Stanford Research Systems

Lock-In Amplifiers

SR124 Single Phase Analog Lock-in Amplifier

SR2124 Dual Phase Analog Lock-in Amplifier

SR510 Single Phase Lock-In Amplifier

SR530 Dual Phase Lock-In Amplifier

SR810 DSP Single Phase Lock-In Amplifier

SR830 DSP Dual Phase Lock-In Amplifier

SR844 200 MHz Lock-In Amplifier

SR850 DSP Dual Phase Lock-In Amplifier

SR860 500 kHz Lock-in Amplifier

SR865A 4 MHz Lock-in Amplifier

Analog Lock-In Amplifiers

SR124 and SR2124 — Analog lock-in amplifiers

SR124 & SR2124 Analog Lock-Ins

- ***Low-noise, all analog design***
- ***No digital interference***
- ***0.2 Hz to 200 kHz measurement range***
- ***Low-noise current and voltage inputs***
- ***Harmonic detection (f, 2f, or 3f)***
- ***Selectable input filtering***

For over a half century, the lock-in amplifier has been the instrument of choice for measuring small AC signals in the presence of noise. Early instruments were designed with analog electronics, multi-gang mechanical switches, needle indicators, etc., and measurements were often monitored with chart recorders. Microprocessor based designs emerged in the 1980s, and by the early 1990s even the lock-in's analog demodulators were replaced by high-resolution ADCs and digital signal processors (DSP). Remote computer control, digital readouts and user-friendly front panels all resulted.

The capabilities of the modern DSP lock-in amplifier in stability, dynamic reserve, and flexibility were revolutionary, making it a mainstay for researchers and engineers across multiple fields. But in moving forward, something was left behind. For a core group of users, including low-temperature researchers in particular, the new instruments became a potential source of high-frequency interference. This is best reflected in the persistence of one instrument — the PAR124A — still actively used by many researchers decades after discontinuation by its long-gone manufacturer.

Back to Analog

Recognizing that one size shouldn't have to fit all, SRS is proud to introduce the SR124 Single-Phase and SR2124 Dual-Phase Analog Lock-In Amplifiers. Inspired by the best of an earlier generation's lock-ins, but availing itself of today's low-noise analog components and design methodologies, the SR124 and SR2124 are a tour de force in low-noise, high-performance analog instrumentation.

Architecture

The SR124/SR2124 designs follows two basic themes. First, the signal path is entirely built from low-noise analog electronics: the best JFETs, transistors, op-amps, and discrete components. Second, configuration control is managed by a microcontroller whose system clock only oscillates during the brief moments needed to change gains or filter settings. This "clock-stopping" architecture, first introduced by SRS in the SR560 Voltage Preamplifier, eliminates the inconvenience and reliability issues associated with mechanical panel controls, and makes full remote operation of these lock-ins possible.

Don't let the numeric displays fool you — the SR124 and SR2124 really stop all digital clocks during operation. The numeric displays show precision setting information, such as input filter frequency, demodulator phase shift, and source output amplitude. The drive electronics are completely static, with no "scanning" or refresh to generate the slightest interference.

Whenever the microcontroller becomes active, the "CPU Activity" indicator illuminates, clearly showing when the digital clock is running. This occurs in response to front-panel button presses or remote computer commands.

When it Really Matters — Run Silent!

Sometimes, you need to be confident your experiment will be undisturbed: you've cooled your sample to a few millikelvin, all your wiring is still intact, and the best device you've built all year is ready for measurement. A locking toggle switch on the front panel can be set to "LOCKED OUT", forcing the digital clock to remain off, even if you press other buttons or knobs. The analog configuration of the lock-in stays steady, letting you run for minutes, hours, days — as long as you need.

Low Noise Input Amplifiers

The SR124 and SR2124 have both voltage and current inputs. The voltage input is a single-ended/differential FET preamp with ultra-low 2.5 nV/√Hz input noise. The input impedance is 10 MΩ, and minimum full-scale input voltage sensitivity is 100 nV. The current input preamp has selectable gains of 10^6 and 10^8 V/A. Both AC and DC coupling is provided, and the instrument can operate in Ground or Float mode.

SRS also makes a variety of remote preamplifiers including the SR550 (FET input), SR551 (Hi-Z input), SR552 (BJT input), and SR554 (transformer input) which can all be powered directly from the SR124's rear-panel preamp power port. These preamplifiers have unique characteristics which are optimized for a variety of experimental conditions. When used with the SR124 or SR2124, they can often significantly improve your measurements.

Input Filters

The SR124 and SR2124 provide several filter types for preconditioning your signal before it reaches the phase-sensitive detector. A choice of flat (no filtering), band pass, high pass, low pass, and notch filtering can be selected, and the Q-factor for the filter can be set between 1 and 100.

In band pass mode, a tunable narrow-band amplifier rejects signals outside of the passband, providing as much as an additional 60 dB of dynamic reserve.

The high pass and low pass filters allow you to limit the band of frequencies presented to the lock-in amplifier, and reject frequencies outside of the passband. The rolloff for these filters is –12 dB per octave.

In notch mode, a tunable band reject filter is engaged that provides up to 80 dB attenuation at a particular frequency.

Dynamic Reserve

The dynamic reserve of a lock-in amplifier, at a given full-scale input sensitivity, is the ratio of the largest interfering signal to the full-scale input voltage. The largest interfering signal is defined as the amplitude of the largest signal at any frequency that can be applied to the input before the lock-in cannot measure a signal with its specified accuracy.

The SR124 and SR2124 have a dynamic reserve of up to 60 dB, depending on the sensitivity setting and the reserve mode. Engaging the input band pass filter can add an additional 20 to 60 dB of dynamic reserve, making the maximum achievable dynamic reserve 100 dB.

Output Time Constants

The SR124 and SR2124 offer two stages of output low pass filtering. Time constants can be chosen as long as 300 s for maximum noise reduction, or as short as 1 ms. A choice of –6 dB or –12 dB per octave rolloff is selectable. The Minimum time constant setting bypasses the output filter, and the output signal bandwidth is simply determined by internal stray capacitance.

Offset

The lock-ins offset feature makes it easy to evaluate small changes in the presence of a full-scale signal. You can adjust the offset manually between ±1000 % (10×) of full-scale, or you can use the auto-offset feature to set the offset equal to the signal value with the push of a button. Once the offset has been adjusted, you can add gain (up to 10×) by decreasing the sensitivity setting.

