <Y>, when switching to <Fast> mode, the output will choose the value of <R> automatically.

5.2.6 Save and Setup Commands

- SSET i The SSET i command saves the current setup in setting buffer i ($1 \leq i \leq 4$). The parameter i selects S1 (i=1), S2 (i=2), S3 (i=3) or S4 (i=4). The setting buffers are retained when the power is turned off.
- RSET i The RSET i command recalls the saved setup from buffer i ($1 \leq i \leq 5$). After executed the RSET i command, the internal parameter will be set to the corresponding parameter in the setting buffer i. The parameter i selects S1 (i=1), S2 (i=2), S3 (i=3), S4 (i=4) and Default (i=5).

5.2.7 Auto Set Commands

- AGAN The AGAN command performs the Auto Gain function. This command is the same as pressing the [Auto Gain] key. Auto Gain may take some time if the time constant is long.
- ARSV The ARSV command performs the Auto Reserve function. This command is the same as pressing the [Auto Reserve] key. Auto Reserve may take some time.
- APHS The APHS command performs the Auto Phase function. This command is the same as pressing the [Auto Phase] key. The outputs will take many time constants to reach their new values. Do not send the APHS command again without waiting the appropriate amount time. If the phase is unstable, then APHS will do nothing.

Use PHAS? Command to query the new value of the phase shift and see if APHS changed the phase shift.

ASCL The ASCL command performs the Auto Scale function. This command is the same as pressing the [Auto Scale] key.

5.2.8 Data Store Commands

SRAT(?)*{i}* The SRAT? command sets or reads the step time of data sampling. This command will return the step time value of sampling. The setting range of X is 1ms-100,000ms. The minimum resolution is 1ms.

SLEN(?)*{i}* The SLEN? command sets or reads the length of data sampling. The maximum length is 16384.

SSLE(?)*{i,j}* The SSLE *i* command sets or reads the chosen parameters in four buffers. The parameter *i* must be set when sending this command. Choose <Buffer 1> when *i*=1; Choose <Buffer 2> when *i*=2; Choose <Buffer 3> when *i*=3; Choose <Buffer 4> when *i*=4. The parameter *j* means the recorded measure value in Buffer.

The parameter *j* selects the parameters below.

j	Parameter
0	R
1	X
2	Y
3	θ
4	Rh1
5	Xh1
6	Yh1
7	θ h1
8	Rh2
9	Xh2
10	Yh2
11	θ h2
12	Noise
13	A1
14	A2
15	A3
16	A4
17	E1
18	E2
19	E3
20	E4
21	Freq

- STRG(?)*{i}* The STRG? command sets or reads the trigger way of data sampling. The mode is <INT> if *i*=0; and the mode is <EXT> if *i*=1.
- SPRM(?)*{i}* The SPRM? command sets or reads the mode of data sampling. If *i*=0 then the mode is <Single>; if *i*=1 then the mode is <Loop>.
- STRD The STRD command start or continue the current data sampling.
- PAUS The PAUS command pauses data sampling. If storage is already paused or reset then this command is ignored.
- REST The REST command resets the data buffers. This command will empty four data buffers, including Buffer1 ~ Buffer4.

5.2.9 Data Read Commands

- OUTP(?)*{i}* The OUTP? *i* command reads the single parameter value. The parameter *i* selects the parameters below.

<i>j</i>	Parameter
1	X
2	Y
3	R
4	θ
5	Xh1
6	Yh1
7	Rh1
8	θ h1
9	Xh2
10	Yh2
11	Rh2
12	θ h2
13	Noise
14	A1
15	A2
16	A3
17	A4
18	Freq

Values are returned as ASCII floating point numbers with units of the Volts, degrees or Hz. This command is a query only command.

- SNAP?*i,j,{k,l,m,n,o,p,q,r,s,t,u}* The SNAP? command records the values of no more than 13 parameters at a single constant.

For example, SNAP? is a way to query values of <X>, <Y>, <R>, < θ > and <F> which are taken at the same time. This is important when the time constant is very short. Using the OUTF? or OUTR? commands will result in time delays, which may be greater than the time constant, between reading two different parameters.

The SNAP? command requires at least two parameters and at most thirteen parameters. The parameters i, j, k, l, m, n, o, p, q, r, s, t, u select the parameters below.

i,j,k,l,m,n,o ,p,q,r,s,t,u	Parameter
1	X
2	Y
3	R
4	θ
5	Frequency
6	Xh1
7	Yh1
8	Rh1
9	θ h1
10	Xh2
11	Yh2
12	Rh2
13	θ h2
14	Noise
15	A1
16	A2
17	A3
18	A4
19	E1
20	E2
21	E3
22	E4

The requested values are returned in a single string with the values separated by commas and in the order in which they are requested. For example, the SNAP?1,2,5,4 will return the values of <X>, <Y>, <Frequency> and < θ >. These values will be returned in a single string such as "0.951359,0.0253297,1000.00,1.234". The first value is <X>, the second is <Y>, the third is Frequency and the fourth is < θ >.

The SNAP? command is only used to record various parameters simultaneously.

- SPTS?** The SPTS? command queries the number of points stored in the buffer. This command can be sent at any time. If the data buffer is reset, then 0 is returned. This command is a query only command.
- TRCA?i,j,k** The TRCA? command queries the data (Buffer1~Buffer 4) in the channel i Buffer.
The values are returned as ASCII floating point numbers with the units of the trace. Multiple points are separated by commas (,) and the final point is followed by a terminator. For example, the response of two points might be “-1.234567e-009, +7.654321e-009”.
The parameter i selects the display buffer (i=1,2,3,4) and is required to send with this command. Points are read from the buffer starting at bin j ($j \geq 0$); A total of k bins are read ($k \geq 1$); To read a single point, set $k=1$. Both j and k are required. If $j+k$ exceeds the number of stored points (as returned by the SPTS? query), then an error occurs. So, the value of $j+k$ should be no more than 16384 which is the maximum number of data stored in the buffer.

5.2.10 Reset and IDN Commands

- RST** The RST command is used to reset OE1022 to its default configurations. All internal status and parameters are set to their default conditions and values. Data stored in the buffers will be lost.
- IDN?** The IDN? Query returns the OE1022's device identification string. This string is in the format “SSL LIA-OE1022, SNXXXXXX, VerXXX”. In this example, the type is OE1022; the serial number is SN0001; the firmware version is Ver1.00.

6. PC USER GUIDE

6.1 Install Software

The required test software is provided by the CD disk as below: Fig 48

Name	Date modified	Type
OE1022_Console Drivers	8/14/2017 3:50 PM	File folder
OE1022_Console_EN	8/14/2017 3:49 PM	File folder
Uart Assistant	8/14/2017 3:50 PM	File folder
Uart Driver	8/14/2017 3:57 PM	File folder
OE1022_introduction_EN.pdf	8/2/2016 2:53 PM	Foxit Reader PDF ...
OE1022_Uer_Manual.pdf	8/12/2016 10:08 AM	Foxit Reader PDF ...
readme.txt	7/13/2016 8:53 AM	Text Document

Fig.48 Software files.

1. Install the UART to USB Driver

Click twice “FT232_drive.exe” in the third file as below: Fig 49

Name	Date modified	Type
Inf installation file	8/14/2017 3:50 PM	File folder
FT232_drive.exe	3/8/2017 2:36 PM	Application
readme.txt	9/22/2014 3:01 PM	Text Document

Fig.49 “Serial Driver” files

Double-click the file “FT232_drive.exe” in Fig 49 red box and then you can see the Fig 50 which shows the installation is running.

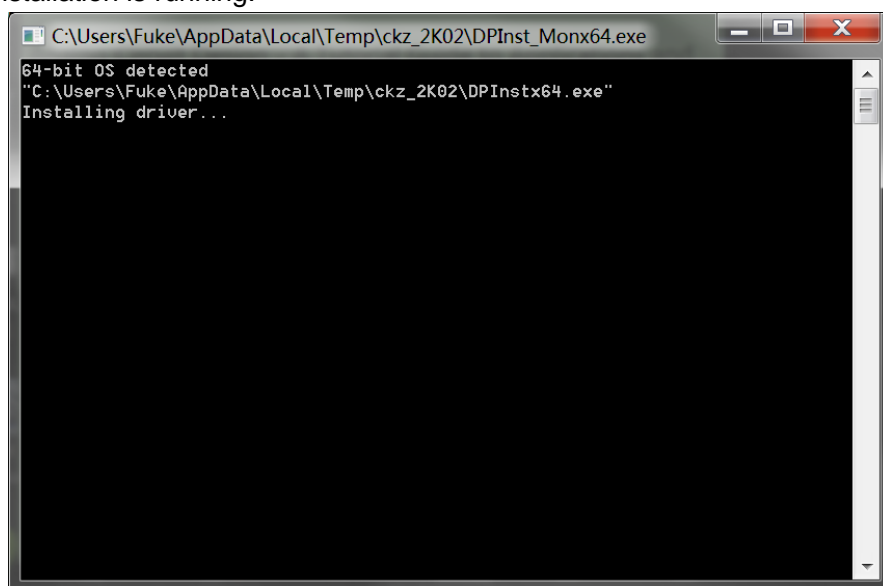


Fig.50 FT232 Driver Installing.

After the installation finished, you will see the Fig 51. Then press “Enter” key to finish it.

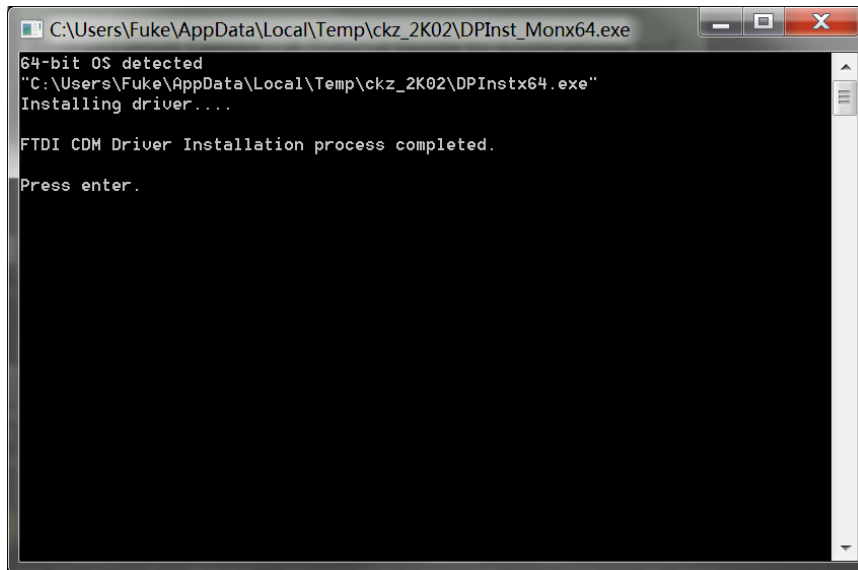


Fig.51 FT232 Driver Install successes.

Now, use a USB cable to connect the PC and the OE1022. If the driver is OK, the connection successes.

Note that if the PC is online, the PC will search the proper driver online when you connect the PC and OE1022. And the installation will run automatically.

If you have installed the Serial to USB diver, skip this step.

If the installation fails, open “readme.txt” in file “Serial Driver” and use file “inf” to install.

2. Install NI LabView 2011 or Higher Version and the VISA Driver

- 1) You need to open the third file “OE1022 software driver” in Fig.48 and start to install just as shown in Fig 52.
- 2) Double click the file “setup.exe” and start to install the VISA driver of OE1022. Generally, just install according to the default configuration.
- 3) Note that after the installation is finished, restart the PC to complete the configuration.

Name	Date modified	Type
bin	8/14/2017 3:49 PM	File folder
license	8/14/2017 3:49 PM	File folder
supportfiles	8/14/2017 3:50 PM	File folder
nidist.id	9/22/2014 4:31 PM	ID File
setup.exe	5/6/2013 5:01 PM	Application
setup.ini	9/22/2014 4:31 PM	Configuration sett...

Fig.52 “OE1022 Software Driver” File

3. Install OE1022_Console_EN.

- 1) Open the first file “OE1022” in Fig 48.
This file contains Chinese and English application software as the Fig 53 and they both can operate in Windows 7/XP.
- 2) Double click the file “OE1022_Console_EN.exe” in Fig 53 red box.
If the installation is right, and then you will see the Fig 54.
- 3) Now you can configure the OE1022 parameters in PC.

Name	Date modified	Type
OE1022_Console_EN.aliases	8/16/2017 9:10 AM	ALIASES File
SSI OE1022_Console_EN.exe	8/16/2017 9:10 AM	Application
OE1022_Console_EN.ini	8/16/2017 9:10 AM	Configuration sett...
OE1022_Console_EN.tlb	8/16/2017 9:10 AM	TLB File
OE1022ConsoleEN.log	8/16/2017 9:10 AM	Text Document

Fig.53 “OE1022” Files

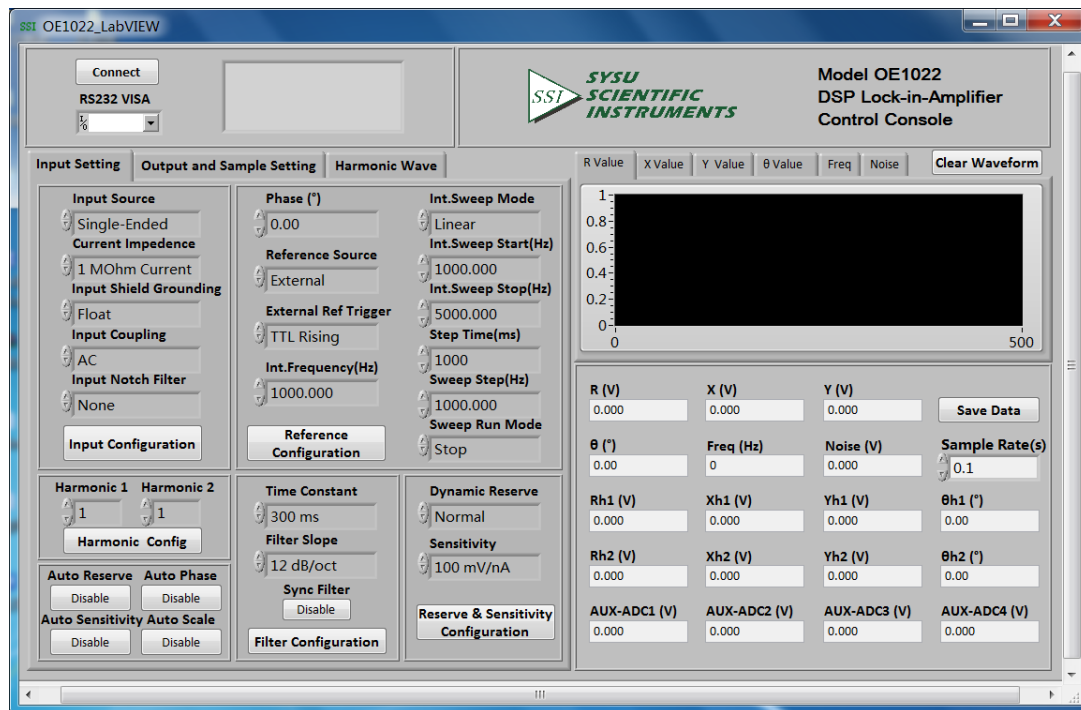


Fig.54 OE1022 Software Interface

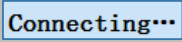
6.2 Software Guide

6.2.1 Begin to Run

The left part in Fig 55 is at the top left part of Fig 54.

If you see [Connecting] as Fig.55(left), it means the program is running.

If you see [Connect] as (right), it shows the program breaks down.

You can click the button  to switch between these two statuses.

Note that before the program runs, the Baud rate of the OE1022 should set to 921600bd.

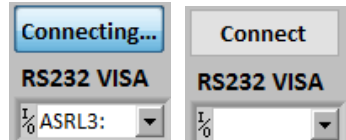


Fig.55(left) Program is running (right) Program stops.

6.2.2 Connection

This part shows you how to connect the PC and the OE1022.

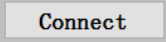
As is shown in Fig 56, click the button .



Fig.56 Current Connection Status

The program begins to run and search for the proper COM number automatically. If the connection succeeds, you will see the version information in Fig.57.

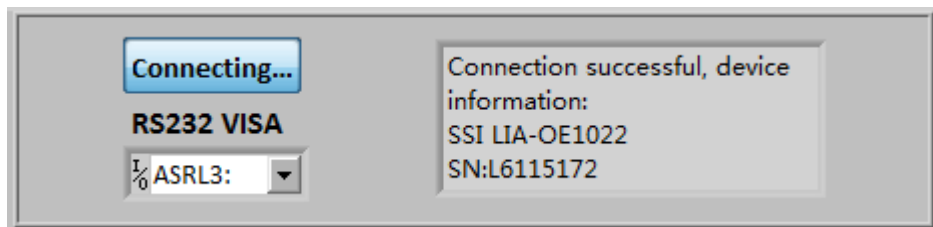


Fig.57 Connection Succeeds

Wait for a few seconds. If the interface pops up a prompt box like Fig.58, it means that the connection between PC and OE1022 fails.

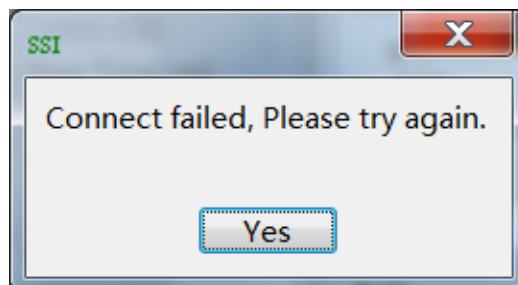


Fig.58 Connection fails and USB device search failed.

Click the button [YES] to check the status of the connection. Now the right connect status window will display the wrong information, as is shown in Fig.59.

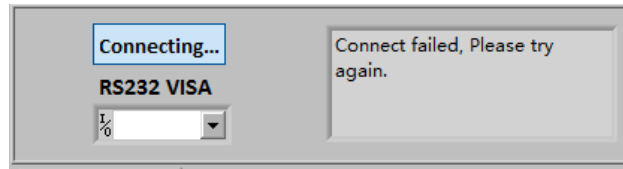

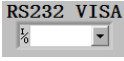



Fig.59 Connection fails and try re-connection

Two solutions to re-connect:




The first solution:

- 1) Click  at the right side of the option .
- 2) Click  at the drop-down list.
- 3) Choose the right COM number. If the COM is right, the connection will success after few seconds.






Note that when the PC is connected to OE1022 with USB, you can go to “Device Manager” to search “COM and LPT”. In this case, you can know which COM is used to connect currently.

If the COM is right, wait for a few seconds and the connection status will refresh to Fig.57

The second solution:

- 1) Click . Wait until it becomes .
- 2) Click  again.
- 3) Repeat the operations 1 and 2 until the connection is successful.

After connection successes, as is shown in Fig.60, the data in red box will be empty and display numbers again. The value display R in default.

You can choose      to display X, Y, θ , frequency and noise value at top of the red box. The software interface will display the parameters of the OE1022 current configuration. You can set other parameters shown on the GUI.

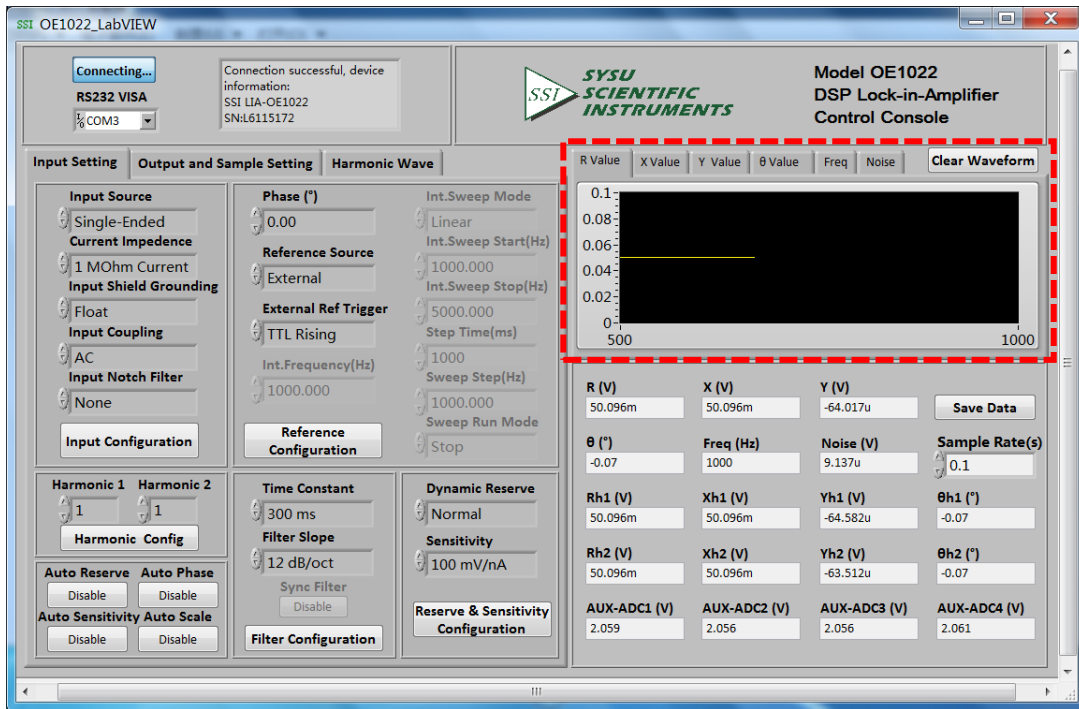


Fig.60 OE1022 Software Connection Succeeds

6.2.3 Input Configuration

The program configuration area of input signal is as shown in red box in Fig.61. The detail of the configuration is listed on the Table 3.

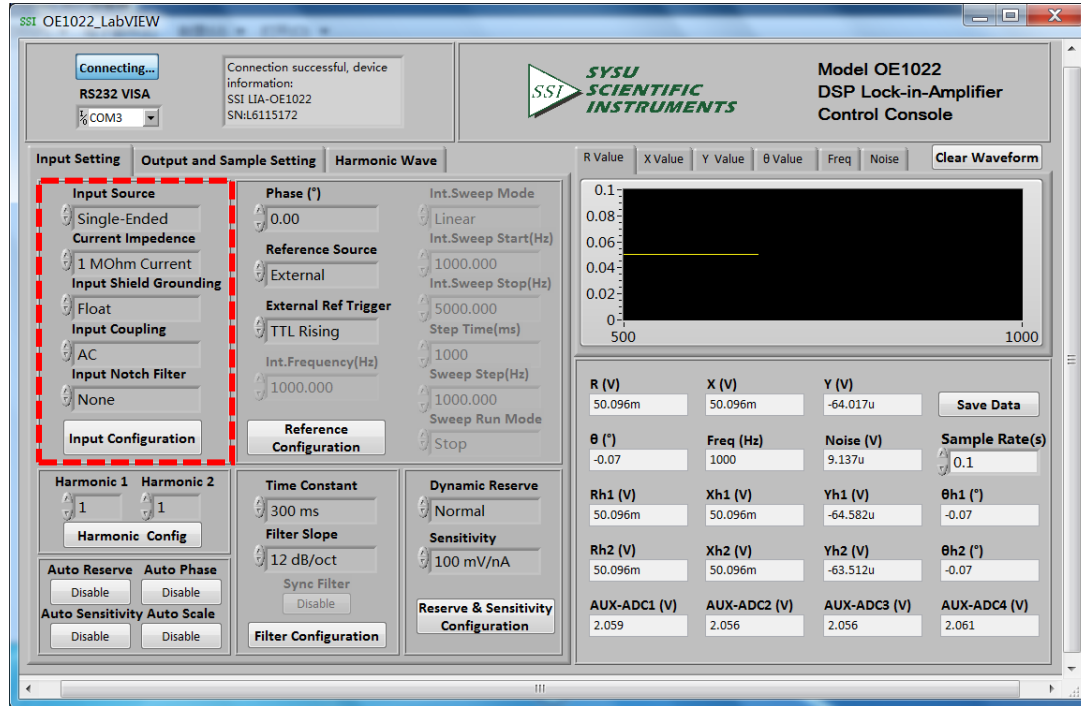


Fig.61 The Configuration area of Input Signal

Input Source	Single-Ended Voltage
	Differential Voltage
	Current
Current Impedance	1M Ω Current Gain (the input signal is small, the magnification is 10E6 V/A)
	100M Ω Current Gain (the input signal is small, the magnification is 10E8 V/A)
Input Shield Grounding	Float (the input connects and the instrument ground is isolate by a 10 k Ω resistor.)
	Ground (the input connects and the instrument ground is isolate by a 10 Ω resistor.)
Input Coupling	AC coupling
	DC coupling
Input Notch Filter	None (Don't start the notch filter)
	Line Notch (start 50 Hz notch filter and suppress the frequency interference)
	2x Line Notch (start 50 Hz and 100 Hz notch filters and suppress the frequency and frequency second harmonic interference).
	Both Notch Filters (start 100 Hz Notch Filters and suppress the frequency interference).

Note that:

1. After finishing all the settings, click **Input Configuration** to finish the configuration for input signal. All settings can be changed at the same time and you just need to click this button once.
2. After changing the settings, you need to click **Input Configuration** to finish this configuration. Otherwise this setting is void.

6.2.4 Reference and Sweep Frequency Configuration

Reference Signal Configuration:

The reference signal configuration area is shown in red box in Fig.62. The details of configuration are shown in Table 4.

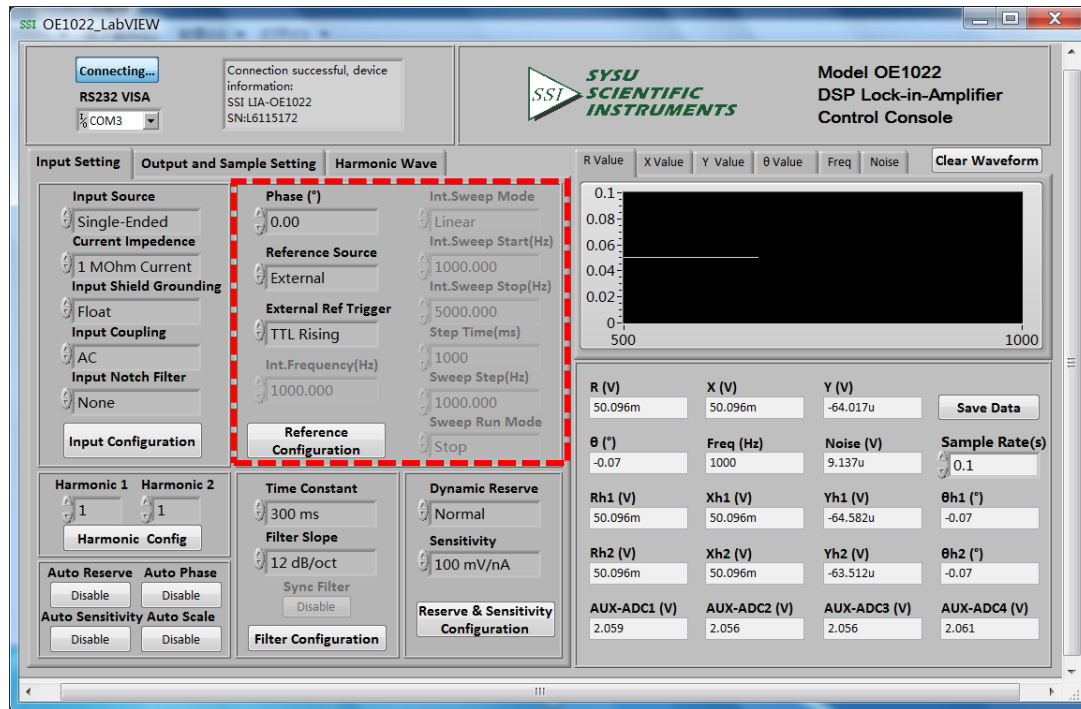


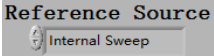
Fig.62 The Configuration Area of Reference Signal

PHASE	Setting the phase shift of two orthogonal reference signals for PSD algorithm. -180° to +180° by one step of 0.01°
Reference Source	External
	Internal
External Ref Trigger	TTL Rising Edge
	Sine Zero Crossing
Int. Frequency	Manually, 1mHz to 120kHz by one step of 1mHz at least.

Note that:

1. After finishing all the settings, click the button **Reference Configuration** to finish the configuration for input signal.; all settings can be changed at the same time and you just need to click the button this button once.
2. After changing the settings, you need to click **Reference Configuration** to finish this configuration. Otherwise this setting is void.

Sweep Frequency Configuration:

Choose the button  to configure internal sweep frequency as is shown in Fig 63. The details of configuration are shown in Table 5.

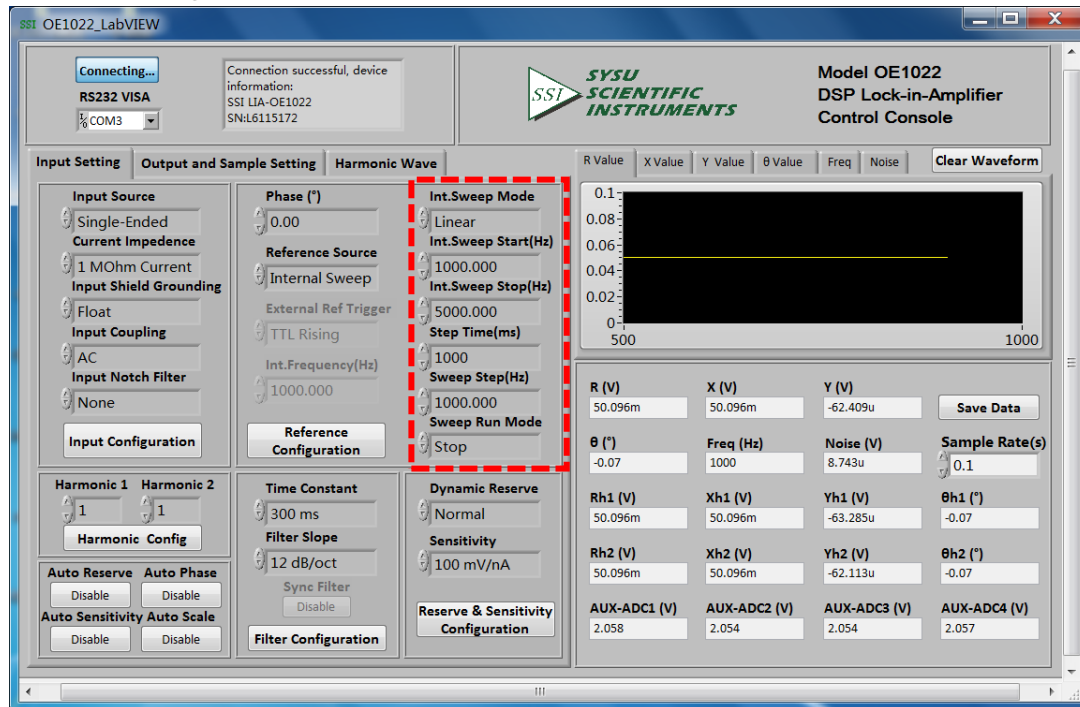


Fig.63 The Configuration Area of Internal Sweep Frequency

Int. Sweep Type	Linear
	Log
Int. Sweep Start (Hz)	Setting the start frequency of sweep, manually, the frequency range is from 1mHz to 100kHz and the minimum resolution is 1mHz.
Int. Sweep Stop (Hz)	Setting the stop frequency of sweep, manually, the frequency range is from 1mHz to 100kHz and the minimum resolution is 1Hz.
Linear Step Time (Hz)	Setting the step time for every sweep, manually, the step range is from 1ms to 100s and the minimum resolution is 1ms.
Int. Sweep Step (Hz)	Setting the step frequency for every sweep, manually, the step range is from 1Hz to 100kHz and the minimum resolution is 1Hz.
Int. Sweep Run Mode	Single
	Loop
	Stop

Note that:

After finishing all the settings, click the button **Reference Configuration** to finish the configuration for input signal. All settings can be changed at the same time and you just need to click this button once.

6.2.5 Dynamic Reserve and Sensitivity Configuration

The configuration area of Dynamic Reserve and Sensitivity is in the red box in ig.65. The detail of configuration is listed on the Table 6.

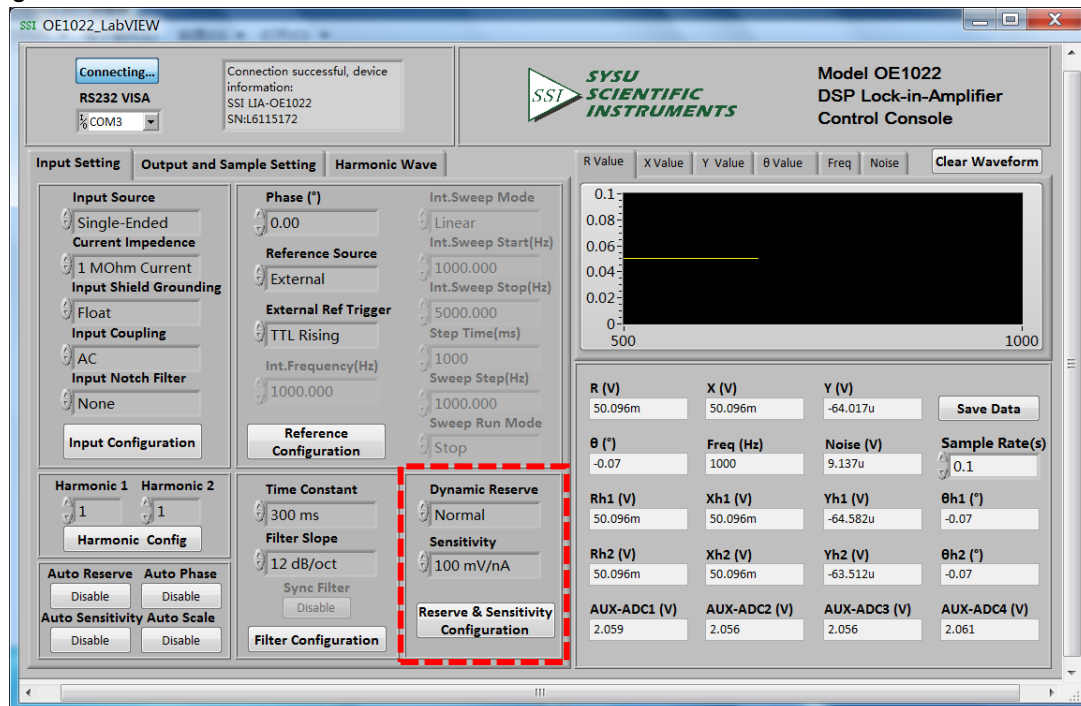
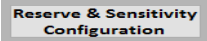


Fig.64 The Configuration Area of Dynamic Reserve and Sensitivity

Dynamic Reserve	Low Noise			
	Normal			
	High Reserve			
Sensitivity	1nV/fA	200nV/fA	50µV/pA	10mV/nA
	2nV/fA	500nV/fA	100µV/pA	20mV/nA
	5nV/fA	1µV/pA	200µV/pA	50mV/nA
	10nV/fA	2µV/pA	500µV/pA	100mV/nA
	20nV/fA	5µV/pA	1mV/nA	200mV/nA
	50nV/fA	10µV/pA	2mV/nA	500mV/nA
	100nV/fA	20µV/pA	5mV/nA	1V/µA

Note that:

1. After finishing all the settings, click the button  to finish the configuration for input signal. All settings can be changed at the same time and you just need to click this button once.

2. Once you change the settings, you need to click  to finish this configuration. Otherwise this setting is void.

6.2.6 Harmonic Configuration

The harmonic configuration is in red box in the Fig.65. The details of configuration are shown in Table 7.

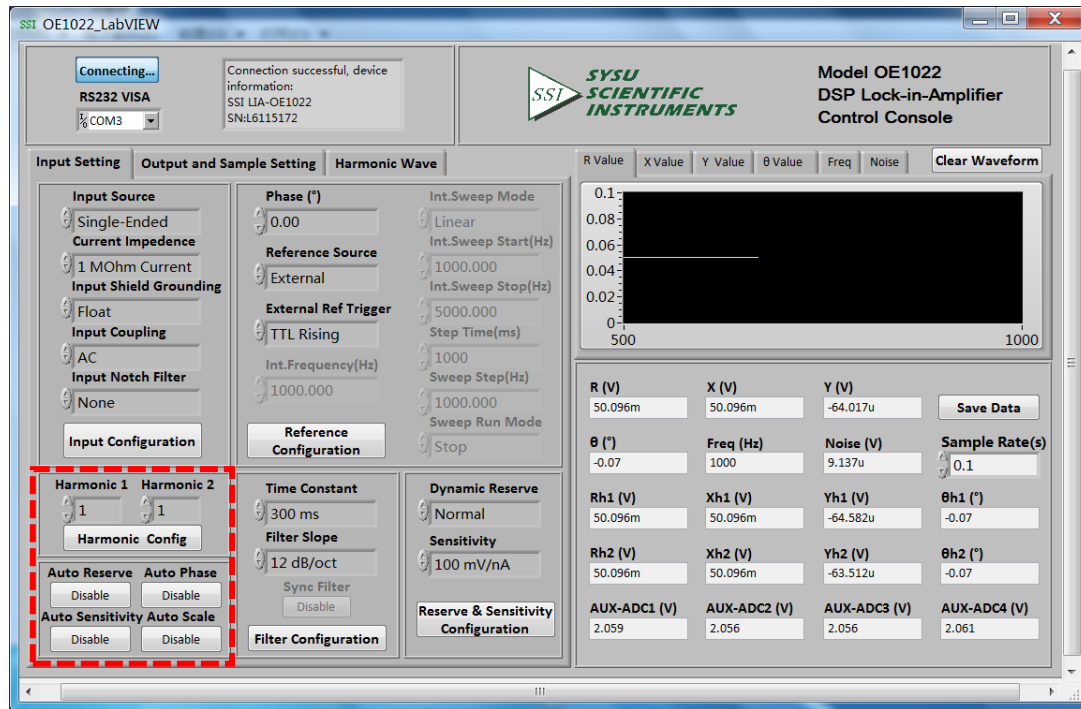


Fig.65 The Configuration Area of Filter

Setting	Configuration Options
Harmonic 1	Manually, the range is 1-32767.
Harmonic 2	Manually, the range is 1-32767.
Auto Sensitivity	Disable / Enable
Auto Reserve	Disable / Enable
Auto Phase	Disable / Enable
Auto Scale	Disable / Enable

Note that:

- After choosing all the settings, click the button **Harmonic Config** to finish the configuration; all settings can be changed at the same time and you just need to click this button once.
- The configurations of “Auto Sensitivity,” “Auto Reserve,” “Auto Phase” and “Auto Scale” are relatively independent. Click the corresponding **Disable** not the button **Reserve & Sensitivity Configuration** to close or open the auto function. The button will switch to be processing when click the button **Disable**. This means the OE1022 is executing the auto function. After finishing this process, this button will reset to the start status **Disable**. And then the “dynamic reserve” and “sensitivity” will refresh to the value that OE1022 returns.

6.2.7 Filter Configuration

The filter configuration is in red box of the Fig.66. The details of configuration are listed on the Table 8.

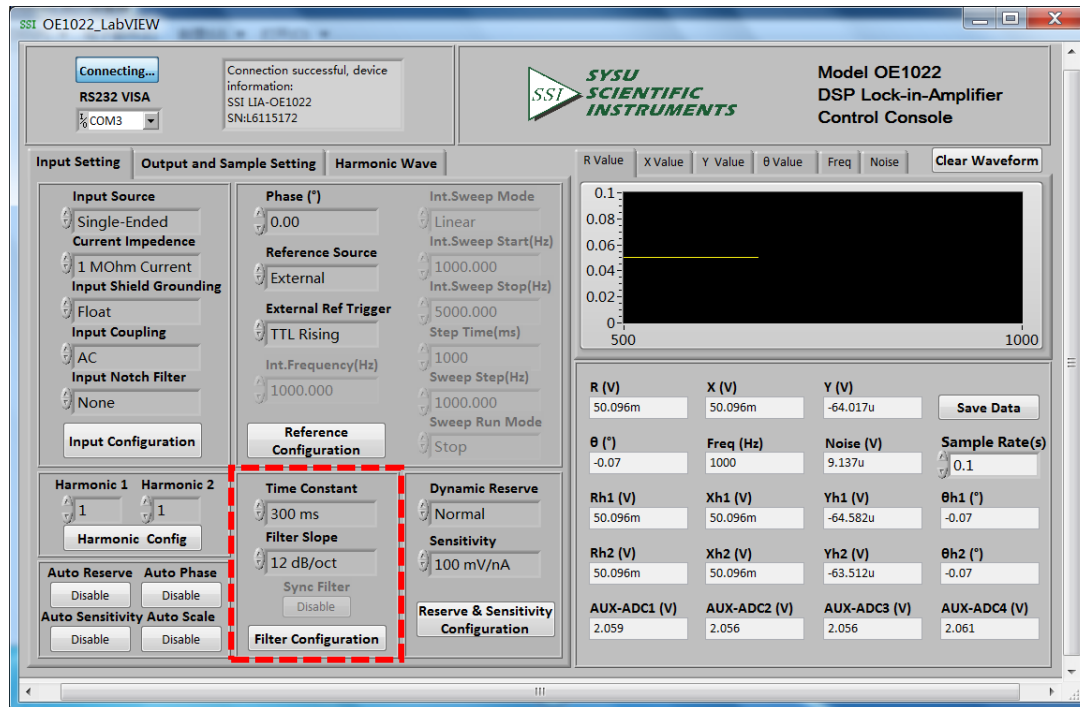


Fig.66 The Configuration Area of Filter

Time Constant	10 μ s	3ms	1s	300s
	30 μ s	10ms	3s	1000s
	100 μ s	30ms	10s	3000s
	300 μ s	100ms	30s	
	1ms	300ms	100s	
Filter Slope	6dB/oct	12dB/oct	18dB/oct	24dB/oct
SYNC Filter	Disable			
	Enable			

Note that:

1. After choosing all the settings, click the button **Filter Configuration** to finish the configuration; all settings can be changed at the same time and you just need to click this button once.
2. After changing the settings, you need to click this button to finish this configuration. Otherwise this setting is void.
3. The configurations of “Sync Filter” is relatively independent. Click the corresponding **Disable** not the button **Filter Configuration** to close or open the auto function. The button will switch to

Sync Filter **Disable** when click the button **Disable**. This means the OE1022 is executing the auto function.

If you need to close sync filter, click this button again and it will reset to the start status **Disable**. This means you have closed the sync filter successfully.

6.2.8 Output Configuration

The output configuration is in red box of the Fig.67. The details of the configuration are listed on the Table 9.

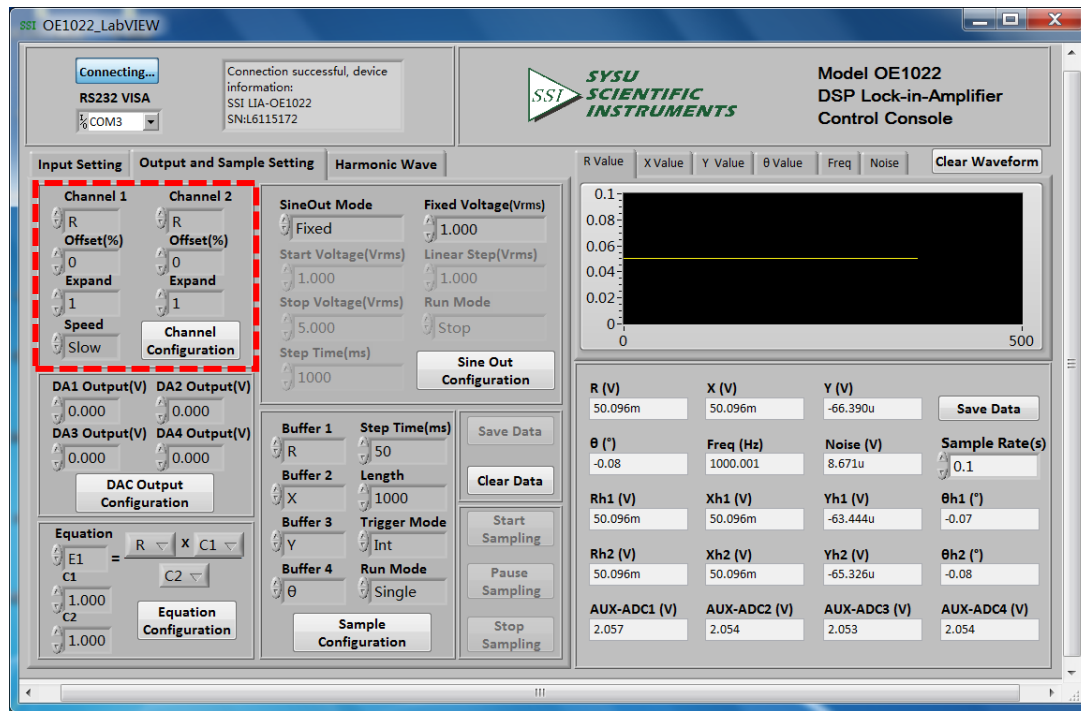
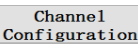
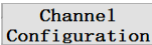


Fig.67 The Configuration Area of Output Channel

Channel 1	Control CH1 to output the right values, the value type contains the X/Y/R/θ value of signal and signal harmonic, the noise value and the E1/E2/E3/E4 value.
Channel 2	Control CH2 to output the right values, the value type contains the X/Y/R/θ value of signal and signal harmonic, the noise value and the E1/E2/E3/E4 value.
Offset (%)	-100%~+100%, the minimum step is 0.01%, 0.00% in default, only set the R/X/Y value.
Expand	1~256, 1 in default.
Speed	Choose “Fast” / “Slow”. When choosing “Fast”, the CH1 and CH2 can only output the R/X/Y value.