Auto Features

Convenient auto features allow you to quickly configure the lock-in's optimum settings. Pressing the Gain, Phase, or Offset buttons starts the microcontroller, which then adjusts the instrument for either best sensitivity (Gain), phase shift to maximize signal (Phase), or null the output (Offset). The Ref Range button toggles the frequency auto-ranging feature on and off, which allows the SR124 to automatically set the appropriate reference range whenever the oscillator unlocks.

Reference Channel

There are three reference modes in the SR124 and SR2124: Internal, External, and Rear VCO. In all modes, the frequency range is first chosen in the reference section of the front panel — either manually or by the auto Ref Range feature.

In external reference mode, the instrumnent locks to external signals with at least 100 mVpp amplitude. The reference oscillator will phase-lock to the positive zero-crossings of the external reference input. Locking at f, 2f (second harmonic), or 3f (3rd harmonic) is supported.

Operated in internal mode, the reference frequency is set from the front panel with ±0.1 % accuracy. In addition to internal and external reference modes, the there is a built-in voltage controlled oscillator (VCO) that can be the lock-in's reference. The rear-panel VCO input accepts a 0 to +10 VDC signal which corresponds to the lowest and highest frequencies in the range set on the front panel. This convenient feature allows you to lock to a variable or swept control voltage.

A synchronous reference output signal is always present at the front-panel Ref Out BNC connector. Both sine and square waveforms are selectable, and the output amplitude can be set between 100 nV and 10 V. The reference is also available on the rear panel. Four phase-shifted 1 Vrms outputs at 0°, 90°, 180° and 270° can used for a variety of applications.

DC Bias

A bipolar DC bias voltage, independent of the AC reference amplitude, can be added to the reference output by switching "DC Bias" on. This feature is particularly helpful when making differential conductance and related transport measurements, where the small-signal AC response of your experiment must be measured at a range of different bias values. Bias values can be set up to ±1000× the reference amplitude, depending on amplitude.

SR2124 front panel

SR124 & SR2124 rear panel

Phase Control

The SR2124 is a dual phase lock-in amplifier which has displays for both X and Y. The SR124 is a single phase lock-in amplifier and has just one display for X. The phase of the reference will often need to be adjusted. Manually nulling the phase is easy—press the phase button and turn the large knob until the signal is nulled, then shift the phase by 90°. Or, simply press the auto Phase button. The phase resolution is 0.01°, and phase accuracy is ±1° at mid-band frequencies.

AC Voltmeter Mode

For most applications, users will typically operate in Lock-In mode, but the mode can be changed to AC Volt allowing the lock-in to operate as a wideband or frequency selective AC voltmeter. In this mode, the average absolute value of an AC signal can be quickly measured without the need for a reference signal.

Computer Control

For those who need computer control of their lock-in amplifier, there is an RS-232 interface on the rear panel. All functions of the instrument can be set or read via the interface. When sending commands to the instrument, the microcontroller will be activated, and digital noise may be present. During these times, the front-panel Remote Activity LED alerts you that communications are taking place.

For remote interfacing with complete electrical isolation, there is a rear-panel fiber optic interface. When connected to the SX199 Remote Computer Interface Unit, this provides a path for controlling the the lock-in via GPIB (IEEE-488.2), Ethernet, and RS-232.

SR124 front panel

Ordering Information

SR124	Single phase lock-in amplifier
SR2124	Dual phase lock-in amplifier
SX199	Remote computer interface unit

SR124 & SR2124 Specifications

Signal Channel

Voltage inputs	Single-ended or differential
Sensitivity	100 nV to 500 mV
Current input	10^6 or 10^8 V/A
Input impedance	
Voltage	10 MΩ + 35 pF, AC or DC coupled
Current	1 kΩ to virtual ground
Gain accuracy	±1 %
Gain stability	100 ppm/°C (flat mode, normal reserve)
Noise (rms)	2.5 nV/√Hz at 1 kHz 0.14 pA/√Hz at 1 kHz (10^6 V/A) 0.014 pA/√Hz at 100 Hz (10^8 V/A)
Signal filters	(Tunable from 0.2 Hz to 200 kHz)
Flat	Flat response to within ±1 % from 10 Hz to 100 kHz, ±2 % from 100 kHz to 200 kHz, and ±10 % below 10 Hz.
Band pass	Bandwidth adjustable from 1 % to 100 % of center frequency (Q from 100 to 1).
High pass	–12 dB/oct rolloff
Low pass	–12 dB/oct rolloff
Notch	Up to 80 dB attenuation
CMRR	100 dB to 10 kHz, decreasing by 6 dB/oct above 10 kHz
Dynamic reserve	(without band pass filter)
Low noise	20 dB
Normal	40 dB
High reserve	60 dB

Reference Channel

Frequency range	0.2 Hz to 200 kHz
Reference input	TTL or sine (100 mVpp min.)
Input impedance	1 MΩ
Phase resolution	0.01°
Phase accuracy	±1° (2 to 20 kHz), ±5° (20 kHz to 200 kHz)
Harmonic detection	F, 2F and 3F (ext. ref)

Demodulator

Output stability	
Low noise	20 ppm/°C
Normal	100 ppm/°C
High reserve	1000 ppm/°C
Time constants	1 ms to 300 s (6 or 12 dB/oct rolloff). MINIMUM time position, typically 500 µs, is determined by stray capacitance. ±10 % (to 200 kHz)

Internal Oscillator

Range	0.2 Hz to 200 kHz
Outputs	Sine, square (selectable) (When using an external reference, output is phase locked to the external reference.)
Frequency accuracy	0.1 %
Frequency resolution	3½ digits or 1 mHz, whichever is greater
Amplitude	1 µV to 20 Vpp into 10 kΩ, 50 Ω output impedance.
Amplitude stability	50 ppm/°C

VCO

VCO input	A 0 to 10 V signal corresponds to the beginning and ending frequencies in the range set on the front panel.