Note that:

1. After setting the output configuration, click the button  to finish the configuration; all settings can be changed at the same time and you just need to click this button once.
2. After changing the settings, you need to click  to finish this configuration. Otherwise this setting is void.

6.2.9 Aux Output Configuration

The sine output configuration is below the Harmonic configuration as the Fig.68.

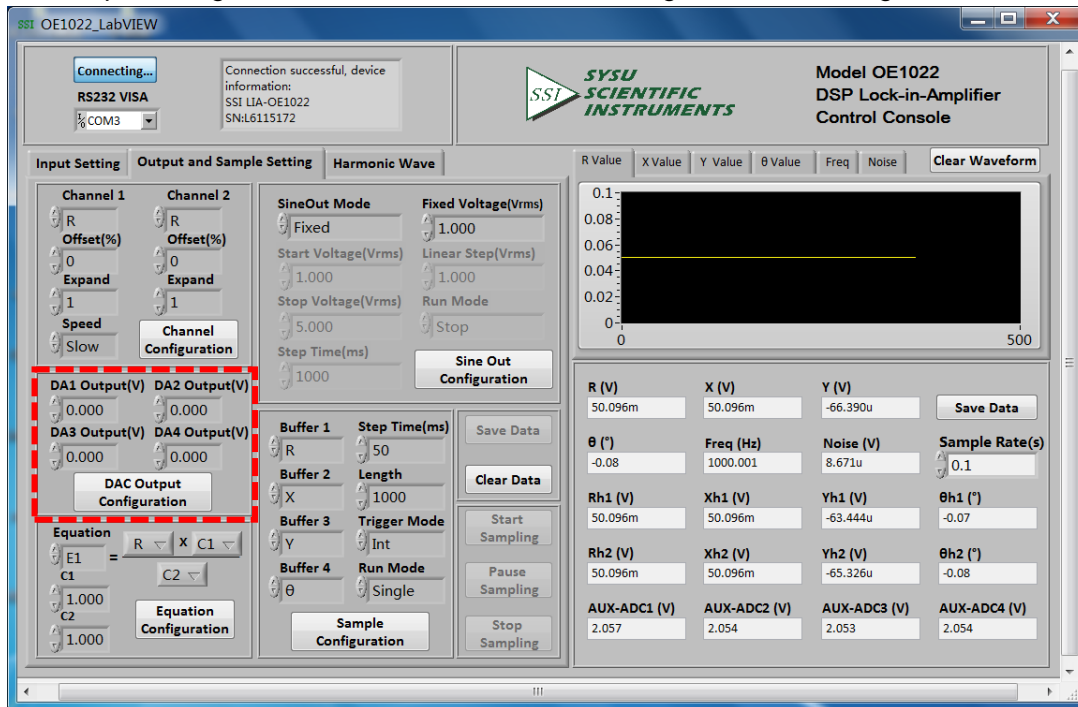


Fig.68 The Configuration Area of AUX OUTPUT

DA1 Output	Control the 4 AUX_DAC output AC voltage, manually, the voltage range is from -10 V to 10 V and the minimum resolution is 1mV.
DA2 Output	
DA3 Output	
DA4 Output	

Note that:

1. After setting the output configuration, click the button **DAC Output Configuration** to finish the configuration.

All settings can be changed at the same time and you just need to click the button **DAC Output Configuration** once.

2. After changing the settings, you need to click this button to finish this configuration. Otherwise this setting is void.

6.2.10 Custom Equation Configuration

The custom equation configuration is shown in red box of Fig.69. The detail of configuration is shown in Table 11.

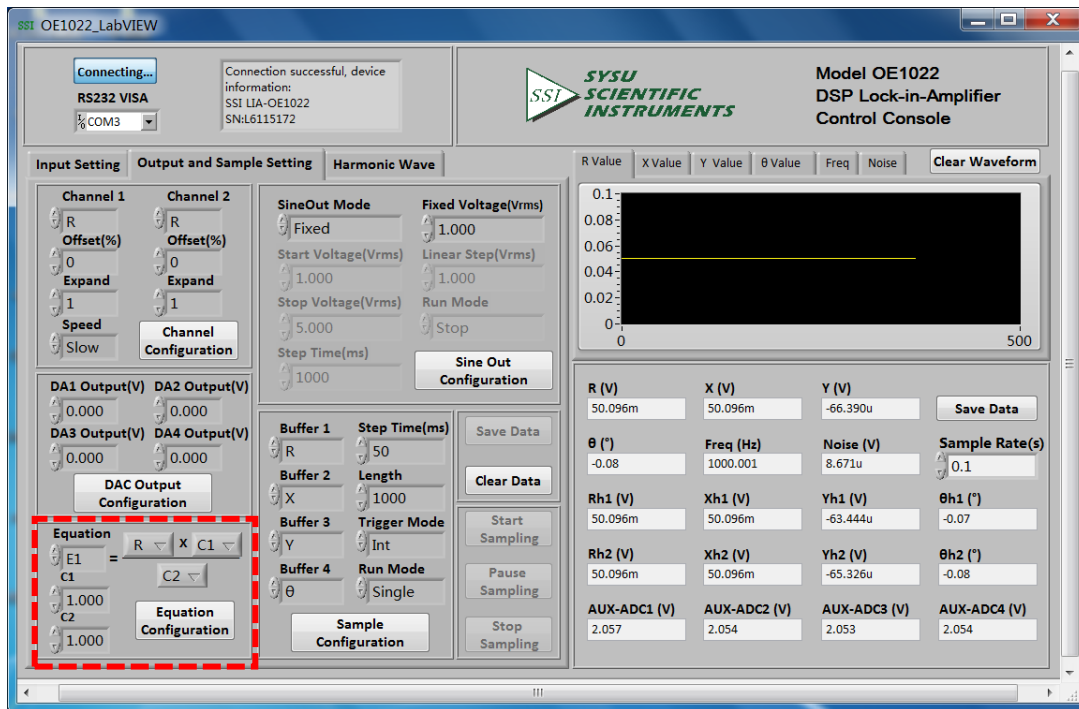


Fig.69 The Configuration Area of Equation

Table 11. Equation Configuration Options	
Equation	The output of Equation can be E1/E2/E3/E4. The input can be the X/Y/R/θ of signal or signal harmonic, the ADC1/ADC2/ADC3/ADC4 of AUX_ADC input, noise, frequency and C1/C2.
C1	Set the input of Equation, manually, the range is -10~+10, the minimum resolution is 0.001.
C2	

Note that:

- After setting the output configuration, click the button Equation Configuration to finish the configuration; all settings can be changed at the same time and you only need to click the button Equation Configuration once.
- After changing the settings, you need to click this button to finish this configuration. Otherwise this setting is void.

6.2.11 Sine Signal Configuration

The sine signal configuration is shown in red box in Fig.70. The detail of configuration is shown in Table 12.

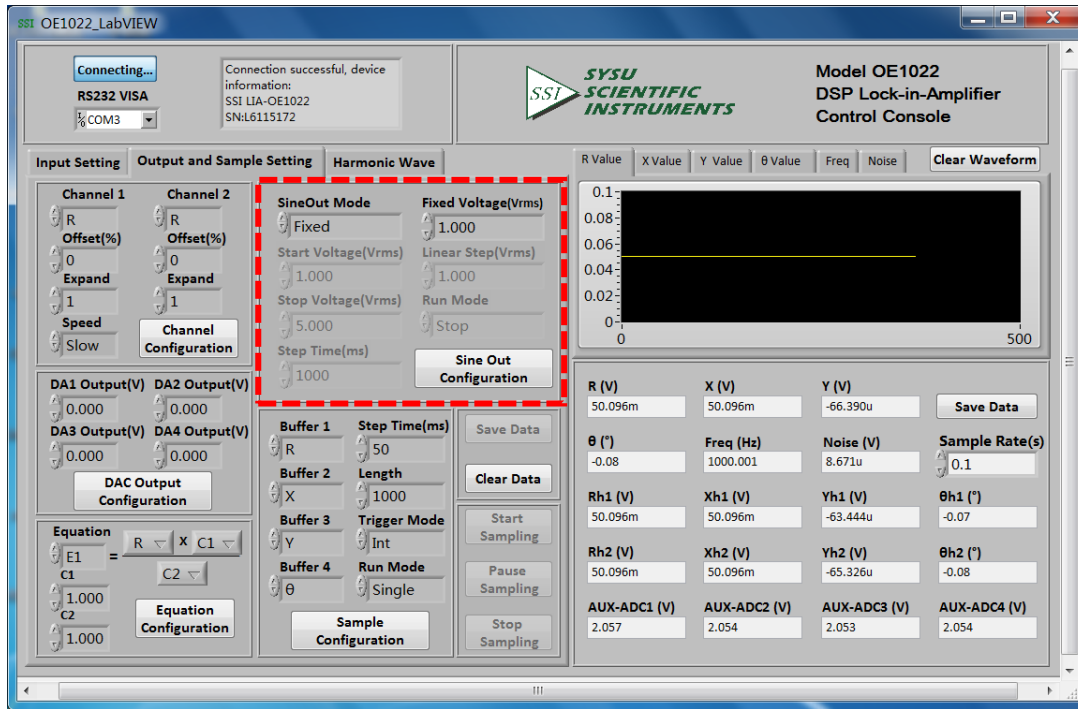


Fig.70 The Configuration Area of SINE OUTPUT

Table 12. Sine Signal Output Configuration Options	
Sine Out Mode	Fixed
	Linear
	Log
Sine Out Voltage (Vrms)	The Sine Out Mode is Fixed, manually, the peak-peak voltage is 1 mVrms-5 Vrms, the minimum resolution is 1 mVrms.
Sine Out Start Voltage (Vrms)	Set the start of sweep frequency, manually, the frequency range is 1 mVrms-5 Vrms, the minimum resolution is 1 mVrms.
Sine Out Stop Voltage (Vrms)	Set the stop of sweep frequency, manually, the frequency range is 1 mVrms-5 Vrms, the minimum resolution is 1 mVrms.
Step Time (ms)	Set the step time, manually, the range is 1ms – 100s, the minimum resolution is 1 ms.
Linear Step (Vpp)	Set the step frequency, manually, the range is 1 mVrms-5 Vrms, the minimum resolution is 1 mVrms.
Sine Out Run Mode	Single
	Loop
	Stop

Note that:

1. After setting the output configuration, click the button **Sine Out Configuration** to finish the configuration; all settings can be changed at the same time and you just need to click this button once.
2. After changing the settings, you need to click **Sine Out Configuration** to finish this configuration. Otherwise this setting is void.

6.2.12 Buffer Configuration

The buffer configuration is shown in red box in Fig.71. The detail of configuration is shown in Table 13.

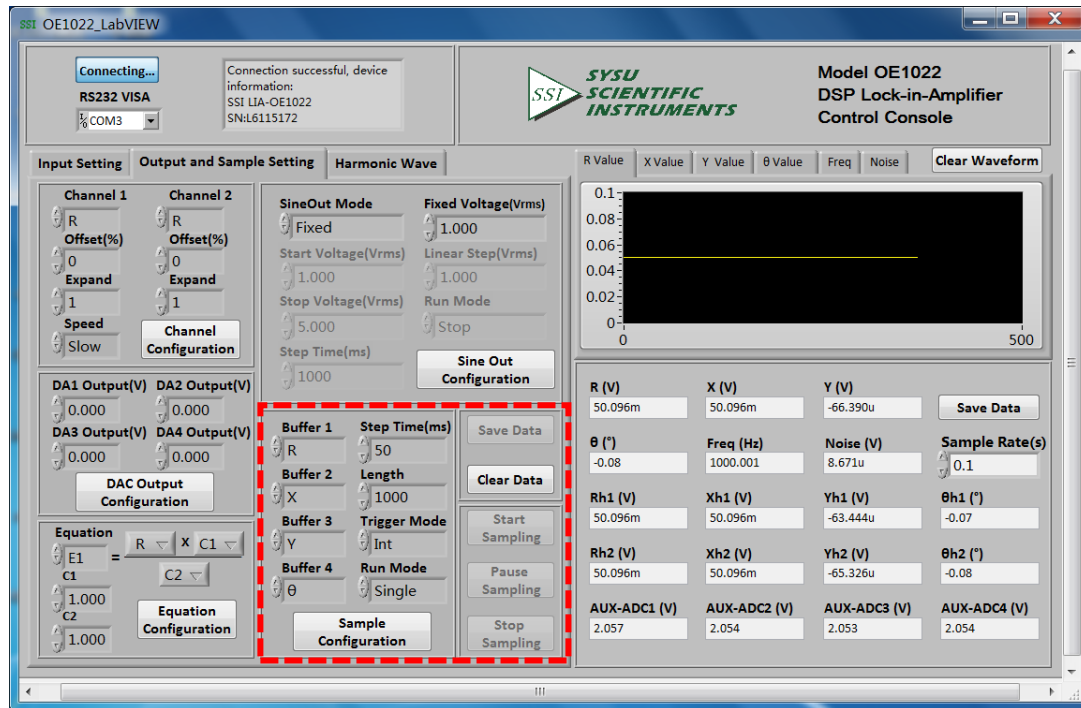
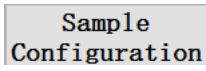
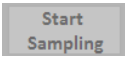
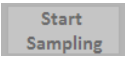
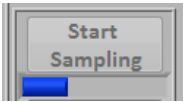

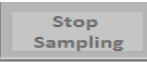
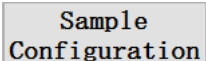




Fig.71 The Configuration Area of Data Buffer

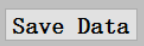
Buffer 1	The signal can be the X/Y/R/θ of signal or signal harmonic, the ADC1/ADC2/ADC3/ADC4 of AUX_ADC input, noise, frequency and C1/C2.
Buffer 2	
Buffer 3	
Buffer 4	
Step Time (ms)	Set the step time, manually, the time range is 1ms – 100s, the minimum resolution is 1 ms.
Length	Set the data length, manually, the length range is 1 – 16384, the minimum resolution is 1.
Int/Ext	Int
	Ext
Single/Loop	Single
	Loop

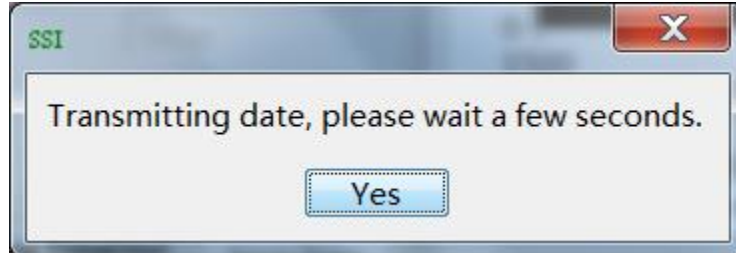
Note that:

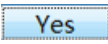
1. After choosing all the settings, click the button  and then click the right  to set. After changing the settings, you need to click this button to finish this configuration and start sampling. Otherwise this setting is void.

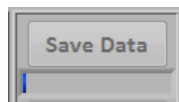
2. Click the button , and then there will be a progress bar  at the bottom of this button. This means the OE1022 has started sampling. The sampling will finish if the progress bar runs to 100%. During sampling, you can control the sampling progress by clicking the button  and . All settings can be set at the same time and you just need click  once.


3. After finishing this sample, you can operate on the button  and . These two buttons are used to save and clear data in buffer.

4. After clicking the button , the interface will callout this window



After clicking the button , the OE1022 starts to save data. There will be a progress bar



at the bottom of this button. When the progress runs to 100%, the buffer finishes saving the data. Now an excel will be generated in current directory and its name is "Buffer_Data.xls". Click the button , then the 4 data buffers and the excel will be cleared.

6.2.13 Save Data

The software has the function of saving data. Users choose to save the data or not that the OE1022 collects at a time.

The saved data contains the X/Y/R/ θ of measure signal or signal harmonic, frequency, noise and the ADC1/ADC2/ADC3/ADC4 of 4 AUX_ADC input.

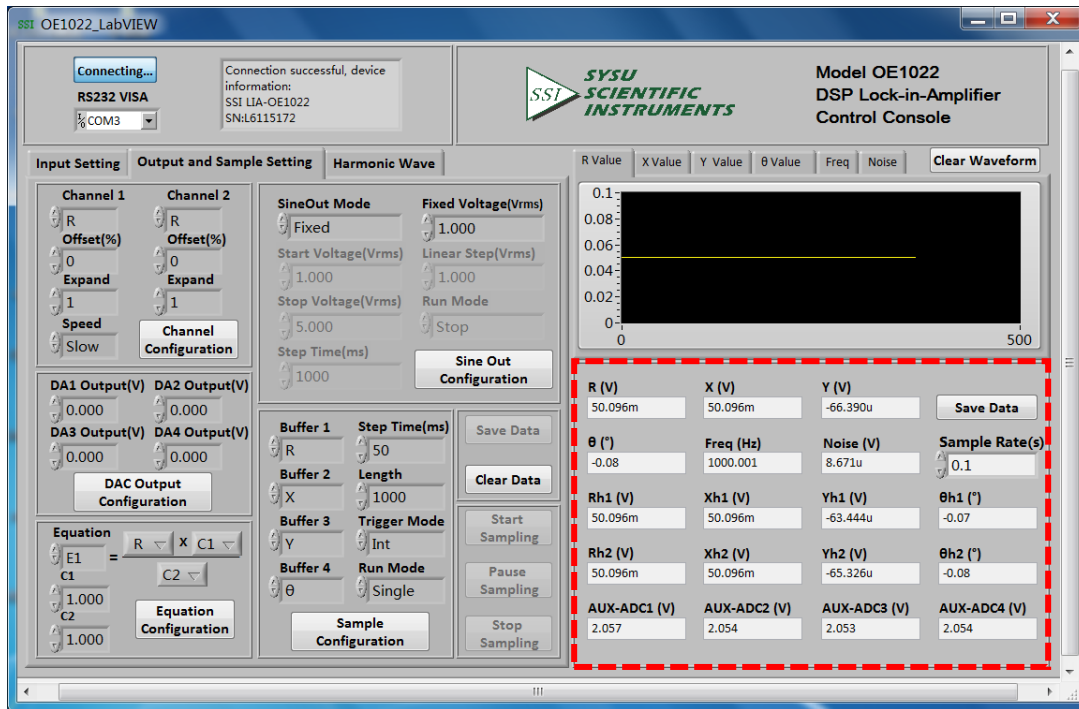


Fig.72 The Configuration Area of saving data

The steps for choosing to save data or not is below:

1. The data is saved by Excel. The file name is "Data_recorded_excel.xls" and is saved the program directory.
2. When the software is executing, click the button **Save Data** in red box in Fig.72. After clicking this button and displaying **Saving...**, the software is saving the current collected data.
3. Click the button **Saving...** again, and the button status will switch to **Save Data** again. This means the software stop saving collected data.
4. In box **Sample Rate(s)**, you can modify the sampling rate of the current display and saved data. The input range is 0.1s ~ 100s.

6.2.14 Display Harmonic Waveform

Choose the “display harmonic waveform” option in left window of the software.

Now there are two XY coordinates charts displaying harmonic. Set to display R/X/Y/ θ for every harmonic, as is shown in Fig.73.

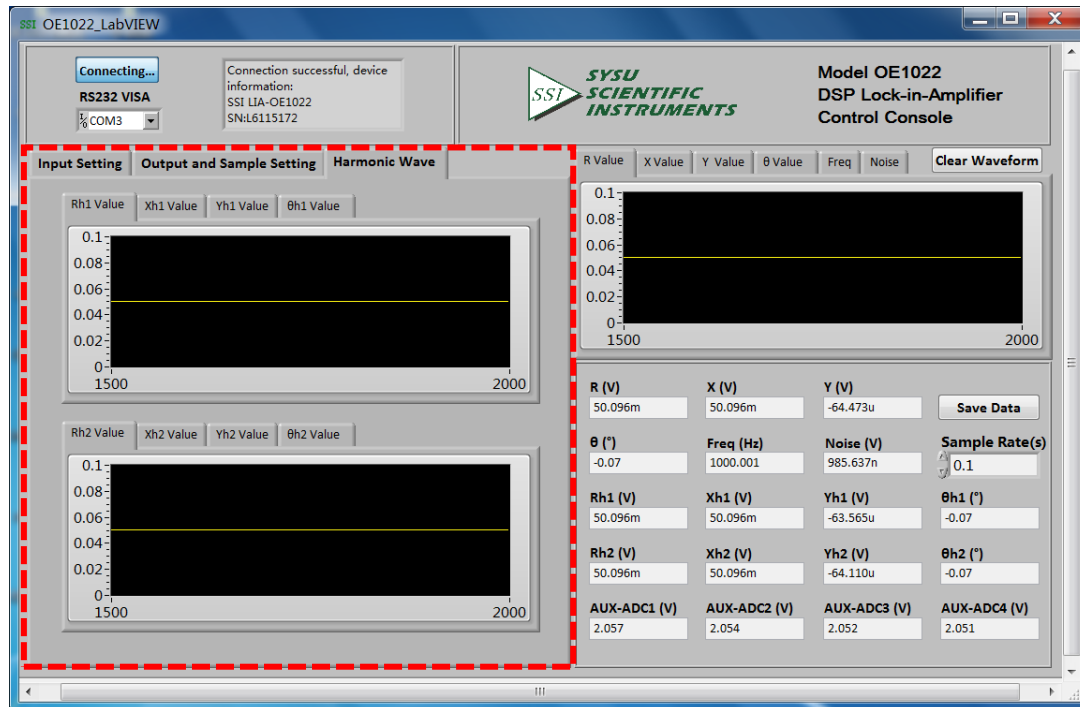


Fig.73 The Harmonic Waveform Display Diagram

6.3 Use Cases

This example will show how to use OE1022 PC software to configure parameters, observe and record the value of R/X/Y/ θ .

First, connect the OE1022 and PC according to the software use guide in 6.2 and then you can start to configure.

Suppose that lock-in amplifier configurations are shown in Table 14.

Input Signal Type	Single input voltage
Input Signal Size	40mV
Input Coupling Way	AC
Start Notch Filter	Close
Dynamic Reserve	Low Noise
Sensitivity	Auto Sensitivity
Input Reference Signal	External reference, 1000Hz
Reference Signal trigger way	TTL rising edge trigger
Phase Shift Angle	0
Time Constant of Low Pass Filter	300ms
Roll Off	12 dB/oct
Sampling Rate	125Hz
Buffer 1	X
Buffer 2	Y

The operation steps to finish this configuration are as below:

1. Choose these options in input signal configurations, including input signal type, input coupling way and start notch filter or not with other options in default, as is shown in Fig.74.

In the end, click the button **Input Configuration** to finish this configuration.