Displays

Panel meter	Center-zero, mirror-backed (a single meter for SR124, two meters for SR2124)
Offset	Output can be offset up to ±1000 % of full scale.
Reference	3½-digit LED display

Inputs and Outputs

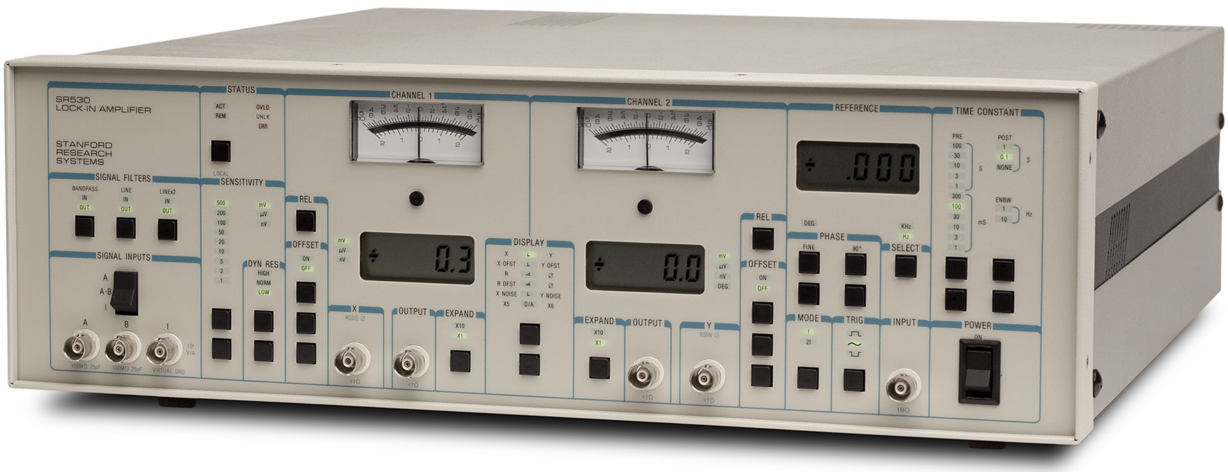
Lock-In/AC Volt	Instrument can be operated as a lock-in amplifier or as a frequency selective AC voltmeter.
Output	
Lock-In	X (Rcosθ), ±10 V Y (Rsinθ), ±10 V, SR2124 only
AC Volt	±10 V
Ref. Out	Analog output. Sine or square wave, up to ±20 Vpp
Remote preamp	Provides power to the optional SR55X preamps
Fiber optic interface	Connection for SX199 Remote Computer Interface Unit. The SX199 has GPIB (IEEE-488.2), RS-232, and Ethernet interfaces for remotely controlling the SR124.
RS-232 interface	RS-232 interface is standard. All instrument functions can be controlled and read through the interface.
Quadrant outputs	Four phase-shifted outputs at 0°, 90°, 180° and 270° from the reference. Output levels are 1 Vrms sinewaves.

General

Power	40 W, 100/120/220/240 VAC, 50/60 Hz
Dimensions	17" × 5.25" × 19.5" (WHD)
Weight	23 lbs.
Warranty	One year parts and labor on defects in materials and workmanship

Lock-In Amplifiers

SR510 and SR530 — Lock-in amplifiers



SR530 Lock-In Amplifier

SR510 & SR530 Lock-In Amplifiers

- **0.5 Hz to 100 kHz frequency range**
- **Current and voltage inputs**
- **Up to 80 dB dynamic reserve**
- **Tracking band-pass and line filters**
- **Internal reference oscillator (opt.)**
- **Four ADC inputs, two DAC outputs**
- **RS-232 interface (std.)**
- **GPIB interface (opt.)**

The SR510 and SR530 are analog lock-in amplifiers which can measure AC signals as small as nanovolts in the presence of much larger noise levels. Both the single phase SR510 and the dual phase SR530 have low-noise voltage and current inputs, high dynamic reserve, two stages of time constants, and an internal oscillator. In addition, both lock-ins come equipped with a variety of features designed to make them simple to use.

Sine Wave Mixing

The core of the SR510/SR530 is a precision analog sine-wave multiplier. Lock-ins use a multiplier (demodulator) to translate the input signal (at the reference frequency) down to DC where it can be filtered and amplified. Many lock-ins use square wave multipliers which introduce spurious harmonic responses. The SR510/SR530 use clean sine-wave multipliers which are inherently free of unwanted harmonics.

Signal Input

The SR510 and SR530 have differential inputs with 7 nV/$\sqrt{\text{Hz}}$ of input noise and 100 MΩ input impedance. The input can be configured as a voltage input, or as a current input with 10^6 V/A gain and an input impedance of 1 kΩ to virtual ground. Full-scale sensitivities from 500 mV down to 100 nV are available.

Three input prefilters can be selected. The first is a line notch filter providing 50 dB of rejection at the line frequency. The second filter similarly provides 50 dB of rejection at the second harmonic of the line frequency. The third filter is a band pass filter which automatically tracks the reference frequency. These three filters can eliminate much of the noise in the signal before it is amplified.

Reference Input

The reference input can be set to lock to sine waves or to either edge of a pulsed reference. The reference frequency range is 0.5 Hz to 100 kHz, and detection at both the fundamental and second harmonic of the reference is allowed. A convenient, built-in frequency meter constantly measures and displays the reference frequency with 4-digit resolution. The reference can be phase shifted with 0.025° resolution from the front panel, or shifted in 90° increments for easy measurement of quadrature signals. The SR530 has an auto-phase feature that lets you quickly determine the phase of the signal relative to the reference with a single key-press.

Output Time Constants

Two stages of filtering follow the phase sensitive detector. Time constants can be chosen as long as 100 seconds for maximum noise reduction, or as short as 1 ms (20 µs with modification) for use in real-time servo loops. The two filter stages allow a rolloff of 6 or 12 dB/octave.

Dynamic Reserve

The dynamic reserve of a lock-in amplifier, at a given full-scale input voltage, is the ratio (in dB) of the largest interfering signal to the full-scale input voltage. The largest interfering signal is defined as the amplitude of the largest signal at any frequency that can be applied to the input before the lock-in cannot measure a signal with its specified accuracy.

The SR510 and SR530 have a dynamic reserve of between 20 dB and 60 dB, depending on the sensitivity scale. Selecting the band pass filter adds an additional 20 dB of dynamic reserve, making the maximum dynamic reserve for these lock-ins 80 dB.

Offset and Expand

The SR510/SR530's offset and expand features make it easy to look at small changes in a large signal. Output offset of 0 to 100 % of full scale can be selected manually or by using auto-offset, which automatically selects an offset equal to the signal value. Once the signal is offset, a 10× expand is available to provide increased resolution when looking at small changes from a nominal value.

Analog and Digital Displays

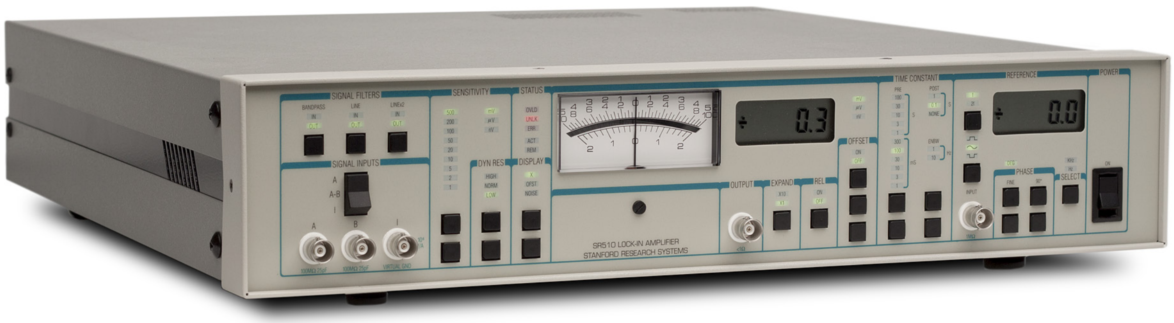
Precision analog meters and 4-digit digital displays are standard on both lock-ins. On the SR510, you can select displays of the signal amplitude, the signal offset, or the measured noise. On the SR530, the first pair of displays show the signal components in rectangular form (X and Y), polar form (R and θ), the offset, noise, or the value of the rear-panel D/A outputs. The other digital display on both lock-ins can be configured to show either the reference phase or the reference frequency.

Noise Measurement

The SR510/SR530's noise measurement feature lets you directly measure the noise in your signal at the reference frequency. Noise is defined as the rms deviation of the signal from its mean. The SR510/SR530 will report the value of the noise in both a 1 Hz and 10 Hz bandwidth around the reference frequency.

Internal Oscillator

An optional internal voltage-controlled oscillator provides both an adjustable-amplitude sine wave output and a synchronous, fixed-amplitude reference output. The sine wave amplitude can be set to 0.01, 0.1 or 1 Vrms, and can drive up to 20 mA. The oscillator frequency is controlled by a rear-panel voltage input and can be adjusted between 1 Hz and 100 kHz. Typically, the sine wave output is used to excite some aspect of an experiment, while the reference output provides a frequency reference to the lock-in.



SR510 Lock-In Amplifier

A/Ds and D/As

There are four A/Ds and two D/As on the rear panel that provide flexibility in interfacing the SR510/SR530 with external signals. These input/output ports measure and supply analog voltages with a range of ±10.24 VDC and a resolution of 2.5 mV. The A/Ds digitize signals at a rate of 1 kHz. The D/A output is ideal for controlling the frequency of the SR510/530's internal voltage-controlled oscillator. A built-in ratio feature allows the SR510/SR530 to calculate the ratio of its output to a signal at one of the A/D ports. This feature is important in servo applications to maintain a constant loop gain, or in experiments that normalize a signal to an intensity level.

Available Preamplifiers

Although the SR510 and SR530 are completely self contained and require no preamplification, sometimes an external preamplifier can be useful. Remote preamplifiers provide gain where it's most important—right at the detector, before the signal-to-noise ratio is permanently degraded by cable noise and pickup. The SR550 FET-input preamplifier, the SR552 bipolar-input preamplifier, and the SR554 transformer-input preamplifier are ideally suited for use with the SR510/SR530 lock-ins. These preamplifiers are especially useful when measuring extremely low-level signals.

Computer Interfaces

An RS-232 computer interface is standard on both the SR510 and SR530. An optional GPIB interface is also available. All features of the instruments can be queried and set via the computer interfaces.

Ordering Information

SR510	Single phase lock-in amplifier
SR530	Dual phase lock-in amplifier
Option 01	GPIB interface for SR510/SR530
Option 02	Internal oscillator
SR550	Voltage preamplifier (100 MΩ, 3.6 nV/√Hz)
SR552	Voltage preamplifier (100 kΩ, 1.4 nV/√Hz)
SR554	Transformer preamplifier (0.091 nV/√Hz)
SR555	Current preamplifier
SR556	Current preamplifier
SR540	Optical chopper

SR510 and SR530 rear panels (with Opt. 01 & Opt. 02)

SR510 and SR530 Specifications

Signal Channel

Inputs	
Voltage	Single-ended or differential
Current	10^6 V/A
Impedance	
Voltage	100 MΩ + 25 pF, AC coupled
Current	1 kΩ to virtual ground
Full-scale sensitivity	
Voltage	100 nV to 500 mV
Current	100 fA to 0.5 µA
Maximum inputs	
Voltage	100 VDC, 10 VAC damage threshold, 2 Vpp saturation
Current	10 µA damage threshold, 1 µApp saturation
Noise	
Voltage	7 nV/√Hz at 1 kHz (typ.)
Current	0.13 pA/√Hz at 1 kHz (typ.)
Common Mode	
Range	1 Vp
Rejection	100 dB (DC to 1 kHz, degrades by 6 dB/oct above 1 kHz)
Gain accuracy	1 % (2 Hz to 100 kHz)
Gain stability	200 ppm/°C
Signal filters	60 Hz notch, –50 dB (Q = 10, adjustable from 45 Hz to 65 Hz) 120 Hz notch, –50 dB (Q = 10, adjustable from 100 Hz to 130 Hz) Tracking band pass (Q = 5). Filter adds 20 dB to dynamic reserve.
Dynamic reserve	LOW (20 dB), 5 ppm/°C (1 µV to 500 mV sensitivity) NORM (40 dB), 50 ppm/°C (100 nV to 50 mV sensitivity) HIGH (60 dB), 500 ppm/°C (100 nV to 5 mV sensitivity)