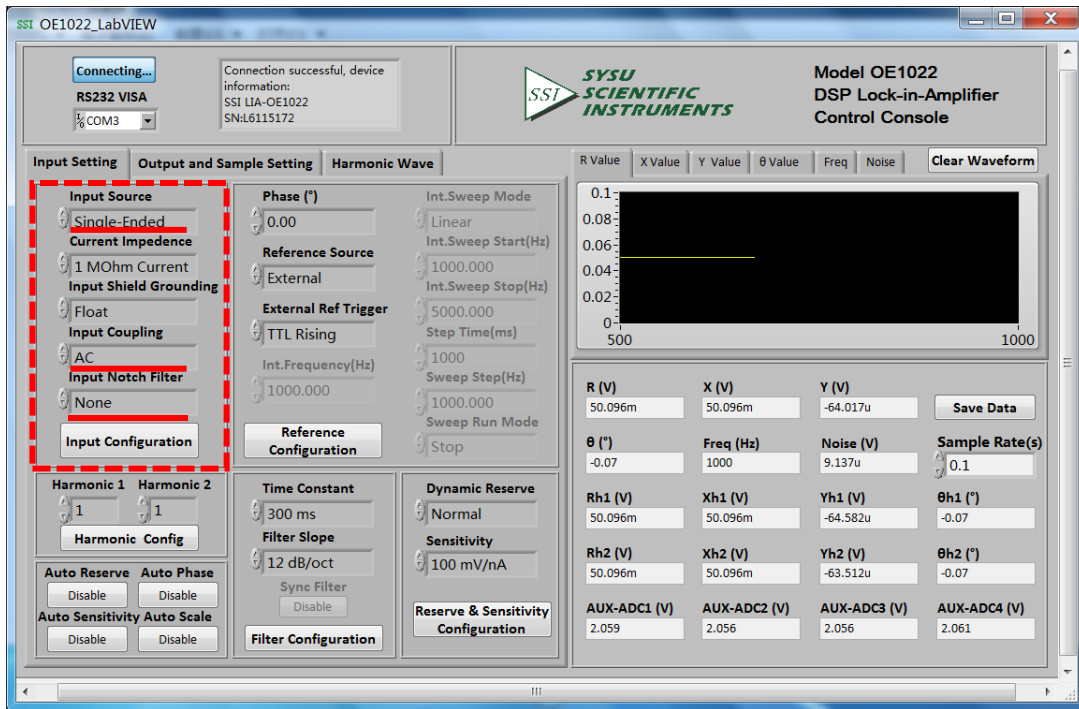


Fig.74 Input Signal Configuration Diagram

2. Choose these options in reference signal configurations, including reference signal source type, external reference and reference phase with other options in default, as is

shown in Fig.75. In the end, click the button **Reference Configuration** to finish this configuration.

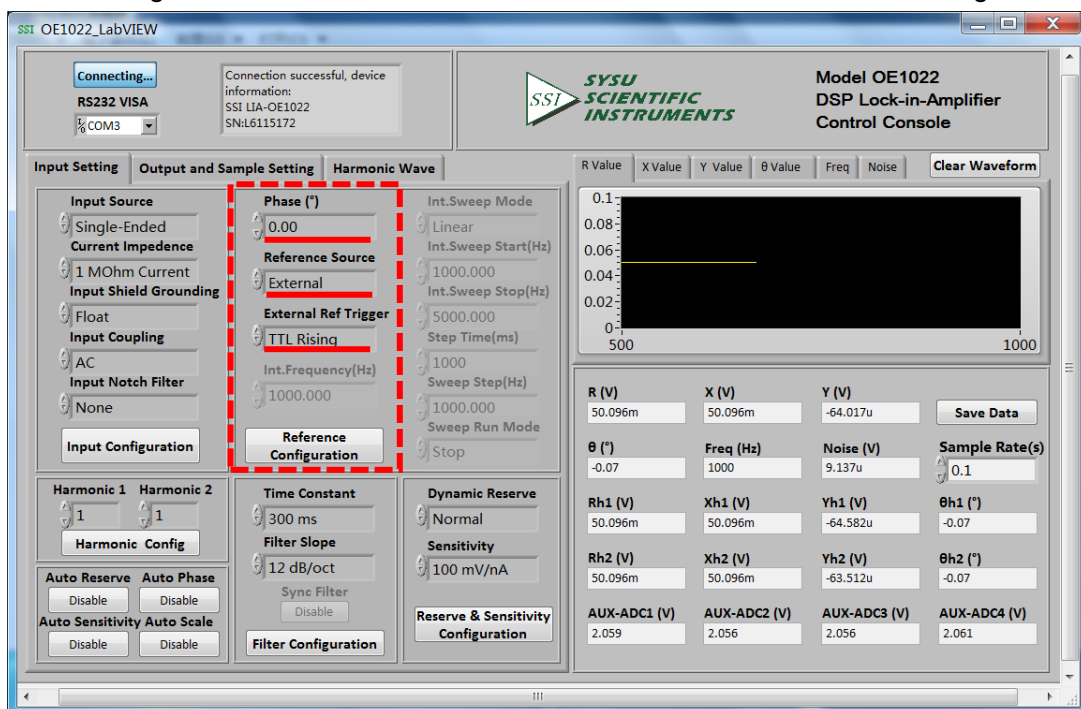


Fig.75 Reference Signal Configuration Diagram

If you don't use "Auto Phase" and "Auto Scale" to set the phase shift and scale display automatically, do not click the corresponding button **Disable** and just keep it.

If you use “Auto Phase” to set phase shift angle automatically, you need to click the corresponding button **Disable**. When this button is clicked and display [being progressing], the OE1022 is executing the auto phase function. After finishing this function, this button will reset to the original status **Disable**. Now the option “Phase” will update to the phase shift angle value returned from OE1022.

3. Choose these two options in filter configuration area, including time constant and slope of the filter with other options in default, as is shown in Fig.76. In the end, click the button

Filter Configuration to finish this configuration.

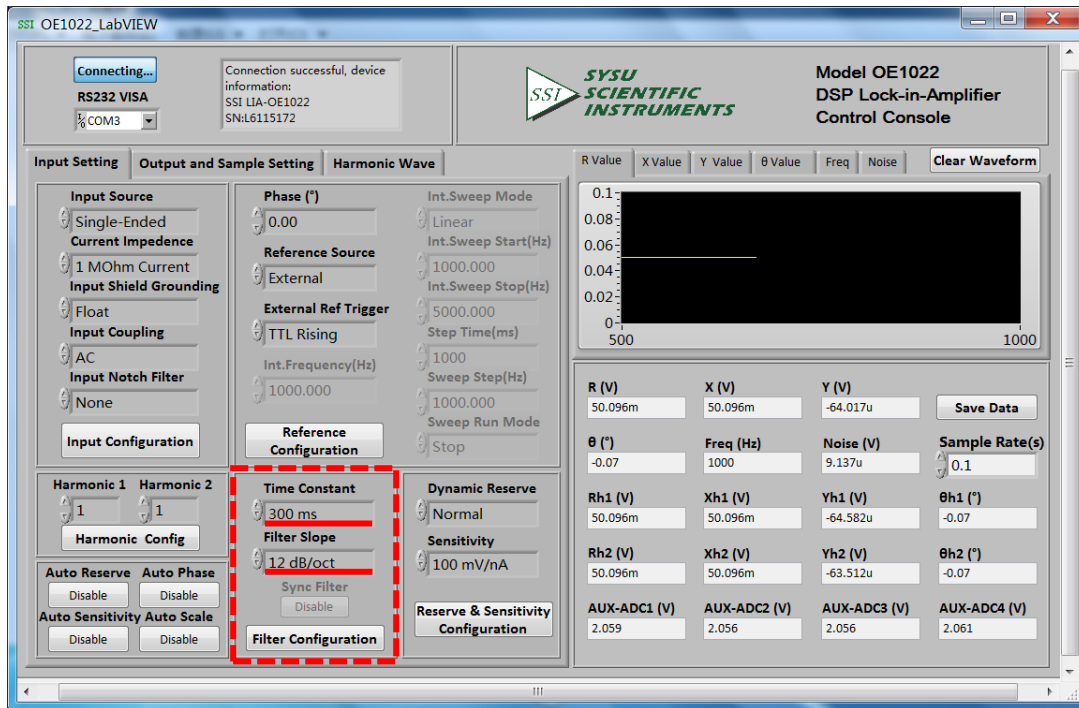


Fig.76 Filter Configuration Diagram

If you don't use sync filter, do not click the corresponding button [close] and just keep it. If you use sync filter, click the corresponding button **Disable**. When this button is clicked and display open, the OE1022 has started the sync filter function. Click this button again and it will reset to the original status “**Disable**”. This means the OE1022 has closed this function.

4. Choose these two options in dynamic reserve and sensitivity configuration area, including dynamic reserve type and sensitivity type with other options in default, as is

shown in Fig.77. In the end, click the button **Reserve & Sensitivity Configuration** to finish this configuration.

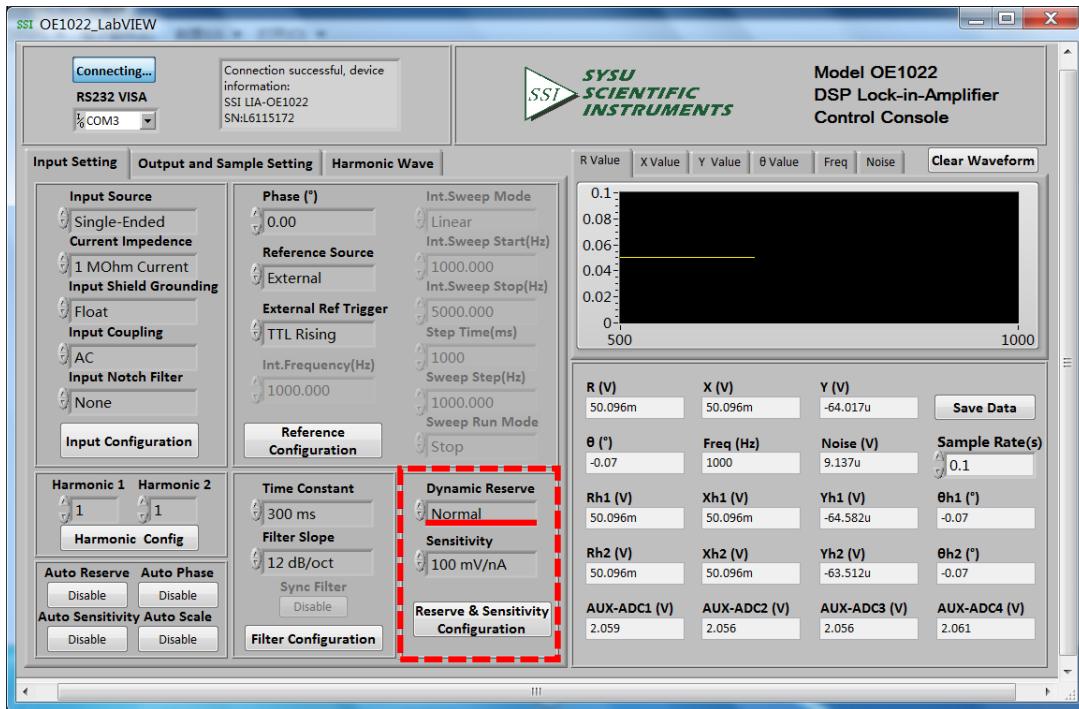


Fig.77 Dynamic Reserve and Sensitivity Configuration Diagram

Use “Auto Sensitivity” to set sensitivity. Click the button **Disable** in Auto Sensitivity option. And then this button switches to be progressing. This means the OE1022 is executing auto sensitivity function. And after finishing this function, this button will reset to the original status **Disable**. Now the “Dynamic Reserve” and “Sensitivity” options will update to the values returned from OE1022. At this time, the “Sensitivity” option change to a suitable one contrasting with Fig.77, as is shown in Fig.78.

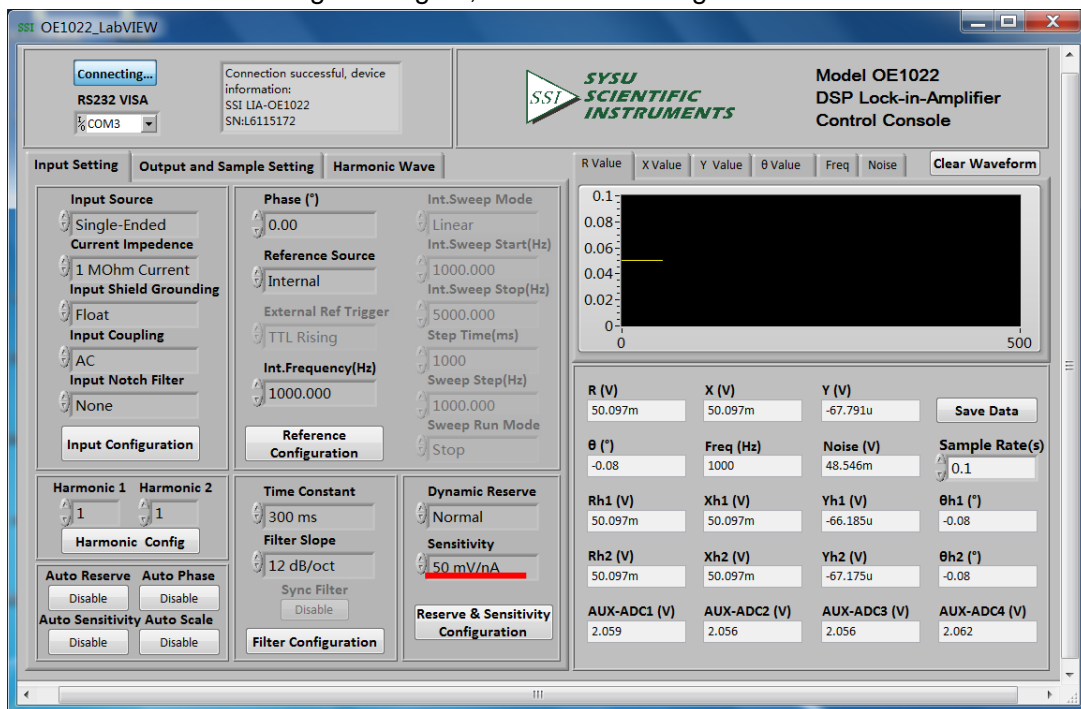


Fig.78 Auto Sensitivity Configuration Diagram

Compare the two OE1022 interfaces before and after configuration as is shown in Fig.79 and Fig.80, and you will see this configuration is successful.

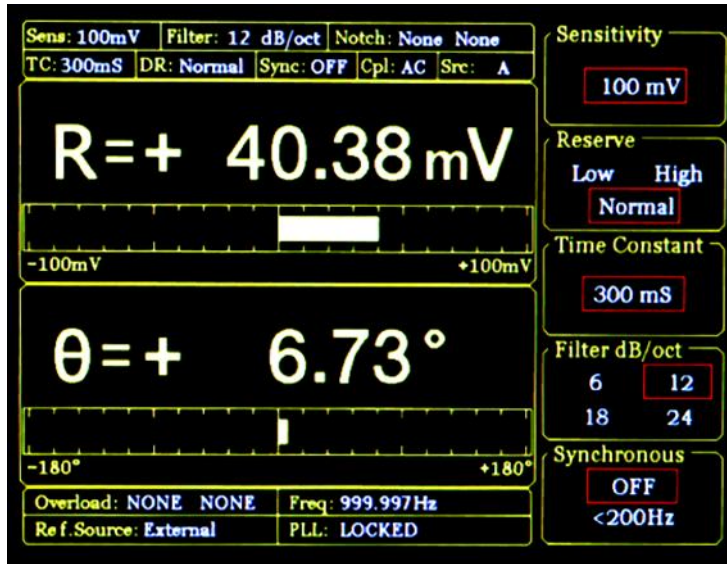


Fig.79 Set <SENS> in front interface to 100 mV.

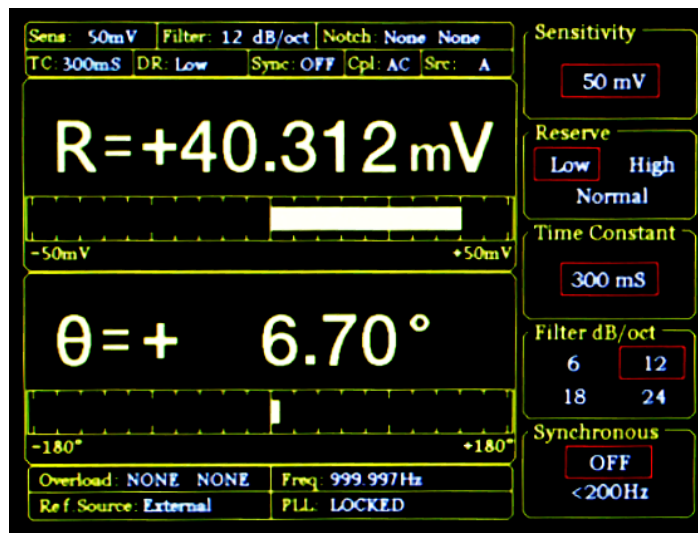


Fig.80 Set <SENS> in rear interface to 50 mV.

5. The configuration for OE1022 is finished. Other options are in default. Next collect and save data.

Data is saved by Excel in chosen directory. The file name is “Data_recorded_excel.xls” and it has 18 columns data.

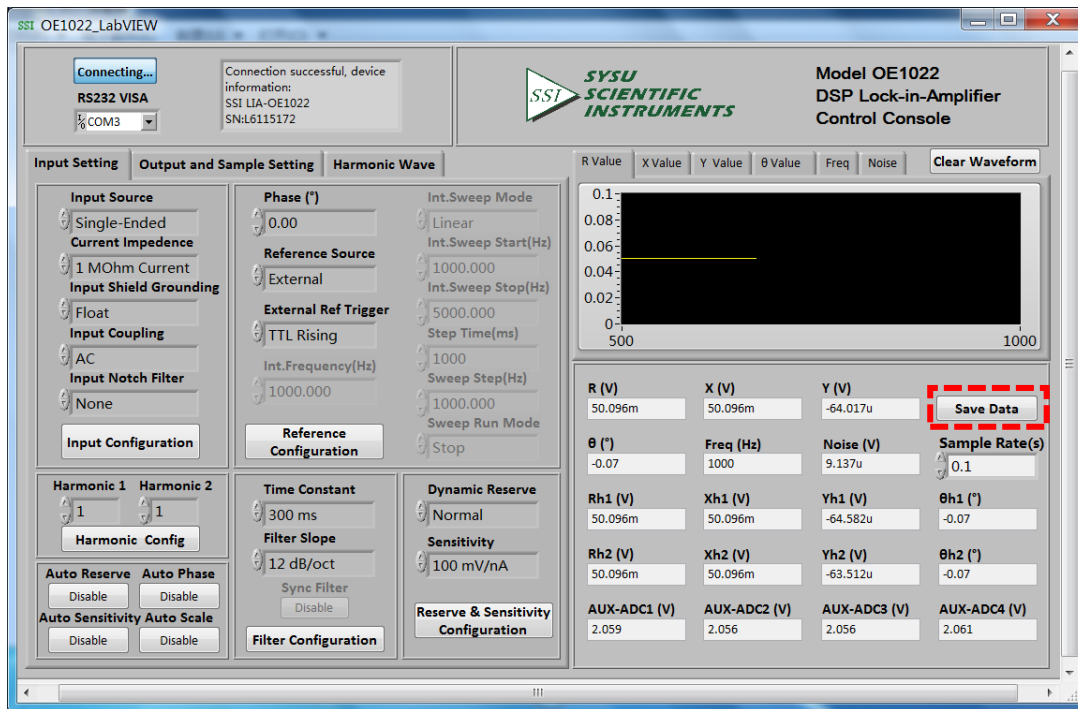


Fig.81 The Data Saving is paused

As is shown in Fig.81, click the button in red box. When this button is clicked and Display “ ”. This means the OE1022 is saving the current collected data, as is shown in Fig.82.

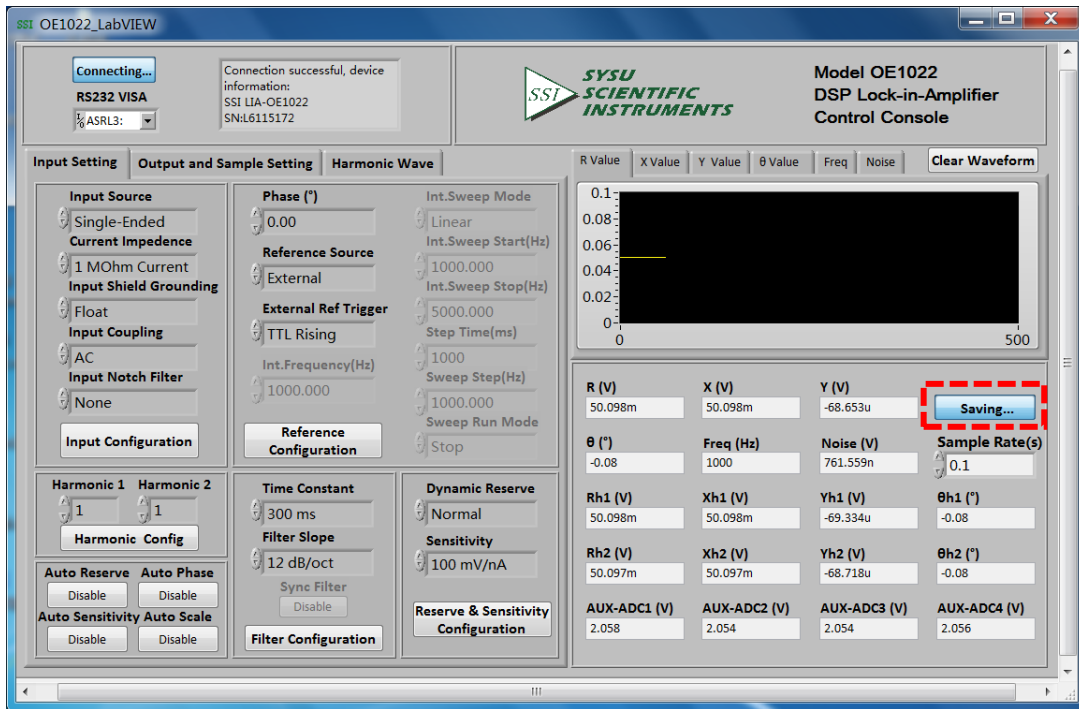


Fig.82 The Data Saving is executing

- There is another way to save data. Set different data sampling rate and save data in 4 buffers. One buffer can collect one kind data. Data is saved by Excel in current directory. The file name is Buffer_Data.xls, as is shown in Fig.83.

Name	Date modified	Type
Data_recorded_excel.xls	8/16/2017 10:51 AM	Microsoft Excel 97...
OE1022_Console_EN.aliases	8/16/2017 10:57 AM	ALIASES File
SSI OE1022_Console_EN.exe	8/16/2017 10:57 AM	Application
OE1022_Console_EN.ini	8/16/2017 10:57 AM	Configuration sett...
Buffer_Data.xls	8/16/2017 10:53 AM	Microsoft Excel 97...