Reference Channel

Frequency	0.5 Hz to 100 kHz
Input impedance	1 MΩ, AC coupled
Trigger	
Sine	100 mV minimum, 1 Vrms nominal
Pulse	±1 V, 1 µs minimum width
Mode	Fundamental (f), 2nd harmonic (2f)
Acquisition time	25 s (1 Hz ref.), 6 s (10 Hz ref.), 2 s (10 kHz ref.)
Slew rate	1 decade per 10 s at 1 kHz
Phase control	90° shifts, fine shifts in 0.025° steps
Phase noise	0.01° rms at 1 kHz (100 ms, 12 dB/oct rolloff time constant)
Phase drift	0.1°/°C
Phase error	Less than 1° above 10 Hz
Orthogonality*	90° ± 1°

Demodulator

Stability	5 ppm/°C (LOW reserve) 50 ppm/°C (NORM reserve) 500 ppm/°C (HIGH reserve)
Time constants	
Pre	1 ms to 100 s (6 dB/octave)
Post	1 s, 0.1 s, none (6 dB/octave)
Offset	Up to 1× full scale (10× on expand)
Harmonic rejection	–55 dB (band pass filter in)

Outputs and Interfaces

Channel 1 outputs	X (Rcosθ), X Offset, X Noise, R*, R Offset*, X5 (ext. D/A)*
Channel 2 outputs*	Y (Rsinθ), Y offset, θ, Y noise, X6 (ext. D/A)
Output meters	2 % precision analog meter
Output LCD	4-digit LCD display shows same value as the analog meter.
Output BNC	±10 V corresponds to full-scale input (<1 Ω output impedance)
Reference output	4-digit LCD display for reference phase or frequency
X1 to X4	4 analog inputs, 13-bit, ±10.24 V
X5, X6	2 analog outputs, 13-bit, ±10.24 V
X output*	X (Rcosθ), ±10 V, <1 Ω output impedance
Y output*	Y (Rsinθ), ±10 V, <1 Ω output impedance
Ratio	Ratio output equals 10× signal output divided by the denominator of the input.
Internal oscillator	
Range	1 Hz to 100 kHz
Accuracy	10 %
Stability	150 ppm/°C (frequency) 500 ppm/°C (amplitude)
Distortion	2 % THD
Amplitude	10 mVrms, 100 mVrms, 1 Vrms
Computer interfaces	RS-232 standard, GPIB optional. All instrument functions can be controlled and read through the interfaces.

General

Power	35 W, 100/120/220/240 VAC, 50/60 Hz
Dimensions	(SR510) 17" × 3.5" × 17" (WHD) (SR530) 17" × 5.25" × 17" (WHD)
Weight	12 lbs. (SR510), 16 lbs. (SR530)
Warranty	One year parts and labor on defects in materials and workmanship

** SR530 only*

Digital Lock-In Amplifiers

SR810 and SR830 — DSP lock-in amplifiers

SR830 DSP Lock-In Amplifier

SR810 & SR830 DSP Lock-In Amplifiers

- ***1 mHz to 102.4 kHz frequency range***
- ***>100 dB dynamic reserve***
- ***5 ppm/°C stability***
- ***0.01 degree phase resolution***
- ***Time constants from 10 μs to 30 ks (up to 24 dB/oct rolloff)***
- ***Auto-gain, -phase, -reserve and -offset***
- ***Synthesized reference source***
- ***GPIB and RS-232 interfaces***

The SR810 and SR830 DSP Lock-In Amplifiers provide high performance at a reasonable cost. The SR830 simultaneously displays the magnitude and phase of a signal, while the SR810 displays the magnitude only. Both instruments use digital signal processing (DSP) to replace the demodulators, output filters, and amplifiers found in conventional lock-ins. The SR810 and SR830 provide uncompromised performance with an operating range of 1 mHz to 102 kHz and 100 dB of drift-free dynamic reserve.

Input Channel

The SR810 and SR830 have differential inputs with 6 nV/√Hz input noise. The input impedance is 10 MΩ, and minimum full-scale input voltage sensitivity is 2 nV. The inputs can also be configured for current measurements with selectable current gains of 10^6 and 10^8 V/A. A line filter (50 Hz or 60 Hz) and a 2× line filter (100 Hz or 120 Hz) are provided to eliminate line related interference. However, unlike conventional lock-in amplifiers, no tracking band-pass filter is needed at the input. This filter is used by conventional lock-ins to increase dynamic reserve. Unfortunately, band pass filters also introduce noise, amplitude and phase error, and drift. The DSP design of these lock-ins has such inherently large dynamic reserve that no band pass filter is needed.

Extended Dynamic Reserve

The dynamic reserve of a lock-in amplifier, at a given full-scale input voltage, is the ratio (in dB) of the largest interfering signal to the full-scale input voltage. The largest interfering signal is defined as the amplitude of the largest signal at any frequency that can be applied to the input before the lock-in cannot measure a signal with its specified accuracy.

Conventional lock-in amplifiers use an analog demodulator to mix an input signal with a reference signal. Dynamic reserve is limited to about 60 dB, and these instruments suffer from poor stability, output drift, and excessive gain and phase error. Demodulation in the SR810 and SR830 is accomplished by sampling the input signal with a high-precision A/D converter, and multiplying the digitized input by a synthesized reference signal. This digital demodulation technique results in more than 100 dB of true dynamic reserve (no prefiltering) and is free of the errors associated with analog instruments.

Digital Filtering

The digital signal processor also handles the task of output filtering, allowing time constants from 10 µs to 30,000 s with a choice of 6, 12, 18 and 24 dB/oct rolloff. For low frequency measurements (below 200 Hz), synchronous filters can be engaged to notch out multiples of the reference frequency. Since the harmonics of the reference have been eliminated (notably 2F), effective output filtering can be achieved with much shorter time constants.

Digital Phase Shifting

Analog phase shifting circuits have also been replaced with a DSP calculation. Phase is measured with 0.01° resolution, and the X and Y outputs are orthogonal to 0.001°.

Frequency Synthesizer

The built-in direct digital synthesis (DDS) source generates a very low distortion (–80 dBc) reference signal. Single frequency sine waves can be generated from 1 mHz to 102 kHz with 4½ digits of resolution. Both frequency and amplitude can be set from the front panel or from a computer. When using an external reference, the synthesized source is phase locked to the reference signal.

Useful Features

Auto-functions allow parameters that are frequently adjusted to automatically be set by the instrument. Gain, phase, offset and dynamic reserve are quickly optimized with a single key press. The offset and expand features are useful when examining small fluctuations in a measurement. The input signal is quickly nulled with the auto-offset function, and resolution is increased by expanding around the relative value by up to 100×. Harmonic detection isn't limited to 2F — any harmonic (2F, 3F, ... nF) up to 102 kHz can be measured.

Analog Inputs and Outputs

Both instruments have a user-defined output for measuring X, R, X-noise, Aux 1, Aux 2, or the ratio of the input signal to an external voltage. The SR830 has a second, user-defined output that measures Y, θ, Y-noise, Aux 3, Aux 4 or ratio. The SR810 and SR830 both have X and Y analog outputs (rear panel) that are updated at 256 kHz. Four auxiliary inputs (16-bit ADCs) are provided for general purpose use — like normalizing the input to source intensity fluctuations. Four programmable outputs (16-bit DACs) provide voltages from –10.5 V to +10.5 V and are settable via the front panel or computer interfaces.

Internal Memory

The SR810 has an 8,000 point memory buffer for recording the time history of a measurement at rates up to 512 samples/s. The SR830 has two, 16k point buffers to simultaneously record two measurements. Data is transferred from the buffers using the computer interfaces. A trigger input is also provided to externally synchronize data recording.

Easy Operation

The SR810 and SR830 are simple to use. All functions are set from the front-panel keypad, and a spin knob is provided to quickly adjust parameters. Up to nine different instrument configurations can be stored in non-volatile RAM for fast and easy instrument setup. Standard RS-232 and GPIB (IEEE-488.2) interfaces allow communication with computers.

Ordering Information

SR830	DSP dual phase lock-in amplifier
SR810	DSP single phase lock-in amplifier
SR550	Voltage preamplifier (100 MΩ, 3.6 nV/√Hz)
SR552	Voltage preamplifier (100 kΩ, 1.4 nV/√Hz)
SR554	Transformer preamplifier (0.091 nV/√Hz)
SR555	Current preamplifier
SR556	Current preamplifier
SR540	Optical chopper

SR810 DSP Single Phase Lock-In Amplifier

SR810/830 rear panel

Signal Channel

Voltage inputs	Single-ended or differential
Sensitivity	2 nV to 1 V
Current input	10^6 or 10^8 V/A
Input impedance	
Voltage	10 MΩ + 25 pF, AC or DC coupled
Current	1 kΩ to virtual ground
Gain accuracy	±1 % (±0.2 % typ.)
Noise (typ.)	6 nV/√Hz at 1 kHz 0.13 pA/√Hz at 1 kHz (10^6 V/A) 0.013 pA/√Hz at 100 Hz (10^8 V/A)
Line filters	50/60 Hz and 100/120 Hz (Q = 4)
CMRR	100 dB to 10 kHz, decreasing by 6 dB/oct above 10 kHz
Dynamic reserve	>100 dB (without prefilters)
Stability	<5 ppm/°C

Reference Channel

Frequency range	0.001 Hz to 102.4 kHz
Reference input	TTL or sine (400 mVpp min.)
Input impedance	1 MΩ, 25 pF
Phase resolution	0.01° front panel, 0.008° through computer interfaces
Absolute phase error	<1°
Relative phase error	<0.001°
Orthogonality	90° ± 0.001°
Phase noise	
Internal ref.	Synthesized, <0.0001° rms at 1 kHz
External ref.	0.005° rms at 1 kHz (100 ms time constant, 12 dB/oct)
Phase drift	<0.01°/°C below 10 kHz, <0.1°/°C above 10 kHz
Harmonic detection	2F, 3F, ... nF to 102 kHz (n < 19,999)
Acquisition time	(2 cycles + 5 ms) or 40 ms, whichever is larger

Demodulator

Stability	Digital outputs and display: no drift Analog outputs: <5 ppm/°C for all dynamic reserve settings
Harmonic rejection	–90 dB
Time constants	10 µs to 30 ks (6, 12, 18, 24 dB/oct rolloff). Synchronous filters available below 200 Hz.

Internal Oscillator

Range	1 mHz to 102 kHz
Frequency accuracy	25 ppm + 30 µHz
Frequency resolution	4½ digits or 0.1 mHz, whichever is greater
Distortion	–80 dBc (f < 10 kHz), –70 dBc (f > 10 kHz) @ 1 Vrms amplitude
Amplitude	0.004 to 5 Vrms into 10 kΩ (2 mV resolution), 50 Ω output impedance, 50 mA maximum current into 50 Ω
Amplitude accuracy	1 %
Amplitude stability	50 ppm/°C
Outputs	Sine, TTL (When using an external reference, both outputs are phase locked to the external reference.)

Displays

Channel 1	4½-digit LED display with 40-segment LED bar graph. X, R, X-noise, Aux 1 or Aux 2. The display can also be any of these quantities divided by Aux 1 or Aux 2.
Channel 2 (SR830)	4½-digit LED display with 40-segment LED bar graph. Y, θ, Y-noise, Aux 3 or Aux 4. The display can also be any of these quantities divided by Aux 3 or Aux 4.
Offset	X, Y, R can be offset up to ±105 % of full scale.
Expand	X, Y, R can be expanded by 10× or 100×
Reference	4½-digit LED display