Fig.83 The Data Saving Excel

The specific steps are below. (Suppose that the data sampling step time is 50ms, sampling length is 1000. The buffers 1~4 collect the value of R, X, Y, θ)

- Choose these options in data buffer configuration area, including data sampling type, sampling step time and sampling length with other options in default. Then click the button **Sample Configuration** and then click the button **Start Sampling**. When there is a progress bar at the bottom of this button, the OE1022 starts to collect data, as is shown in Fig.84.

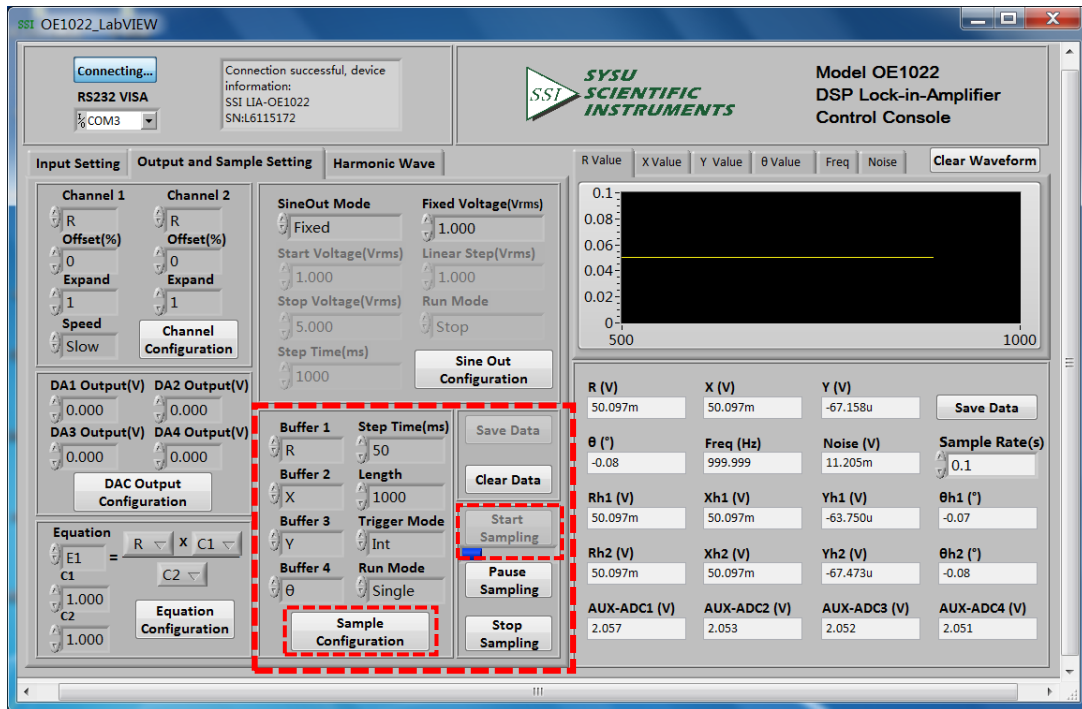


Fig.84 Data Collection

- When the progress bar runs to 100%, the collection for data is finished. Now if you want to save data, just click the button **Save Data** in red box in Fig.85.

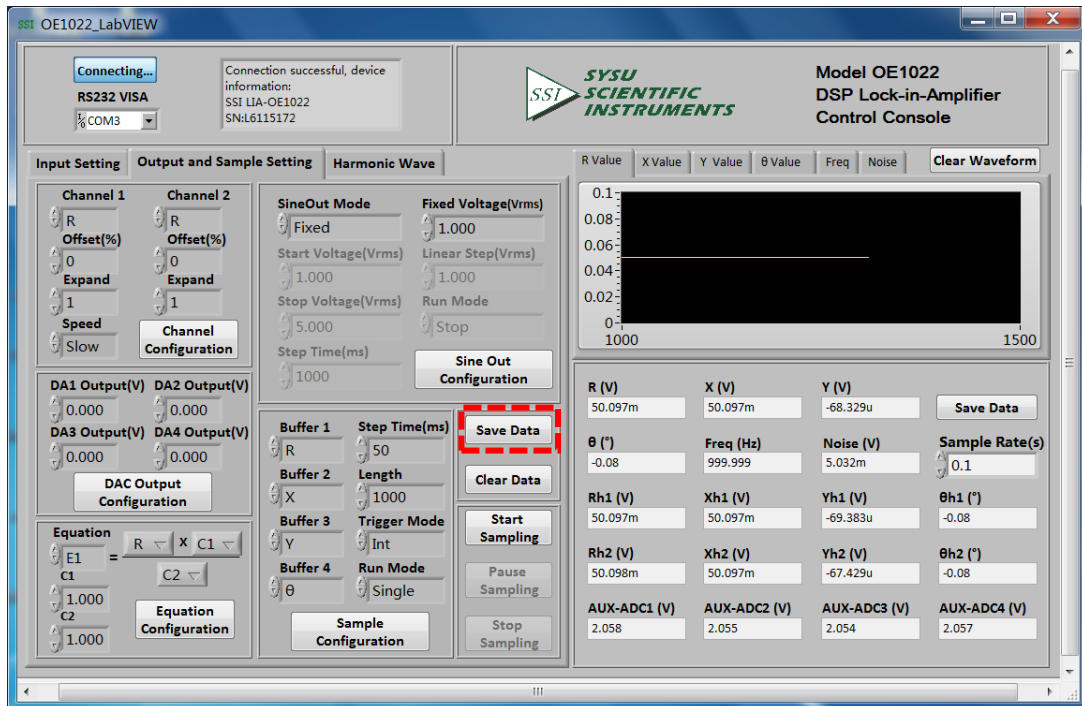


Fig.85 Save the Collected Data

As is shown in Fig.86, after clicking the button **Save Data**, there will be a progress bar at the bottom of this button. When the progress bar runs to 100%, the OE1022 has saved the collected data in buffers. Now four excel files will be generated in current directory.

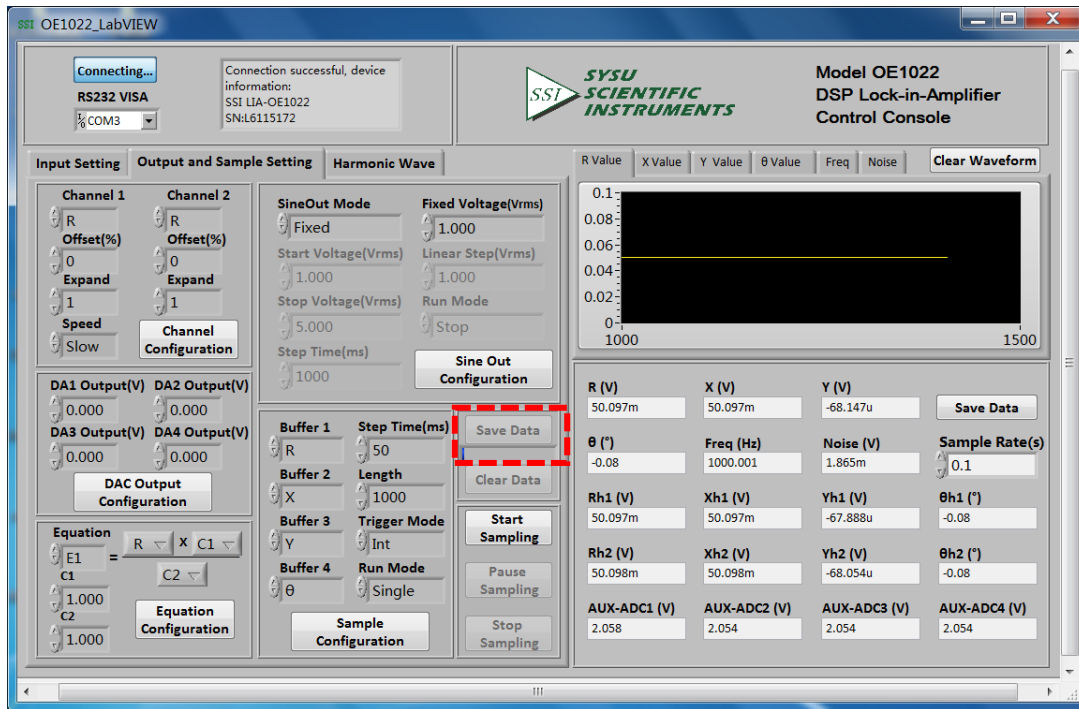


Fig.86 The Collected Data is saving

7. PERFORMANCE TESTING

Introduction	<p>The performance tests are designed to verify that OE1022 can operate normally and enhance users' confidence to our instrument.</p> <p>Every test can be recorded on the Performance Test Record form at the final section of this chapter.</p>												
Serial Number	<p>If you have some questions and need to contact us, please save the serial number of your unit available. The serial number is printed on the CD box, the package box and the back side of your unit. You can also check the serial number at <Info> on the display when the experiment is powered on.</p>												
Firmware Revision	<p>The firmware revision code is shown at <Info> on the display when the unit is powered on.</p>												
Warm Up	<p>The chips have temperature excursion internal instrument. Before each test, it is necessary to start the lock-in and warm up for 30 to 60 minutes in order to reduce errors.</p>												
Test Record	<p>At the end of this section, there is a performance test record. It is necessary to make a copy of it before filling in the record. This record will allow you to determine whether the tests pass or fail and also preserve a record of the tests.</p>												
If a Test Fails	<p>If a test fails, you should check the settings and connections of any external equipment and internal equipment. If possible, verify its operation with a DVM, scope or other pieces of test equipment. After checking the settings, repeat this test from warm up to make sure that the test was performed correctly.</p> <p>If the test continues to fail, contact us for further instructions. Make sure that you have the unit's serial number and firmware revision code handy. Have the test record on hand as well.</p>												
Necessary Equipment	<p>The following equipment is necessary to complete the performance tests. The suggested equipment or its equivalent should be used.</p> <p>1. Function Signal Generator</p> <table> <tr> <td>Freq Range</td> <td>1 Hz to 1 MHz</td> </tr> <tr> <td>Freq Accuracy</td> <td>Better than 5 ppm</td> </tr> <tr> <td>Amplitude Accuracy</td> <td>0.2 dB from 1 Hz to 120 kHz</td> </tr> <tr> <td>Spurious</td> <td>≤ -55 dBc</td> </tr> <tr> <td>TTL SYNC</td> <td>Available</td> </tr> <tr> <td>Output Setup</td> <td>50 Ω or High Z</td> </tr> </table>	Freq Range	1 Hz to 1 MHz	Freq Accuracy	Better than 5 ppm	Amplitude Accuracy	0.2 dB from 1 Hz to 120 kHz	Spurious	≤ -55 dBc	TTL SYNC	Available	Output Setup	50 Ω or High Z
Freq Range	1 Hz to 1 MHz												
Freq Accuracy	Better than 5 ppm												
Amplitude Accuracy	0.2 dB from 1 Hz to 120 kHz												
Spurious	≤ -55 dBc												
TTL SYNC	Available												
Output Setup	50 Ω or High Z												

Recommended	AGILENT 33250A
2. Digital Voltmeter	
Voltage Range	≥ 20 V, 4 1/2 digits
Accuracy	≤ 0.005 %
Recommended	KEITHLEY 2100
3. DC Voltage Source	
Voltage Range	≥ 10 V
Accuracy	< 10 mVpp
Recommended	RIGOL DP831A
4. Feedthrough Terminations	
Impedance	50 Ω

Front Panel Display Test	First, turn on the power switch on the rear panel to start the device. Second, check whether the display is lighted or not. Third, check whether there are bad pixels on the display. End the display test.
Keypad Test	After the device is started, press any button and you will hear "Di" sound once. Then, try to press every button to check whether the display change to the corresponding setting. Finally, press <Sensitivity> and spin the knob to check whether the knob is OK.

7.1 Start Test

The start tests check the lock-in hardware. These tests should be checked before any of the performance tests.

Device

No external device is required for this test.

Steps

1. Open the power switch on the rear panel to start the lock-in amplifier.
2. Observe the device, and check whether the screen, keyboard and cooling fan is OK.
3. Record the test results on the form of the Performance Test Record.

7.2 DC Offset

This test measures the DC offset of the input.

Device

Connect a 50Ω BNC cable to the A/I input. This shorts the input so the lock-in's own DC offset will be measured.

Steps

1. Turn the power switch off and on to restart the lock-in.
2. Press the buttons in the following sequence:
 - <Ref. Source> Set to <Internal>
 - <Ref. Frequency> Set to 1Hz
 - <Sensitivity> Set to <1mV> by the spinning knob
3. Wait 10 seconds, then record the value of R.
4. Change the setting:
 - <Coupling> Set to <DC>
5. Wait 10 seconds, then record the value of R.
6. End the test and fill the result into the performance test form.

7.3 Common Mode Rejection

This test measures the common mode rejection of the lock-in.

Device

Use the internal oscillator sine output to provide the signal.

Connect the [SINE OUT] to both A and B inputs.

Use equal length cables from A and B to a BNC TEE.

Connect the cable from the [SINE OUT] to the TEE. Do not use any termination.

Steps

1. Turn off the power switch and on to restart the lock-in.
2. Press the buttons in the following sequence:
 - <Sensitivity> Set to <1 V> by the spinning knob
 - <Ref. Source> Set to <Internal>
 - <Ref. Frequency> Set to 100 Hz
3. Wait until <R> is steady and <R> should be 0.3536 V (3% error)
4. Press the buttons in the following sequence:
 - <Coupling> Set to <DC>
 - <Source> Set to <A-B>
 - <Sensitivity> Set to <200 μ V> by the spinning knob
5. Wait 10 seconds, and then record the value of R.
6. End the test. The common mode rejection CMRR equals to $20\lg(1/R)$, where the unit of R is volt(V). Fill in the performance test form.

7.4 Amplitude Accuracy and Flatness

This test measures the amplitude accuracy and frequency response.

Device

Use the function signal generator to provide an accurate frequency and sine wave. Use one cable with BNC connector to connect the output of the function signal generator to the A input of the lock-in. Use another cable with BNC connector to connect the reference output of the function signal generator to the REF IN of the lock-in.

Set the function signal generator to:

Function	Sine
Frequency	1 kHz
Amplitude	1 Vrms
Offset	0 V
Output	High Z
Sweep	off
Modulation	none

Steps

1. Turn the power switch off and on to restart the lock-in.
2. Set <Filter> to 24 dB/oct.
3. Amplitude accuracy is verified at 1kHz and various sensitivities. Set the sensitivity of the lock-in and the amplitude of the function signal generator in the following sequence:

Sensitivity	Amplitude
1 V	1.0000 Vrms
200 mV	200.00 mVrms
100 mV	100.00 mVrms
20 mV	20.000 mVrms
10 mV	10.000 mVrms

- a) Set the output amplitude of the function signal generator.
- b) Set <Sensitivity> of the lock-in.
- c) Wait 10 seconds, then record <R>, then test the next group of the sensitivity-amplitude.
- d) Repeat the steps from 3)-a) to 3)-c) until the Sensitivity-Amplitude test is completed.

4. Frequency response is checked at frequencies above 1kHz. Set the frequency in the following sequence:

Test Frequency

24 kHz

48 kHz

72 kHz

96 kHz

120 kHz

- a) Set <Sensitivity> of the lock-in to <200 mV>.
 - b) Set the frequency of the function signal generator to 1 kHz and the amplitude to 200.00mVrms.
 - c) Set the frequency of the function signal generator in the upper sequence.
 - d) Wait 10 seconds, then record <R>, then test the next frequency.
 - e) Repeat from 4)-c) to 4)-d) until all the frequency is tested over.
5. End the test and fill in the performance test form.

7.5 Amplitude Linearity

This test measures the amplitude linearity. It tests the lock-in how to detect accurately when the signal is smaller than the full scale.

Device

Use a function signal generator to provide accurate frequency and sine wave.

Use a cable with BNC connector to connect the output of the function signal generator to the A/I input of the lock-in. Use another cable with BNC connector to connect the reference output of the function signal generator to the REF IN of the lock-in.

Set the function signal generator to:

Function	Sine
Frequency	1 kHz
Amplitude	1 Vrms
Offset	0 V
Output	High Z
Sweep	off
Modulation	none

Steps

1. Turn the power switch off and on to restart the lock-in.
2. Set <Filter> to <24 dB/oct> and <Sensitivity> to <1 V>.
3. The Amplitude of the function signal generator should be 1kHz at various amplitudes. Set the amplitude in the following sequence:

Amplitude
1.0000 Vrms
100.00 mVrms
10.000 mVrms

- a) Set the output amplitude of the function signal generator.
 - b) Wait 10 seconds, then record <R>, then test next amplitude.
 - c) Repeat from 3)-a) to 3)-b) until all amplitudes are tested over.
4. End the test and fill in the performance test form.

7.6 Frequency Accuracy

This test measures the frequency accuracy of the lock-in.

Device

Use the function signal generator to provide the reference signal.

Use one cable with BNC connector to connect the reference signal of the function signal generator to the REF IN of the lock-in.

Steps

1. Turn the power switch off and on to restart the lock-in.
2. Set the frequency of the function signal generator to 10 kHz.
3. Wait until <PLL: UNLOCK> changes to <PLL: LOCKED>, then record <Freq>.
4. End the test and fill in the performance test form.

7.7 Sine Output Amplitude Accuracy and Flatness

This test measures the amplitude accuracy and frequency response of the internal oscillator SINE OUT.

Device

Use a 1-meter length cable with BNC connector to connect the SINE OUT and the A/I of the lock-in.

Steps

1. Turn the power switch off and on to restart the lock-in.
2. Set <Sensitivity> to <1 V> and <Ref. Source> to <Internal>.
3. The frequency of the internal oscillator should be 1kHz steadily. Set <Sensitivity> and the amplitude of the SINE OUT in the following sequence:

Sensitivity	Sine Output
1 V	0.800 Vrms
500 mV	0.400 Vrms
200 mV	0.160 Vrms

- a) Set the amplitude of <SINE OUT>.
- b) Set <Sensitivity>.
- c) Wait 10 seconds, then record <R>, then test next group of Sensitivity-Sine Output.
4. Repeat from 3)-a) to 3)-c) until all the Sensitivity-Sine Output are tested over. The frequency should be above 1 kHz when test the frequency response. Set <Ref. Frequency> in the following sequence:

Test Frequencies
24 kHz
48 kHz
72 kHz
96 kHz
120 kHz

- a) Set <Sensitivity> to <1 V>.
- b) Set the amplitude of the SINE OUT to <0.800 Vrms>.
- c) Set <Ref. Frequency> in the upper sequence.
- d) Wait 10 seconds, then record <R>, then test next frequency.
- e) Repeat from 4)-c) to 4)-d) until all the frequency is tested over.
5. End the test and fill in the performance test form.

7.8 DC Output

This test measures the DC accuracy of the DC outputs of the lock-in.

Device

Use a linear AC regulator to generate AD input.

Use a DVM to measure the DC output of the lock-in.

Use a 50 Ω BNC resistor to short the A/I input of the lock-in.

Steps

1. Turn off and on the power switch on the rear panel to restart the lock-in.
2. Set <Ref.Source> to <Internal>.
3. According to the steps below:
 - a) Use a cable to connect CH1 or CH2 to the DVM and set full scale of the DVM to 19.999 V.
 - b) Set <Offset> of <Channel Output> in the following sequence:

Offset (%)

100.00

50.00

0.00

-50.00

-100.00

- c) Waiting for 10 seconds and record the reading of the DVM. Then, test next group data.
 - d) Repeat steps 3-b) to 4-c) until finishing the tests for CH1. Then, connect the DVM to CH2 and continue to finish the tests for CH2.
4. According to the steps as below:
 - a) use signal cable to connect the DVM to the Lock-in AUX_OUT 1 on rear panel.
 - b) set <DA Output> of <AUX Output> in the following sequence

DA Output (V)

10.000

5.000

0.000

-5.000

-10.000

- c) waiting for 10 minutes and record the reading of the DVM. Then, test next group data.
 - d) Repeat steps 3b to 3c until finishing the tests for DA1. Then connect the DVM to DA2, DA3, DA4 to finish the tests for DA2, DA3, DA4.
5. According to the steps as below:
 - a) Set <Monitor> in <Display> to <Input>.
 - b) use signal cable to connect the AC regulator OUT to AUX_IN 1.
 - c) use signal cable to connect the AC regulator OUT to AUX_IN 1.

Voltage (V)

10.000

5.000

0.000

-5.000

-10.000

- d) Waiting for 10 minutes and recode the reading of <A1> at top of the screen. Then, test next group data.
- e) Repeat steps 4c to 4d until finishing the tests for A1. Then connect the AC Regulator OUT to A2, A3, A4 and finish the tests for A2, A3, A4.
6. End the tests for AD inputs and outputs and fill the data into the performance test record form.

7.9 Input Noise

This test measures the input noise of the lock-in.

Device

Connect a 50 Ω BNC termination to the A/I input of the lock-in. This grounds the input so the lock-in's own noise is measured.

Steps

1. Turn off and on the power switch on the rear panel to restart the lock-in.
2. Set the parameters in the following sequence:

<Ref. Source>	Set to <Internal>
<Ref. Frequency>	Set to 997 Hz
<Sensitivity>	Set to <100 nV> by the spinning knob
<Reserve>	Set to <Low>
<Filter>	Set to <24 dB/oct>
<Trace>	Set <Trace> in <Display> to <Noise>.

3. Wait until the reading is steady, then record the maximum value of <R>.
4. End the test and fill in the performance test form.