Inputs and Outputs

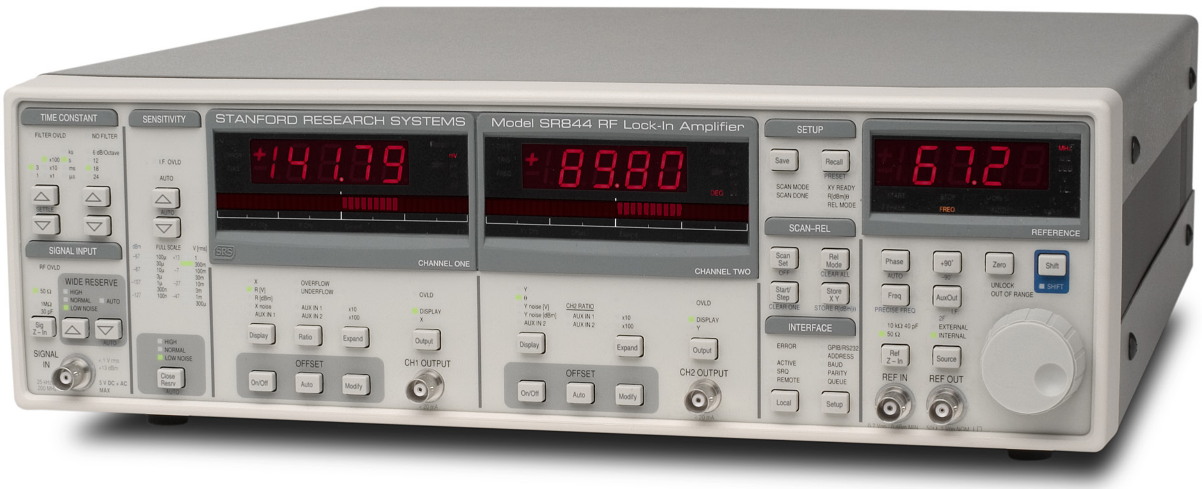
CH1 output	X, R, X-noise, Aux 1 or Aux 2 (±10 V), updated at 512 Hz.
CH2 output (SR830)	Y, θ, Y-noise, Aux 3 or Aux 4 (±10 V), updated at 512 Hz.
X, Y outputs (rear panel)	In-phase and quadrature components (±10 V), updated at 256 kHz
Aux. A/D inputs	4 BNC inputs, 16-bit, ±10 V, 1 mV resolution, sampled at 512 Hz
Aux. D/A outputs	4 BNC outputs, 16-bit, ±10 V, 1 mV resolution
Sine out	Internal oscillator analog output
TTL out	Internal oscillator TTL output
Data buffer	The SR810 has an 8k point buffer. The SR830 has two 16k point buffers. Data is recorded at rates to 512 Hz and read through the computer interfaces.
Trigger in (TTL)	Trigger synchronizes data recording
Remote preamp	Provides power to the optional SR55X preamps

General

Interfaces	IEEE-488.2 and RS-232 interfaces standard. All instrument functions can be controlled and read through IEEE-488.2 or RS-232 interfaces.
Power	40 W, 100/120/220/240 VAC, 50/60 Hz
Dimensions	17" × 5.25" × 19.5" (WHD)
Weight	23 lbs.
Warranty	One year parts and labor on defects in materials and workmanship

High Frequency Lock-In Amplifier

SR844 — 200 MHz dual phase lock-in amplifier



SR844 200 MHz Lock-In Amplifier

- ***25 kHz to 200 MHz frequency range***
- ***80 dB dynamic reserve***
- ***Time constants from 100 μs to 30 ks (6, 12, 18 or 24 dB/oct rolloff)***
- ***"No Time Constant" mode (10 μs to 20 μs update rate)***
- ***Auto-gain, -phase, -reserve and -offset***
- ***Two 16-bit DACs and ADCs***
- ***Internal or external reference***
- ***GPIB and RS-232 interfaces***

The SR844 is the widest bandwidth lock-in amplifier available. It provides uncompromised performance with a frequency range of 25 kHz to 200 MHz and up to 80 dB of drift-free dynamic reserve. It includes the many features, ease of operation, and programmability that you've come to expect from SRS DSP lock-in amplifiers.

Digital Technology

The SR844 uses the same advanced DSP technology found in the SR850, SR830 and SR810 lock-in amplifiers. DSP offers many advantages over analog instruments — high dynamic reserve, low zero-drift, accurate RF phase shifts and orthogonality, and digital output filtering.

Signal Input

The SR844 has both 50 Ω and 1 MΩ inputs. The 1 MΩ input is used with high source impedances at low frequencies, or with a standard 10× scope probe. The 50 Ω input provides the best RF signal matching. Up to 60 dB of RF attenuation or 20 dB of RF gain can be selected in 20 dB increments. Full-scale sensitivities range from 1 Vrms (+13 dBm) to 100 nVrms (–127 dBm). Gain allocation can be optimized to provide up to 80 dB of dynamic reserve.

Reference

The SR844 offers both external and internal reference operation. In both cases, the entire 25 kHz to 200 MHz frequency range is covered without any manual range selection. The external reference input has an auto-threshold feature which locks to sine, square or pulsed signals. The internal reference is digitally synthesized and is adjustable with 3-digit frequency resolution.

Harmonic detection of the 2F component is available for both internal and external reference modes.

A reference output (1.0 Vpp square wave into 50 Ω), which is phase synchronous with the lock-in reference, is available in both external and internal mode.

Output Filters

Time constants from 100 µs to 30 ks can be selected with a choice of 6, 12, 18 or 24 dB/oct rolloff. For high-bandwidth, real-time outputs, the filtering can be by-passed entirely. In this "No Filter" mode, the effective time constant is about 30 µs, with the analog outputs updating every 10 to 20 µs.

Ease of Operation

The SR844 is easy to use. All instrument functions are set from the front-panel keypad, and the knob is used to quickly adjust parameters. Up to nine different instrument configurations can be stored in non-volatile memory for fast, reliable instrument setup. Standard RS-232 and GPIB (IEEE-488.2) interfaces provide connections to your data acquisition systems.

Useful Features

Auto-functions allow parameters that are frequently adjusted to be set automatically. Sensitivity, dynamic reserve, phase and offset are each quickly optimized with a simple key stroke.

The offset and expand features are useful for evaluating small fluctuations in your signal. The input is nulled with the auto-offset function, and output expand increases the resolution by up to 100×.

Ratio mode is used to normalize the signal to an externally applied analog voltage. It is useful to eliminate the effect of source intensity fluctuations.

Transfer function measurements can be easily made from the front panel by a programmable scan of up to 11 frequencies. Setups and offsets are recalled at each frequency in the scan.

Analog Inputs and Outputs

The two displays each have a user-defined output for measuring X, Y, R, R(dBm), θ, and X-noise or Y-noise. Two user-programmable DACs provide –10.5 V to +10.5 V outputs with 1 mV resolution. These outputs may be set from the front panel or via the computer interfaces.

In addition, there are two general-purpose analog inputs. These are 16-bit ADCs which can be displayed on the front panel, read over the interface, or used to ratio the input signal.

Internal Memory

The SR844 has two 16,000 point memory buffers for recording (rates to 512 samples/s) the time history of each displayed measurement. Data may be transferred from the buffers using either interface. A trigger input is also provided to synchronize data recording with external events.