7.10 OE1022 Performance Test Record

OE1022 Performance Test Record				
Serial Number _____		Test By _____		
Firmware Revision _____		Date _____		
Equipment Used _____ _____				
1. Start Tests				
Pass _____		Fail _____		
2. DC Offset				
Input Coupling		Reading		Upper Limit
AC		_____		0.500mV
DC		_____		0.500mV
3. Common Mode Rejection				
Frequency		Reading		Upper Limit
100Hz		_____		30µV
4. Amplitude Accuracy and Flatness				
Sensitivity	Amplitude	Lower Limit	Reading	Upper Limit
1V	1.0000Vrms	0.9800V	_____	1.0200V
200mV	200.00Vrms	198.99mV	_____	202.00mV
100mV	100.00Vrms	98.00mV	_____	102.00mV
20mV	20.000Vrms	19.60mV	_____	20.400mV
10mV	10.000Vrms	9.800mV	_____	10.200mV
Sensitivity	Amplitude	Lower Limit	Reading	Upper Limit
200mV	24kHz	196mV	_____	204mV
200mV	48kHz	196mV	_____	204mV
200mV	72kHz	196mV	_____	204mV
200mV	96kHz	196mV	_____	204mV
5. Amplitude Linearity				
Sensitivity	Amplitude	Lower Limit	Reading	Upper Limit
1V	1.0000Vrms	0.9900V	_____	1.0100V
	100.00Vrms	0.0990V	_____	0.1010V
	10.000Vrms	0.0099V	_____	0.0101V

OE1022 Performance Test Record

6. Frequency Accuracy

Frequency	Lower Limit	Reading	Upper Limit
10kHz	9.990kHz	_____	10.010kHz

7. SINE OUT Amplitude and Flatness

Sensitivity	SINE OUT Ampl.	Lower Limit	Reading	Upper Limit
1 V	2.000 Vpp (0.7071 Vrms)	0.6859 V	_____	0.7283 V
200 mV	0.400 Vpp (141.42 mVrms)	137.18 mV	_____	145.66 mV
50 mV	0.100 Vpp (35.355 mVrms)	34.294 mV	_____	36.416 mV
10 mV	0.020 Vpp (7.071 mVrms)	6.859 mV	_____	7.283 mV

SINE OUT Ampl.	Frequency	Lower Limit	Reading	Upper Limit
2.000 Vpp (0.7071 Vrms)	24 kHz	0.6859V	_____	0.7283V
	48 kHz	0.6859V	_____	0.7283V
	72 kHz	0.6859V	_____	0.7283V
	96 kHz	0.6859V	_____	0.7283V

8. DC Outputs

Output	Offset	Lower Limit	Reading	Upper Limit
CH1	100.00	9.960V	_____	10.040V
	50.00	4.960V	_____	5.040V
	0.00	-0.020V	_____	0.020V
	-50.00	-5.040V	_____	-4.960V
	-100.00	-10.040V	_____	-9.960V

Output	Offset	Lower Limit	Reading	Upper Limit
CH2	100.00	9.960V	_____	10.040V
	50.00	4.960V	_____	5.040V
	0.00	-0.020V	_____	0.020V
	-50.00	-5.040V	_____	-4.960V
	-100.00	-10.040V	_____	-9.960V

Output	Voltage	Lower Limit	Reading	Upper Limit
AUX OUT 1	10.000	9.700 V	_____	10.300 V
	5.000	4.900 V	_____	5.100 V
	0.000	-0.020 V	_____	0.020 V
	-5.000	-5.100 V	_____	-4.900 V
	-10.000	-10.300 V	_____	-9.700 V

OE1022 Performance Test Record				
Output	Voltage	Lower Limit	Reading	Upper Limit
AUX OUT 2	10.000	9.700 V	_____	10.300 V
	5.000	4.900 V	_____	5.100 V
	0.000	-0.020 V	_____	0.020 V
	-5.000	-5.100 V	_____	-4.900 V
	-10.000	-10.300 V	_____	-9.700 V
Output	Voltage	Lower Limit	Reading	Upper Limit
AUX OUT 3	10.000	9.700 V	_____	10.300 V
	5.000	4.900 V	_____	5.100 V
	0.000	-0.020 V	_____	0.020 V
	-5.000	-5.100 V	_____	-4.900 V
	-10.000	-10.300 V	_____	-9.700 V
Output	Voltage	Lower Limit	Reading	Upper Limit
AUX OUT 4	10.000	9.700 V	_____	10.300 V
	5.000	4.900 V	_____	5.100 V
	0.000	-0.020 V	_____	0.020 V
	-5.000	-5.100 V	_____	-4.900 V
	-10.000	-10.300 V	_____	-9.700 V
Input	Voltage	Lower Limit	Reading	Upper Limit
AUX IN 1	10.000	9.960 V	_____	10.040 V
	5.000	4.960 V	_____	5.040 V
	0.000	-0.020 V	_____	0.020 V
	-5.000	-5.040 V	_____	-4.960 V
	-10.000	-10.040 V	_____	-9.960 V
Input	Voltage	Lower Limit	Reading	Upper Limit
AUX IN 2	10.000	9.960 V	_____	10.040 V
	5.000	4.960 V	_____	5.040 V
	0.000	-0.020 V	_____	0.020 V
	-5.000	-5.040 V	_____	-4.960 V
	-10.000	-10.040 V	_____	-9.960 V
Input	Voltage	Lower Limit	Reading	Upper Limit
AUX IN 2	10.000	9.960 V	_____	10.040 V
	5.000	4.960 V	_____	5.040 V
	0.000	-0.020 V	_____	0.020 V
	-5.000	-5.040 V	_____	-4.960 V
	-10.000	-10.040 V	_____	-9.960 V

OE1022 Performance Test Record				
Input	Voltage	Lower Limit	Reading	Upper Limit
AUX IN 3	10.000	9.960 V	_____	10.040 V
	5.000	4.960 V	_____	5.040 V
	0.000	-0.020 V	_____	0.020 V
	-5.000	-5.040 V	_____	-4.960 V
	-10.000	-10.040 V	_____	-9.960 V
Input	Voltage	Lower Limit	Reading	Upper Limit
AUX IN 4	10.000	9.960 V	_____	10.040 V
	5.000	4.960 V	_____	5.040 V
	0.000	-0.020 V	_____	0.020 V
	-5.000	-5.040 V	_____	-4.960 V
	-10.000	-10.040 V	_____	-9.960 V
9. Input Noise				
Frequency	Sensitivity	Reading	Upper Limit	
1 kHz	100nV	_____	15 nV/ $\sqrt{\text{Hz}}$	

8. GETTING STARTED

8.1 Simple Signal Measurements

This example will show the OE1022 how to measure the value of R, X, Y, θ . You need two BNC cables to input measure signal and reference signal. We use the function signal generator to generate a 80mVrms, 1kHz sine signal and use the OE1022 to measure it. The steps are below:

Measure a Sine Signal

1. Disconnect all cables from the lock-in. Connect the power source and then turn on the power switch. The system is in default now.

2. Use a BNC cable to connect the output of the function signal generator and the A/I input of the OE1022. Use another BNC cable to connect the reference signal of the function signal generator and the REF IN of the OE1022, as is shown in Fig.87.

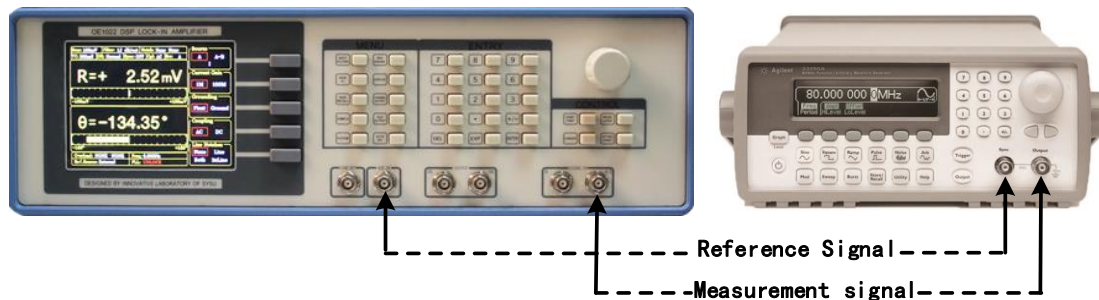


Fig.87 Signal Cable Connection Diagram.

3. Turn on the function signal generator and set “Function: Sine”, “Amplitude: 80mVrms”, “Frequency: 1kHz”, “Output Impedance: High Z”, as is shown in Fig.88.

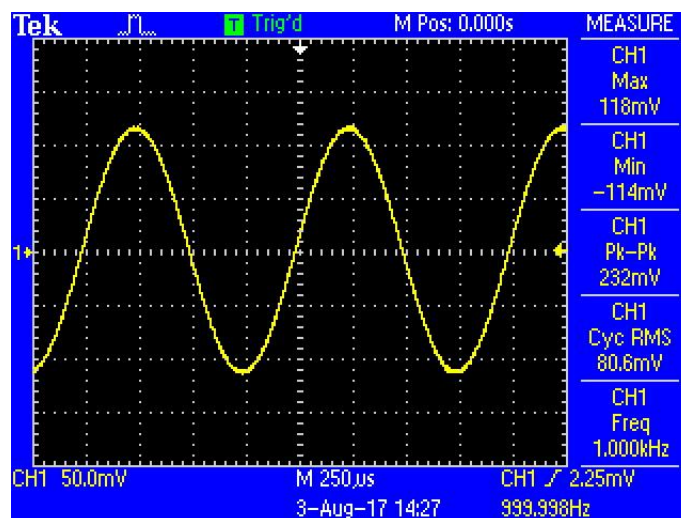


Fig.88 Measured Signal Parameters Diagram

4. Turn on the output of the function signal generator and check whether the scale is overloaded by <Overload>.

Note that if the input of the preamplifier is overload, show <Overload: INPUT NONE>. If the output is overload, show <Overload: NONE GAIN>. If the input and the output are overload at the same time, show <Overload: INPUT GAIN>.

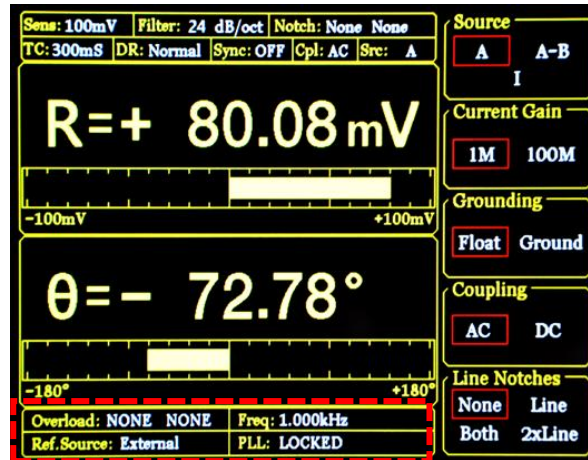


Fig.89 Main Interface Monitoring Bar

When the input of the preamplifier is overload, you should decrease the output amplitude of the function signal generator. If the output gain is overload, you should increase the sensitivity of the OE1022 (the input of the preamplifier will be overload when the peak value is large than 1.7V or the valley value is lower than -1.7V). The default sensitivity is <100mV>. So, this case will not be overload. If you need to adjust the sensitivity, the steps are as below.

5. Press [GAIN/TC] as below and then change <Sensitivity>.



Fig.90 [GAIN/TC] Menu

Press the knob to choose <Sens> and then <Sens> will be lighted. Spin the knob to change <Sens> so that there is no overload and the full scale is the maximum. In this case, you need to adjust these parameters like Fig.91. The result of measurement is: $R=80.08\text{ mV}$, $\theta=0.18^\circ$.

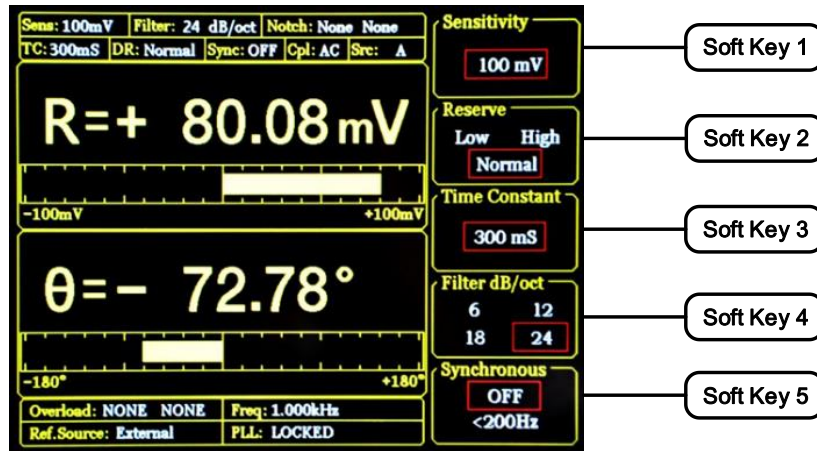


Fig.91 GAIN/TC Menu Interface

6. The main interface data bar displays the value of <R>, <X>, <Y> and < θ >. Press the [DISPLAY] to enter the submenu, as is shown in Fig 92.

It is a default that the top area of the data filed displays <R> and the bottom area of the data filed displays < θ >, as is shown in Fig.93.



Fig.92 [DISPLAY] MENU

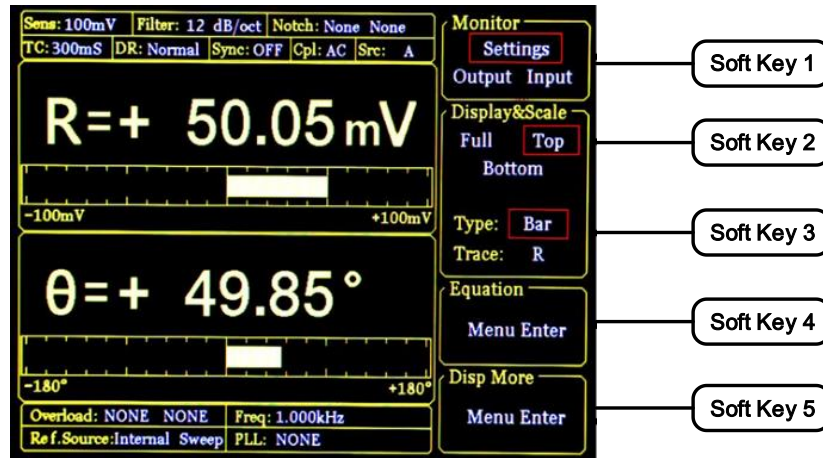
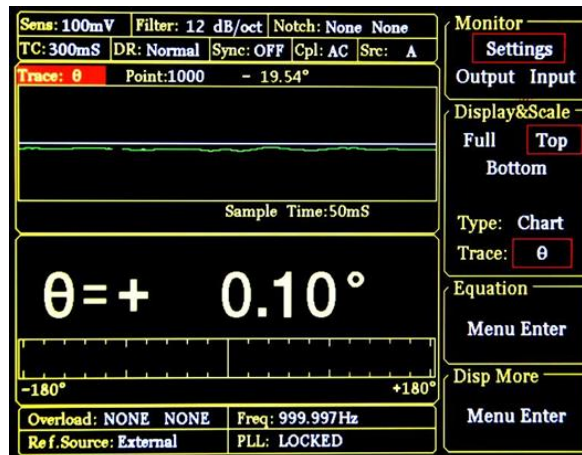


Fig.93 [DISPLAY] Menu Interface

You can change the display way according to steps below.

Change the display <R> in top area to display the < θ > with XY Coordinates Chart. First, press the [soft key 2] to choose <Top>; second, press [soft key 3] to choose <Type> and the <Type> area will be highlighted. Then, spin the knob to choose <Chart> (XY Coordinates) or <Bar> (percentage). And we choose <Chart>;

Third, press [soft key 3] to choose <Trace> and the <Trace> area will be highlighted. Spin the knob to choose the value of <R>, <X>, <Y> and < θ >. We choose < θ >. After these settings, the result is shown in Fig.94.

Fig.94 XY Chart Display < θ >

7. The main interface monitor field displays the value of <R>, <X>, <Y> and < θ >. You can change the contents of monitor field to display the value of <R>, <X>, <Y> and < θ > in a real time.

The steps are below:

press [DISPLAY] to enter the submenu. Then, press [soft key 1] to set the <Monitor> from <Setting> to <Output>. Now the monitor field will display the value of <R>, <X>, <Y> and < θ >, as is shown in Fig.95.

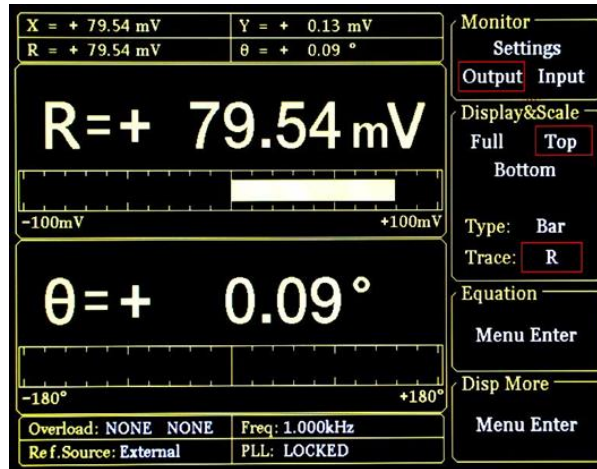


Fig.95 Monitoring Bar Display

8.2 Harmonics Measurements

This example will show how to measure harmonic component of the input signal. you need two BNC cables to measure the input measure signal and reference signal. Use the function signal generator to provide a 160mVpp, 1kHz square wave and then measure the first and third harmonic. The steps are below.

1. Disconnect all cables from the lock-in. Connect the power source and then turn on the power switch. The system is default.
2. Use a BNC cable to connect the output of the function signal generator and the A/I input of the OE1022. Use another BNC cable to connect the reference signal of the function signal generator and the REF IN of the OE1022, as is shown in Fig.96.

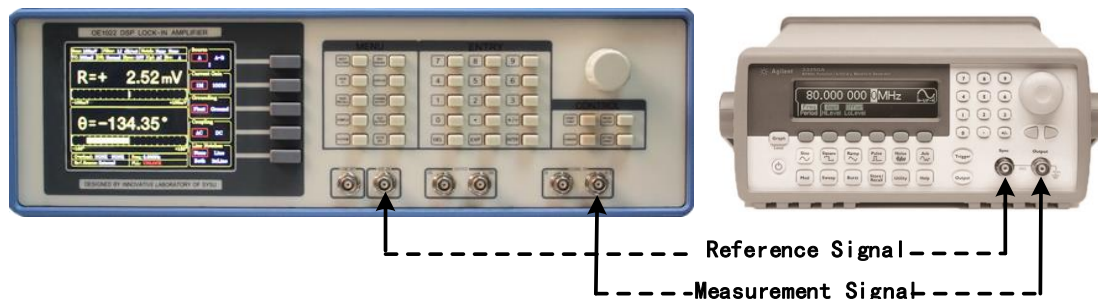


Fig.96 Signal Cable Connect Diagram

3. Turn on the function signal generator and set “Function: Square”, “Amplitude: 80mVrms”, “Frequency: 1 kHz”, as is shown in Fig.97.

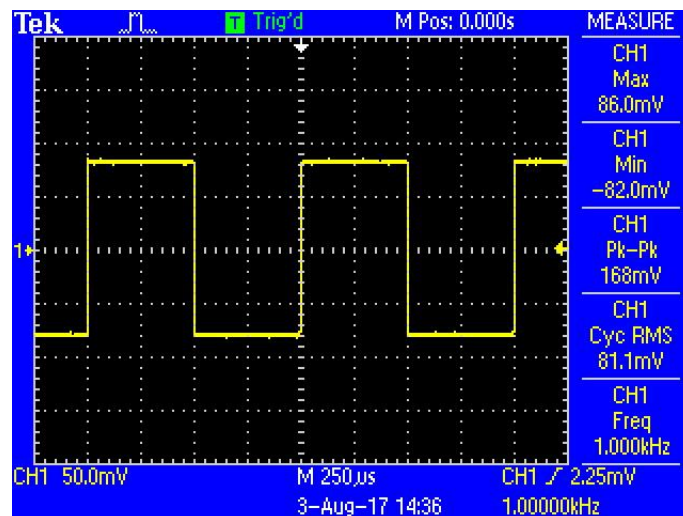


Fig.97 Measured Signal Parameter Diagram

4. Press [REF PHASE] and set <Harmonic> to the required order, as is shown in Fig.98.



Fig.98 [REF PHASE] Submenu

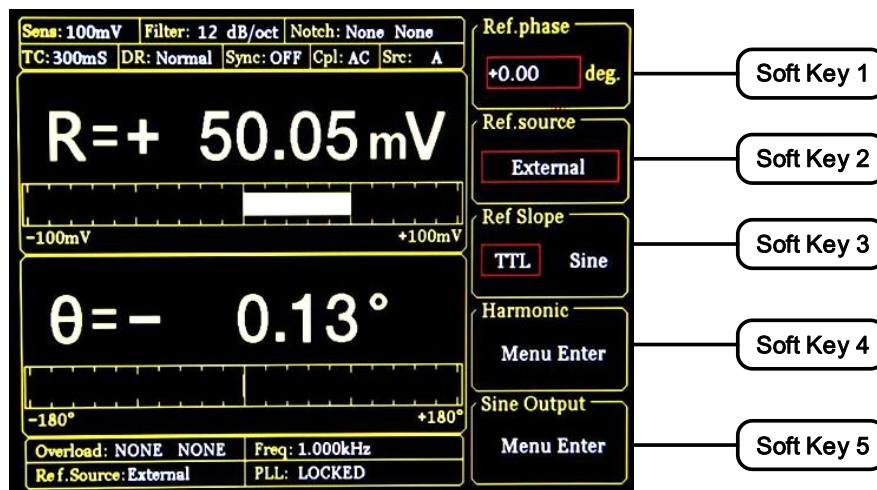


Fig.99 REF PHASE Submenu

Set the harmonic times in <Harmonic> secondary submenu and use keyboard to choose times. The operation method of measuring the first and third harmonic of the input square wave is below, as is shown in Fig.99.

First, press the [soft key 4] to choose harmonic function in [REF PHASE] submenu and enter <Harmonic> secondary submenu, as is shown in Fig.100.

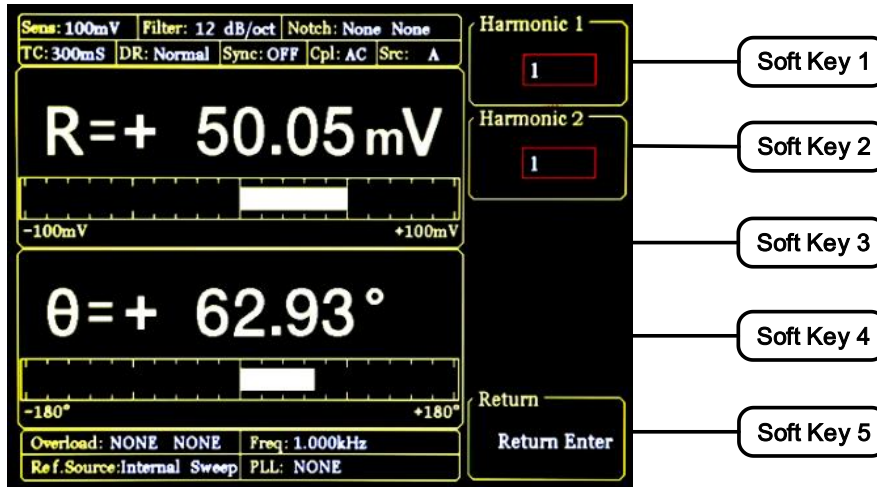


Fig.100 Harmonic Secondary Submenu

Second, press the number key [1] in numeric keyboard and press [ENTER] to confirm. Third, press [soft key 2] and number [3] in keyboard. And then the measure result is the first and third harmonic of input signal.

Choose [DISPLAY] submenu and choose <Full>, <Type> or <List> in <Display & Scale> option. Then, you can read the measured harmonic (harmonic 1 corresponding to <Xh1>, <Yh1>, <Rh1> and <th1>; harmonic 2 corresponding to <Xh2>, <Yh2>, <Rh2> and <th2>). The measure result is shown in Fig.101.

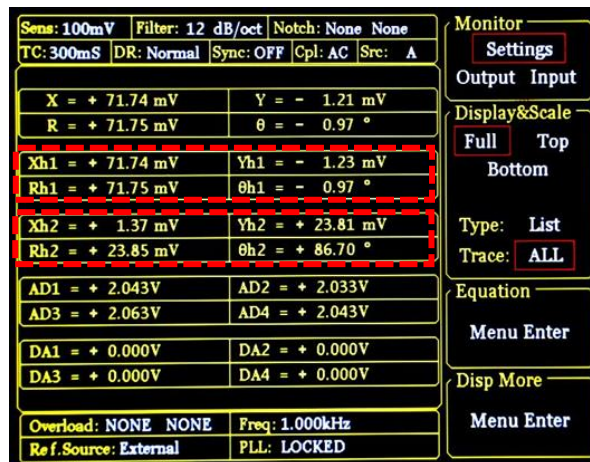


Fig.101 The 3th Harmonic Measurement Result

How to get the amplitude of n^{th} harmonics

Calculate the harmonic theoretical value of the square wave: suppose that the peak-peak value of square value is E and the angular frequency is ω . After Fourier expand, the result is:

$$f(t) = \frac{2E}{\pi} \left(\sin(\omega t) + \frac{1}{3} \sin(3\omega t) + \frac{1}{5} \sin(5\omega t) \cdots + \frac{1}{n} \sin(n\omega t) \right)$$

Where the n times harmonic is sine wave:

$$f(t) = \frac{2E}{n\pi} \sin(n\omega t)$$

Therefore, the valid value of n times harmonic is:

$$R = \frac{\sqrt{2}E}{n\pi}$$

We can verify that whether the measure result is close to the theoretical result or not. In this example, the E is 160mV, and the result of 1-time harmonic is:

$$R = \frac{\sqrt{2} \times 160}{1 \times \pi} mV \approx 72.025 mV$$

The result of 3-time harmonic is:

$$R = \frac{\sqrt{2} \times 160}{3 \times \pi} mV \approx 24.008 mV$$

Compare the measure result with theoretical result according the above method.

8.3 Optical Spectral Measurement

This case shows how to measure a spectral diagram of any light source. You need a light chopper (such as SIGNAL RECOVERY MODEL 197 Light Chopper), a grating monochromator (such as WDG15-Z) and its control system, a photoelectric detector (for example. the electric probe uses the Si photo diode of the S2368 series by Hamamatsu, which is a Japan Inc.), a data collection platform (such as NI cDAQ-9172) and a PC computer. You should control the monochromator to auto sweep in the spectral measurement range. And then measure the photo current using the OE1022. The steps are below:

1. Disconnect all cables from the lock-in. Connect the power source and then turn on the power switch. The system is default.
2. Set the corresponding parameters of OE1022.
 - (1) Press [INPUT/FILTERS] and then set the input mode to <I> and <Amplitude: 1M>. Others do

not change.

(2) Press [REF/PHASE] and then set <Ref. Source: External> and <Type: TTL>.

(3) Press [GAIN/TC] and then set <Sensitivity: $1\mu\text{A}$ > which can be adjusted practically, <Reserve: Normal>, <TC: 300ms> and <Roll off: 12dB/oct>. Finally, turn off the SYNC filter.

(4) Press [OUTPUT/OFFSET] and then set <CH1>, <Source: R> and <Speed: Fast>.

3. Build the spectral measurement platform.

Use a BNC cable to connect the output of the photoelectric detector and the A/I input of the OE1022.

Use a BNC cable to connect the Sync out f1 of the light chopper and the REF IN of the OE1022.

Use a BNC cable to connect the data collection platform and the CH1 OUT of the OE1022.

The sketch is shown in Fig.102

The actual connect figure is shown in Fig.103

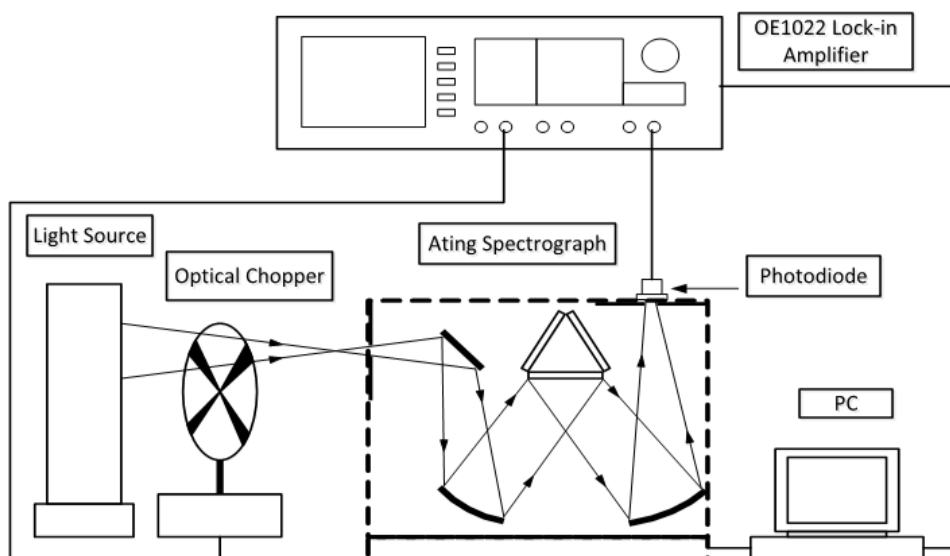


Fig.102 Optical Measurement Platform Diagram

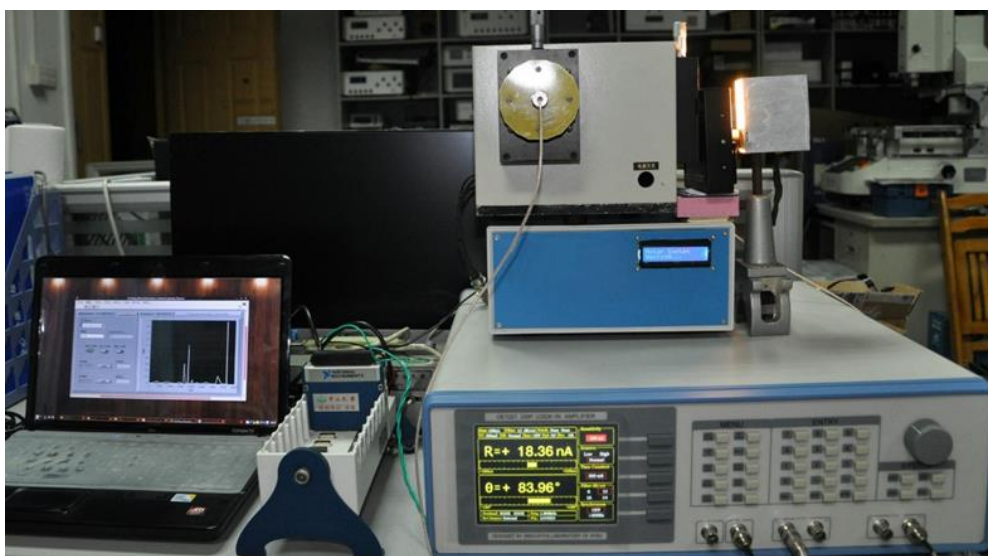


Fig.103 Optical Measurement Platform Picture

4. Start the spectral measurement and collect data from the data collection platform. Then, you will get an uncalibrated spectral image as is shown in Fig.104

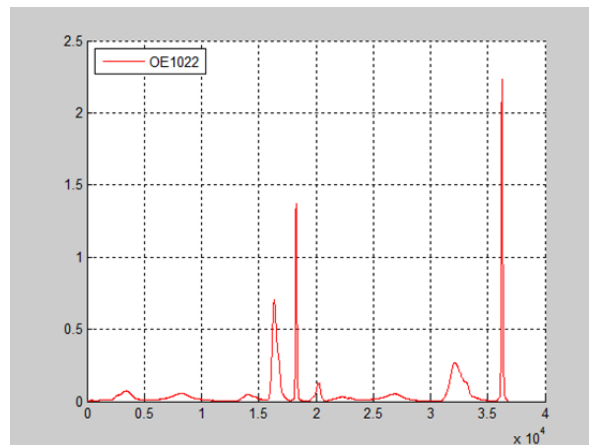


Fig.104 OE1022 Detected Spectrum Curve Chart

5. Change the OE1022 to the SR830. Repeat the steps above to run the same experiment. Then you will get another spectral image as is shown in Fig.105. You can see that these two images are almost the same.

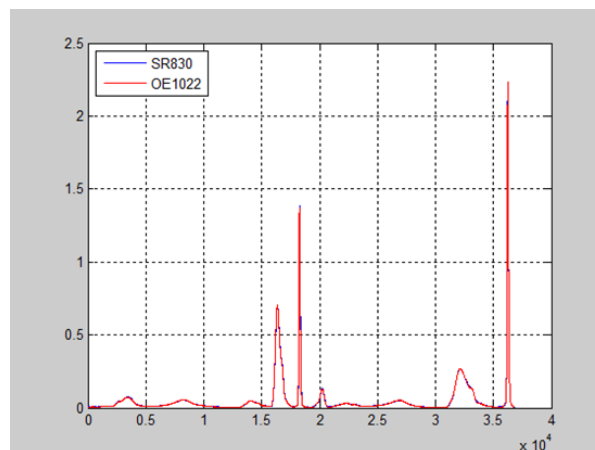


Fig.105 The Contrast Spectrum Chart between SR830 and OE1022

8.4 Serial Communication

This case shows how to remotely run the serial communication. You need a USB cable. Do the steps in the following sequence:

1. Use a USB cable to connect the USB of the OE1201 to the USB of one PC.
2. The PC will recognize the USB device and remind to install the driver program. If your PC system is WIN7, the PC will do these automatically online. You just need to wait for a few minutes. If the installation fails, you need to install the driver artificially according to the Chapter 6.2.
3. Open the folder “uart” in your disk and double click the file UartAssist.exe. This window will call out the software interface, as is shown in Fig.106.

1) Open your disk and then click the “uart” file. Open “UartAssist.exe” and then you see the picture right.

Note that this program can set the communication mode, the receiver mode, the transfer mode. It can also transfer and receive data which shows at the display like Fig.106.

The default Baud rate of the OE1022 is 921600. The OE1022 has no check digit, 8 data digits and 1 stop digit. The COM number choose the verified PC COM number which shows at 3-2), the interface is shown in Fig.107

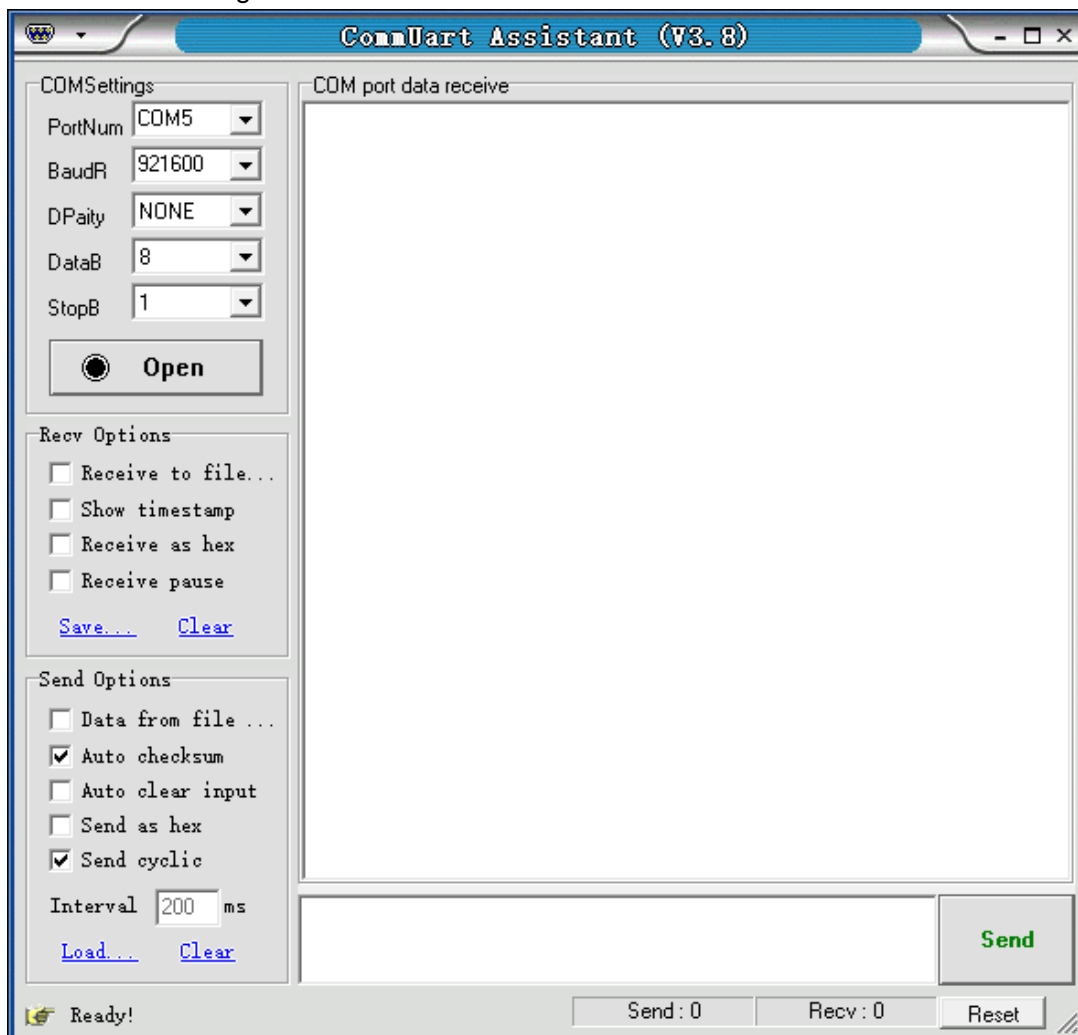
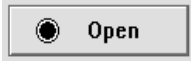



Fig.106 “CommUart Assistant” Software display

2) After these settings are completed, if you see a black circle like  , you need to click the button to make it red like  . If you cannot make it red, please check the COM number and repeat the click. If the connection is OK, you will see Fig.108.

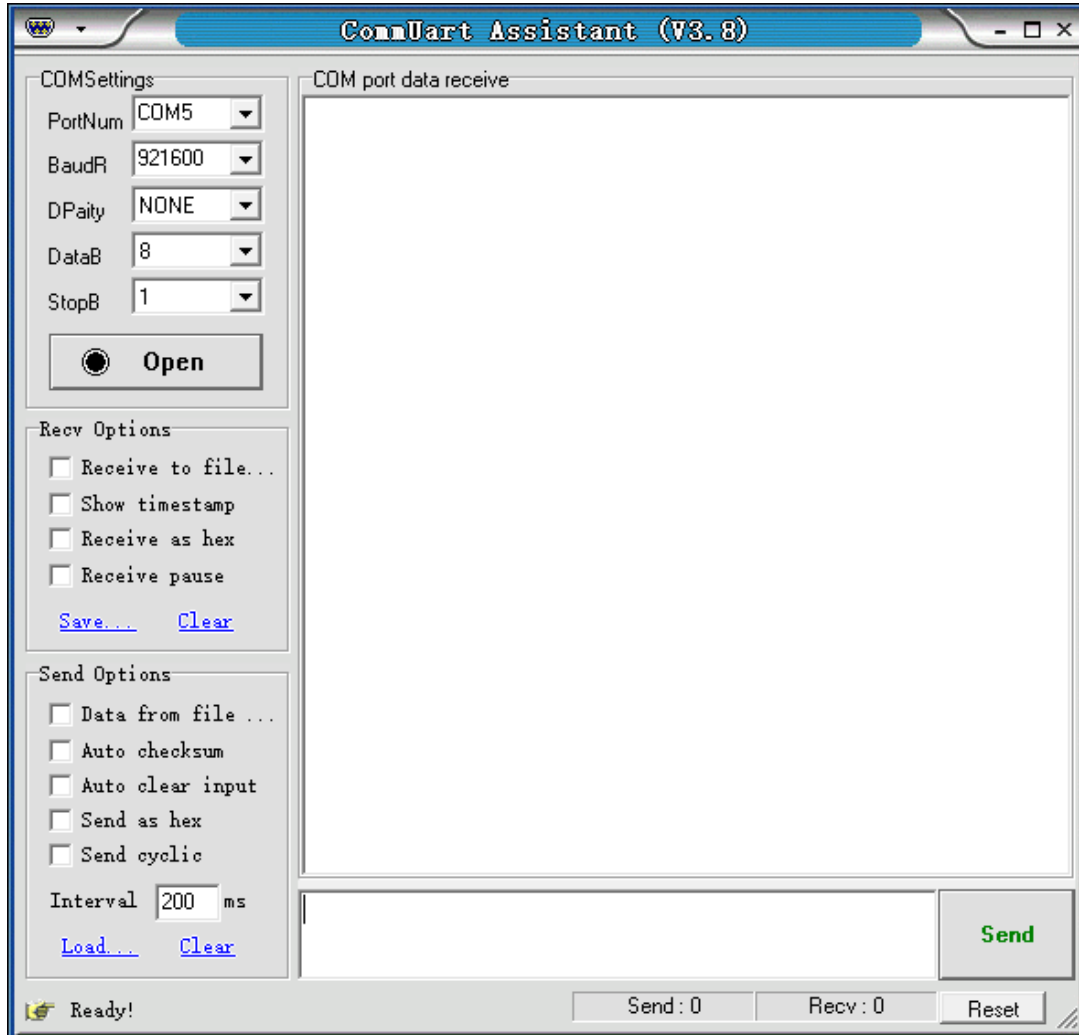


Fig.70 “CommUart Assistant” Software display

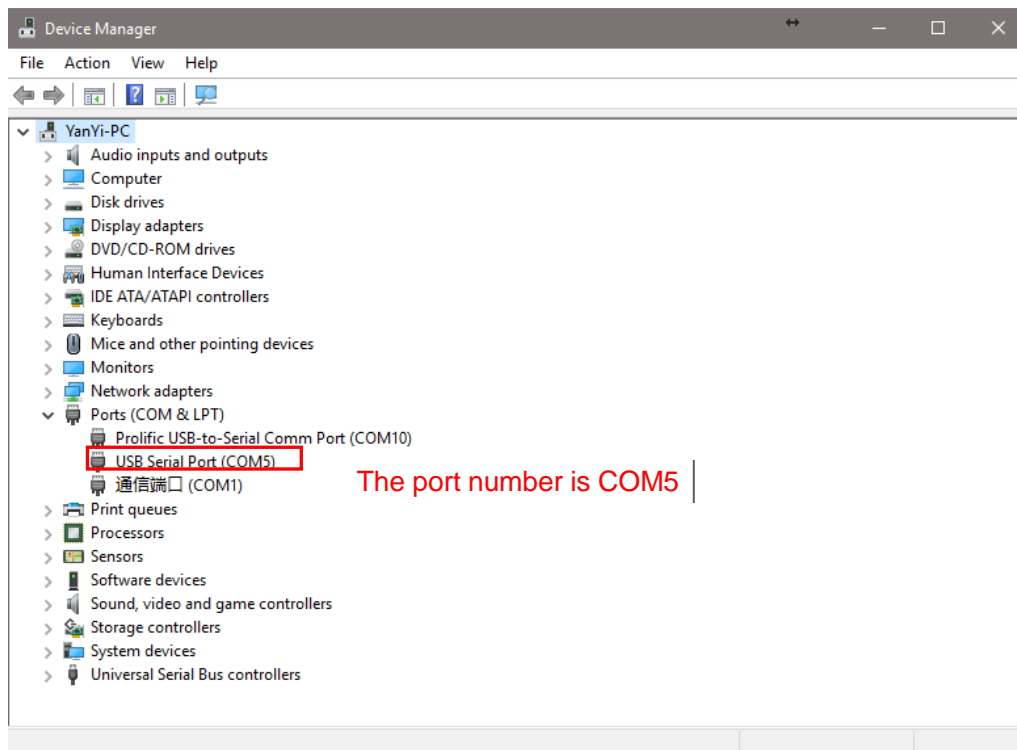


Fig.107 Check the USB COM number at “Device Manager”

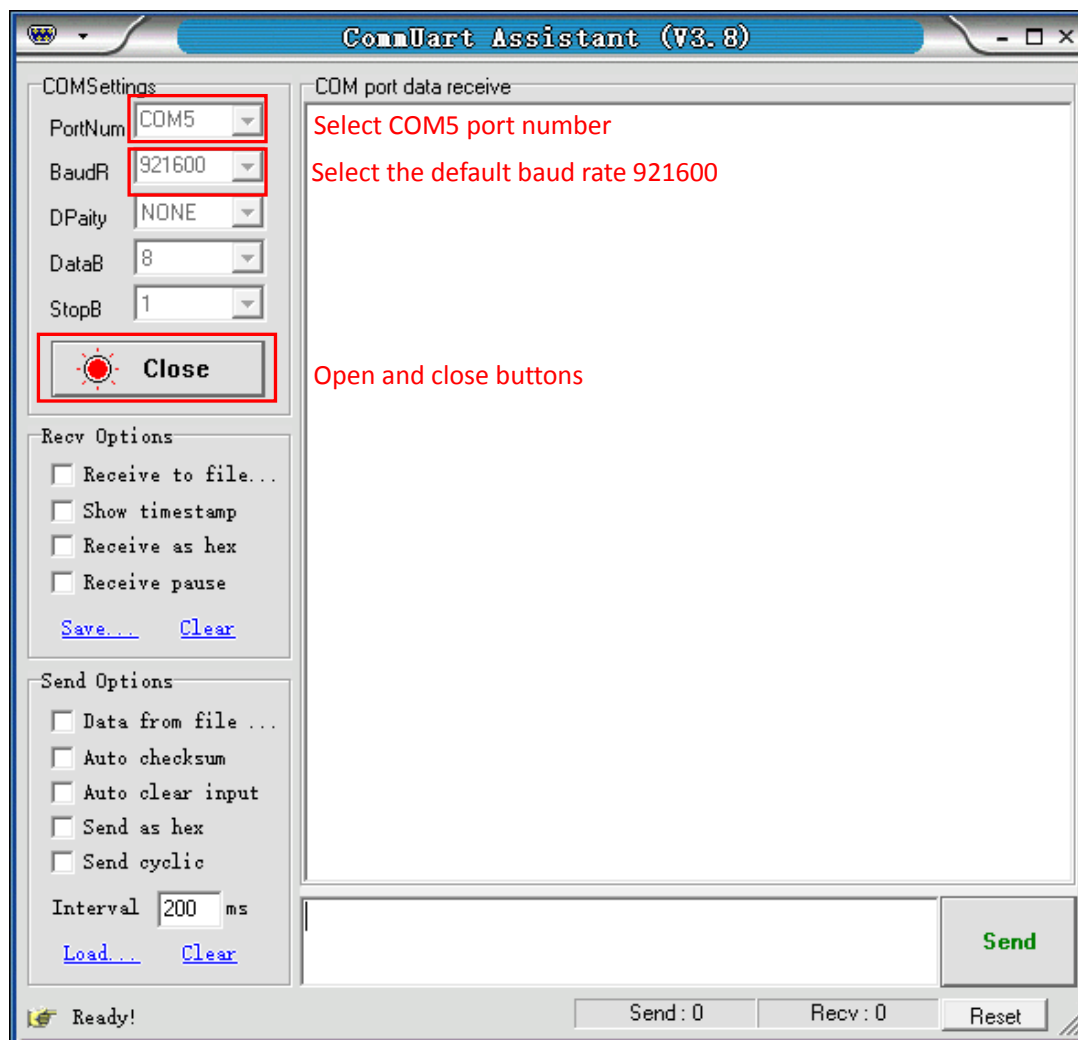


Fig.108 USB connection succeeds

4. Transfer commands to communicate with the OE1022.

1) The commands consist of four mnemonics and several parameters. Several commands at the same line are separated by semicolons. More details see the Chapter Remote Programming. Note that one line should be ended by a terminator: a carriage return. The result is like the Fig.109 and Fig.110.

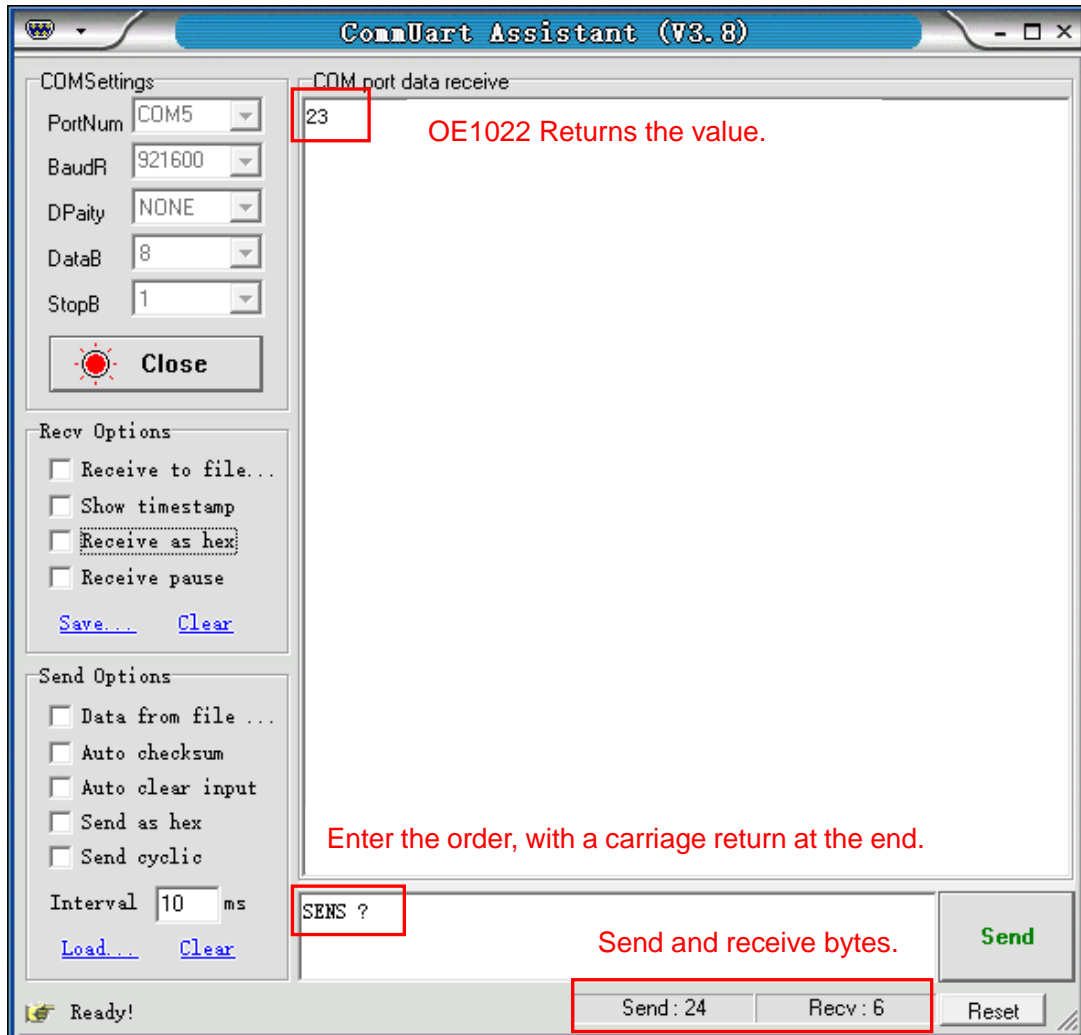


Fig.109 ASCII words send and receive instructions

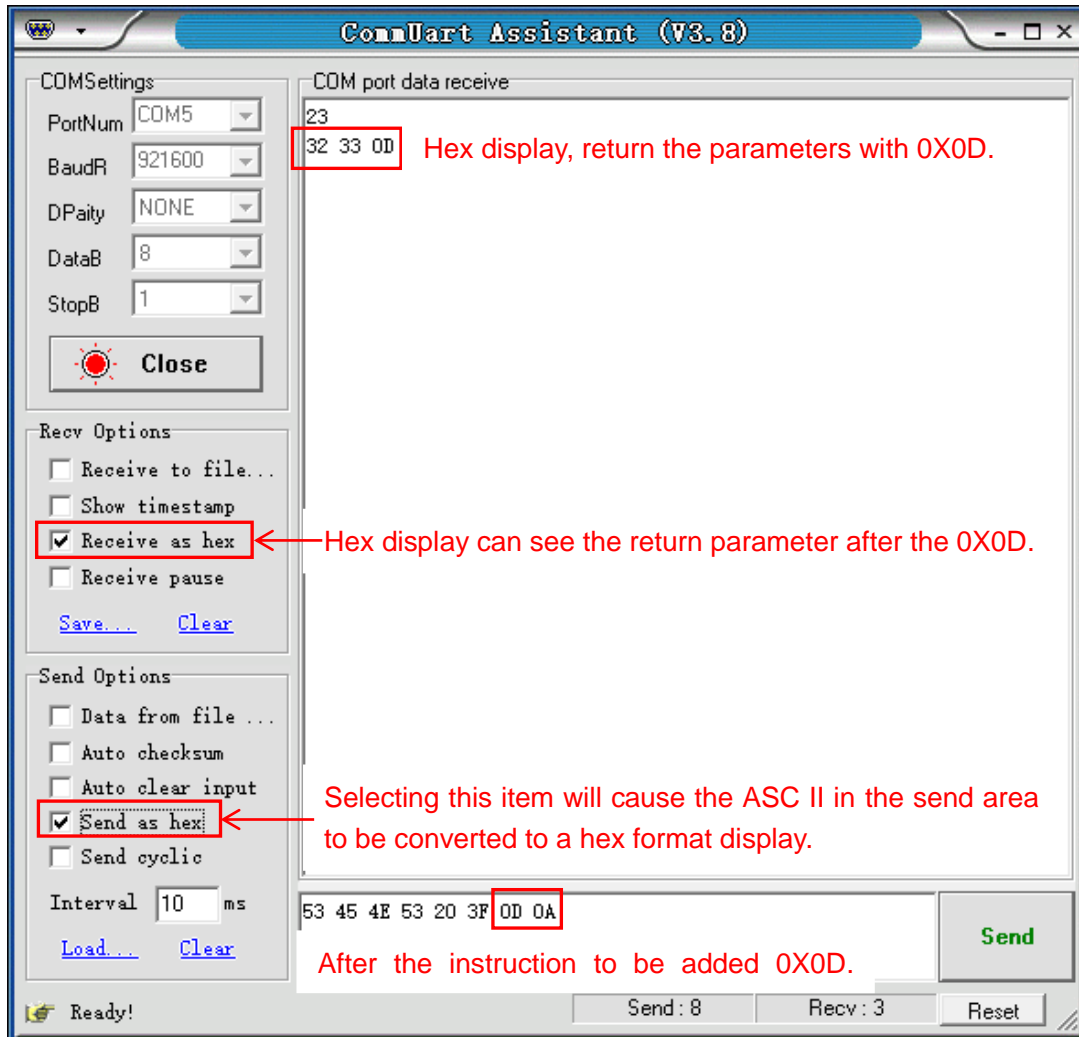


Fig.110 Send and receive HEX instructions

2) You just need to click Auto checksum and choose Fixed Byte Checksum. Finally, set the additional digit to <0D> as Fig.111.

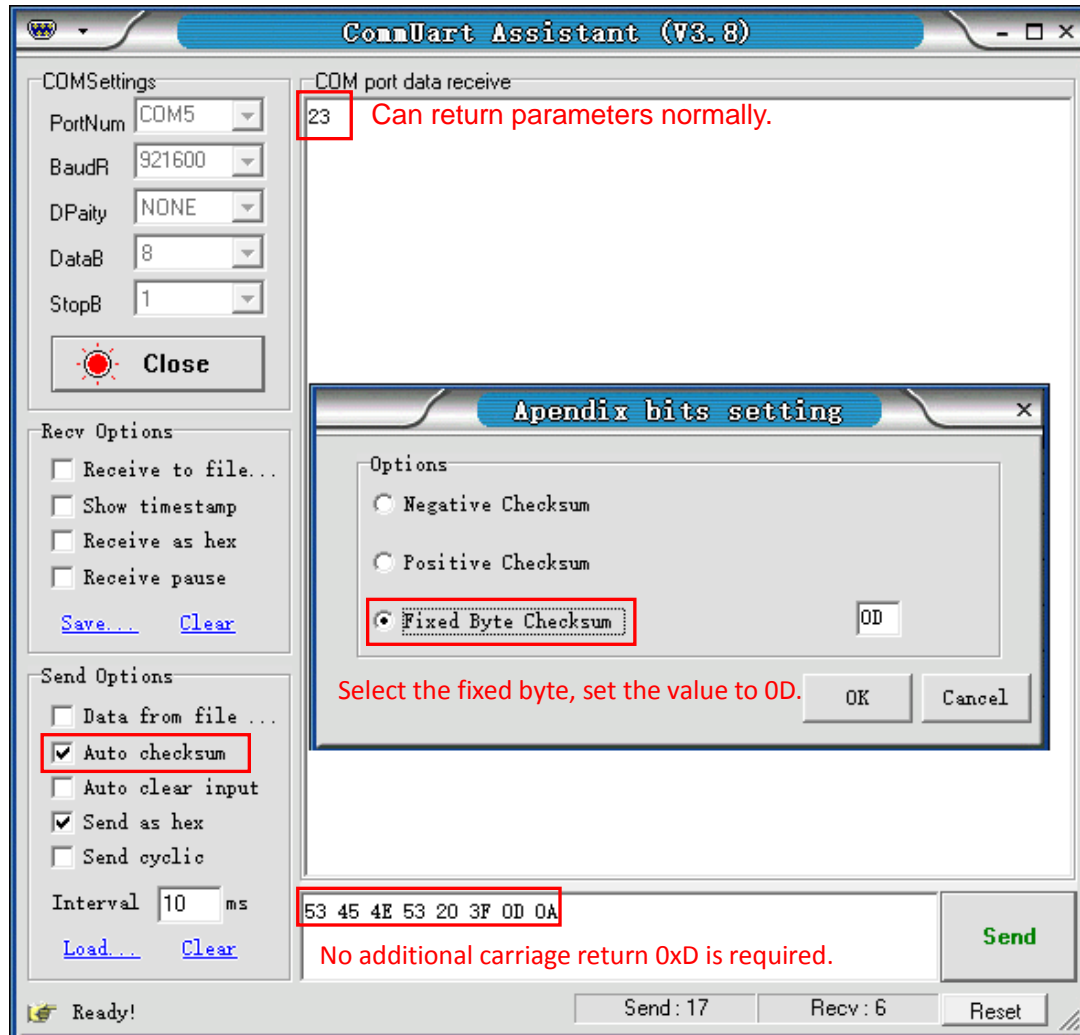


Fig.111 Checksum Settings

3) Multiple instructions need “;” to separate each other, such as “SENS 24;FMOD 1;FREQ 1000;SENS ?;FMOD ?;FREQ ?” like Fig.112.

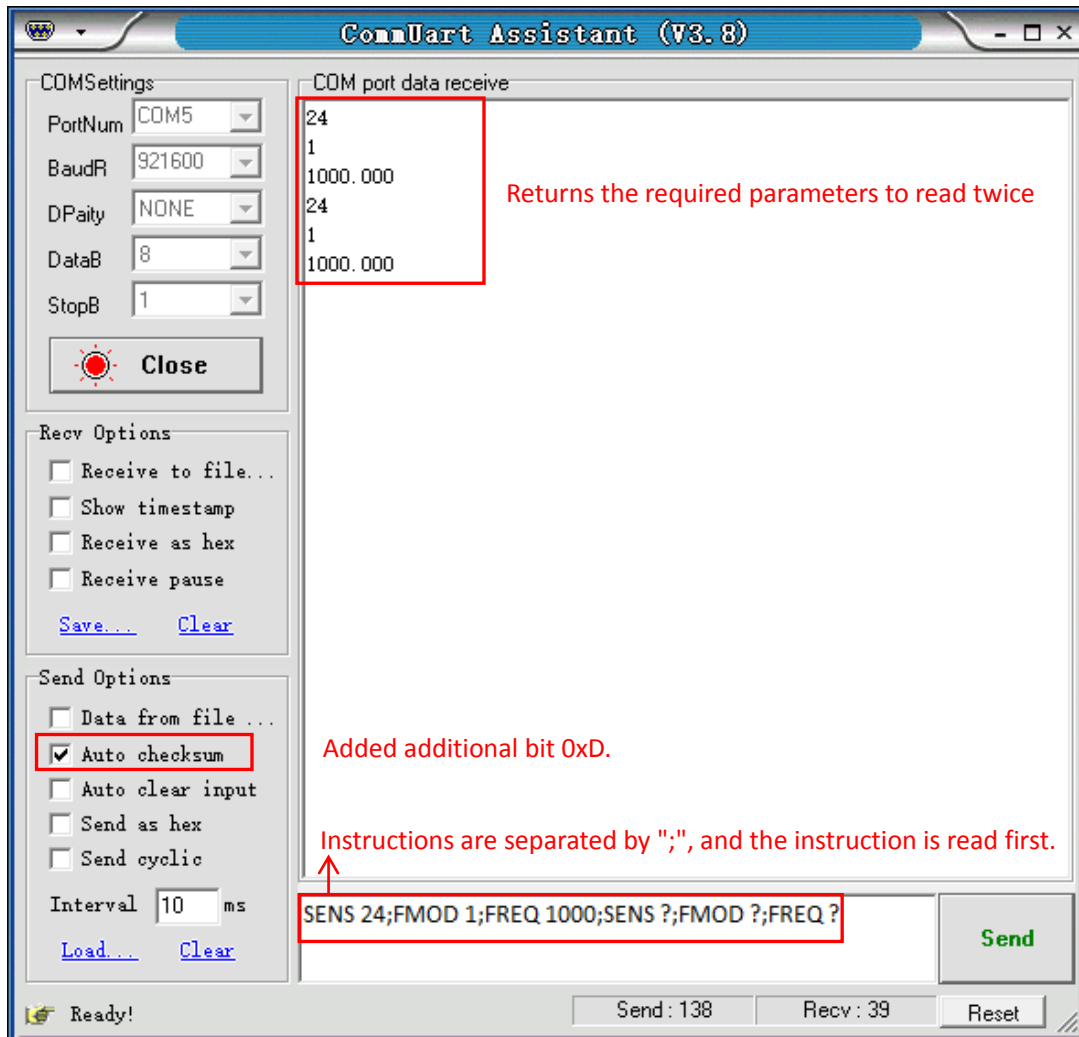


Fig.112 The execution of multiple instructions

4) If you want to read $\langle X \rangle$, $\langle Y \rangle$, $\langle R \rangle$, $\langle \theta \rangle$ and Freq continuously, you can set the transfer pause time as Fig.113 and Fig.114.

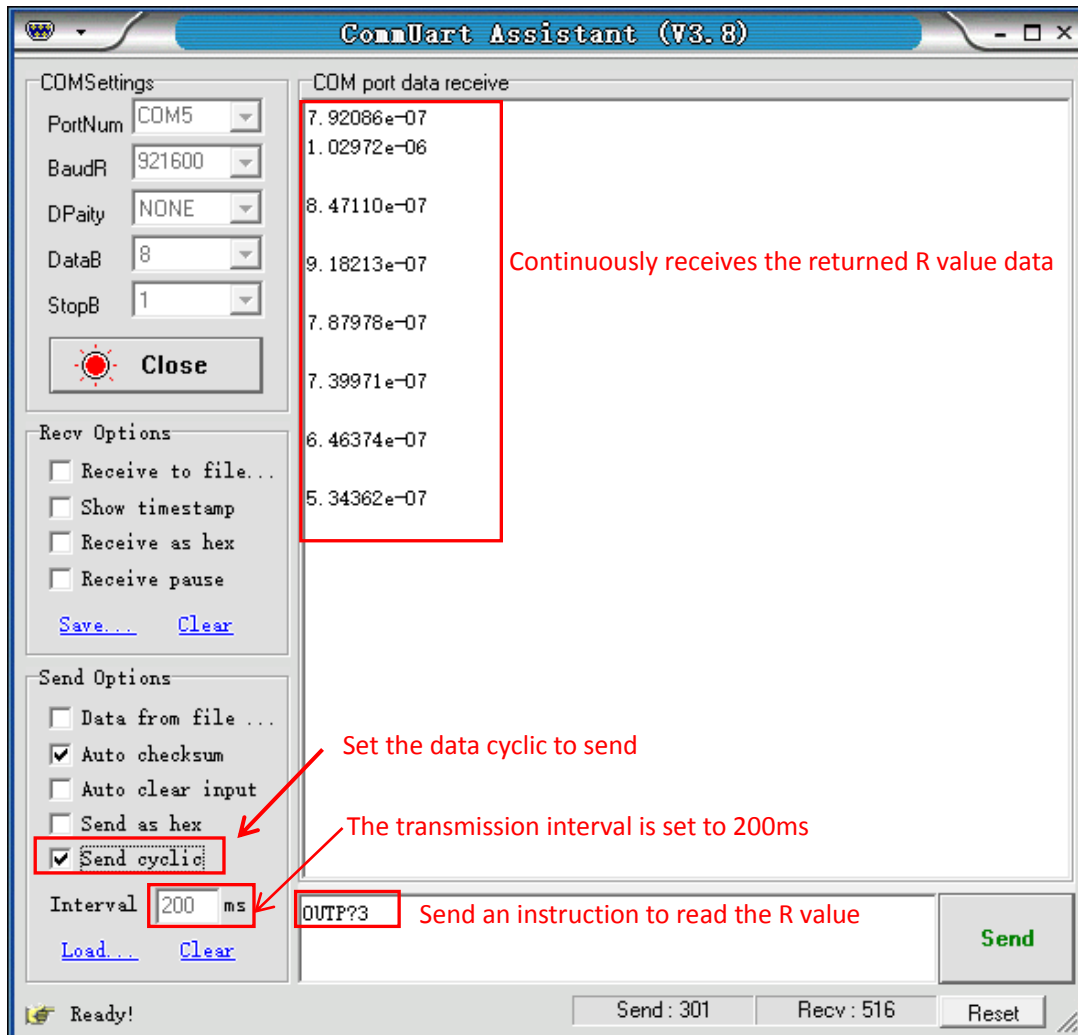


Fig.113 Continuous read single R value

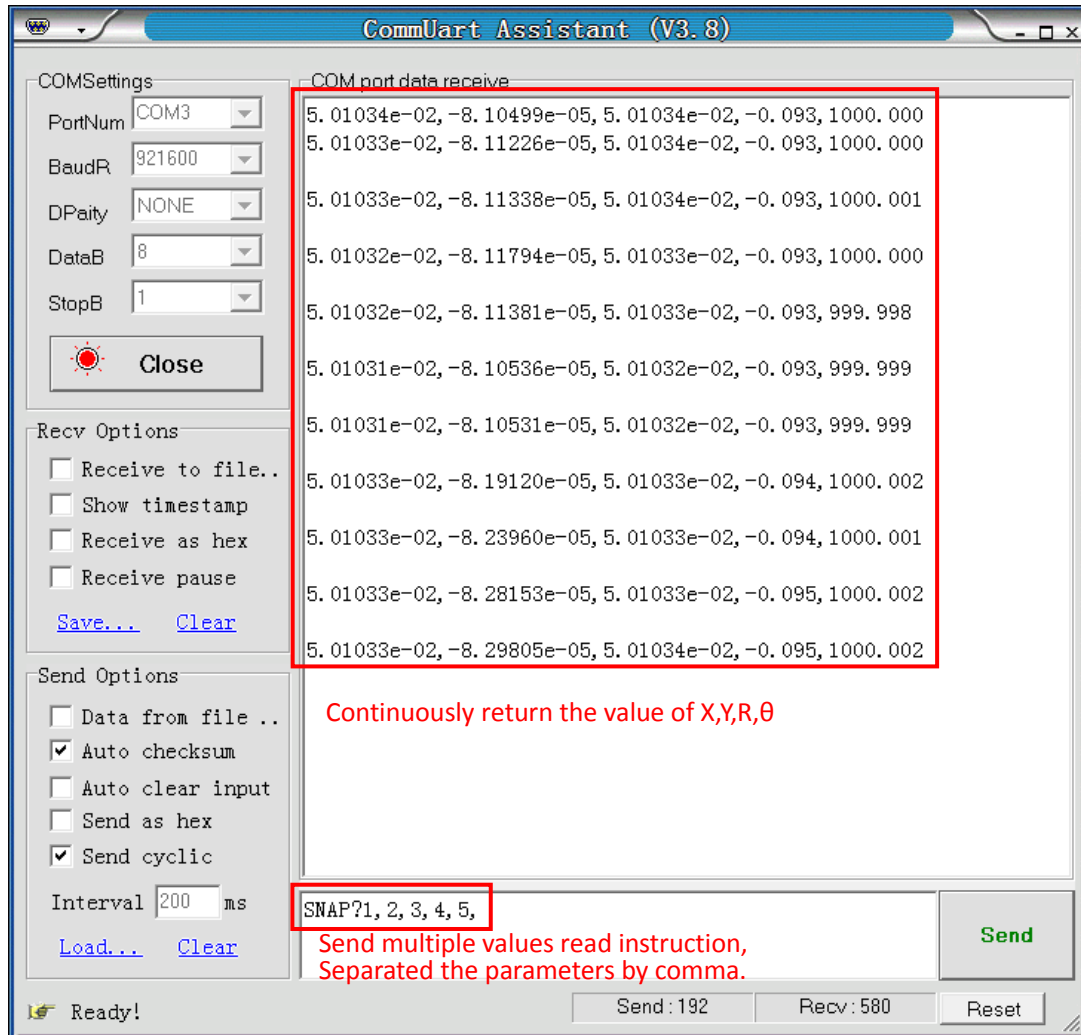


Fig.114 Continuous read the Value of X, Y, R θ and Freq

Note that when use this program to control the OE1022, the LCD display will refresh at the same time. For example, if <Sens: 100mV> equals to the “25” commands, <Sens> will become <Sens: 50mV> when the OE1022 receives the “24” command.

The OE1022 can use many versions of this kind of serial debugging program. You can use other programs to control the OE1022 remotely.