Ordering Information

SR844	200 MHz dual phase lock-in amplifier
SR445A	Voltage preamplifier (350 MHz, 4 channel)

SR844 rear panel

SR844 Specifications

Signal Channel

Voltage input	Single-ended BNC
Input impedance	50 Ω or 1 MΩ + 30 pF
Damage threshold	±5 V (DC + AC)
Bandwidth	25 kHz to 200 MHz
Sensitivity	
<1 MHz	100 nVrms to 1 Vrms full scale
<50 MHz	1 µVrms to 1 Vrms full scale
<200 MHz	10 µVrms to 1 Vrms full scale
Gain accuracy	
<50 MHz	±0.25 dB
<200 MHz	±0.50 dB
Gain stability	0.2 %/°C
Coherent pickup	Low-noise reserve, sens. <30 mV
f < 10 MHz	<100 nV (typ.)
f < 50 MHz	<2.5 µV (typ.)
f < 200 MHz	<25 µV (typ.)
Input noise (50 Ω)	2 nV/√Hz (typ.), <8 nV/√Hz (max.)
Input noise (1 MΩ)	5 nV/√Hz (typ.), <8 nV/√Hz (max.)
Dynamic reserve	up to 80 dB

Reference Channel

External reference	25 kHz to 200 MHz
Impedance	50 Ω or 10 kΩ + 40 pF
Level	0.7 Vpp pulse or 0 dBm sine
Pulse width	>2 ns at any frequency
Threshold setting	Automatic, midpoint of waveform
Acquisition time	<10 s (auto-ranging, any frequency) <1 s (within same octave)
Internal reference	25 kHz to 200 MHz
Freq. resolution	3 digits
Freq. accuracy	±0.1 in the 3rd digit
Harmonic detection	2F (50 kHz to 200 MHz)
Reference outputs	Phase locked to int./ext. reference
Front panel	25 kHz to 200 MHz square wave 1.0 Vpp nominal into 50 Ω
Rear panel (TTL)	25 kHz to 1.5 MHz, 0 to +5 V nominal, ≥3 V into 50 Ω
Phase resolution	0.02°
Absolute phase error	
<50 MHz	<2.5°
<100 MHz	<5.0°
<200 MHz	<10.0°
Rel. phase error, orthog.	<2.5°
Phase noise (external)	0.005° rms at 100 MHz, 100 ms time constant
Phase drift	
<10 MHz	<0.1°/°C
<100 MHz	<0.25°/°C
<200 MHz	<0.5°/°C

Demodulator

Zero stability	Digital displays have no zero-drift. Analog outputs have <5 ppm/°C drift for all dyn. reserve settings.
Time constants	100 µs to 30 ks with 6, 12, 18 or 24 dB/octave rolloff
"No Filter" mode	10 to 20 µs update rate (X and Y)
Harmonic rejection	
Odd harmonics	–9.5 dBc @ 3 × ref, –14 dBc @ 5 × ref, etc. (20 log 1/n, n = 3, 5, 7...)
Even harmonics	<–40 dBc
Sub-harmonics	<–40 dBc
Spurious responses	–10 dBc @ ref ± 2 × IF –23 dBc @ ref ± 4 × IF <–30 dBc otherwise

Displays

Channel 1	
Type	4½-digit LED and 40-seg. bar graph
Quantities	X, R (V or dBm), X-noise, Aux In 1
Channel 2	
Type	4½-digit LED and 40-seg. bar graph
Quantities	Y, θ, Y-noise (V or dBm), Aux In 2
Expand	×10 or ×100 for Ch1 and Ch2
Ratio	X and Y ratioed with respect to Aux In 1 or Aux In 2 before filtering and computation of R. The ratio input is normalized to 1 V and has a dynamic range greater than 100.
Reference	
Type	4½-digit LED
Quantities	Ref Freq, Phase, Offsets, Aux Out, IF Freq, Elapsed Time

Channel 1 and Channel 2 Outputs

Voltage range	±10 V full scale proportional to X, Y or CH1, CH2 displayed quantity
Update rate	
X, Y	48 to 96 kHz
R, θ, Aux inputs	12 to 24 kHz
X-noise, Y-noise	512 Hz

Auxiliary Inputs and Outputs

Inputs	2
Type	Differential, 1 MΩ
Range	±10 V
Resolution	0.33 mV
Bandwidth	3 kHz
Outputs	2
Range	±10 V
Resolution	1 mV
Data buffers	Two 16,000 point buffers. Data is recorded at rates up to 512 Hz and is read using computer interfaces.

General

Interfaces	IEEE-488.2 and RS-232 interfaces are standard.
Power	70 W, 100/120/220/240 VAC, 50/60 Hz
Dimensions	17" × 5.25" × 19.5" (WHD)
Weight	23 lbs.
Warranty	One year parts and labor on defects in materials and workmanship

Digital Lock-In Amplifiers

SR850 — DSP lock-in amplifier with graphical display

SR850 DSP Lock-In Amplifier

- ***1 mHz to 102.4 kHz frequency range***
- ***>100 dB dynamic reserve***
- ***0.001 degree phase resolution***
- ***Time constants from 10 μs to 30 ks (up to 24 dB/oct rolloff)***
- ***Auto-gain, -phase, -reserve and -offset***
- ***Data logging (up to 65k samples)***
- ***Smoothing, curve fitting & statistics***
- ***GPIB & RS-232 interfaces***

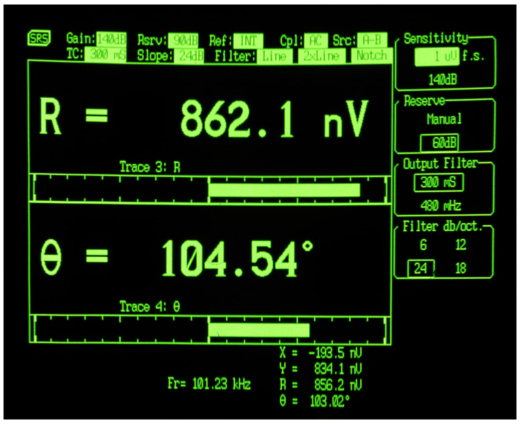
The SR850 is a digital lock-in amplifier based on an innovative DSP (Digital Signal Processing) architecture. The SR850 boasts a number of significant performance advantages over traditional lock-in amplifiers—higher dynamic reserve, lower drift, lower distortion, and dramatically higher phase resolution. In addition, the CRT display and 65,536 point memory make it possible to display and process data in a variety of formats unavailable with conventional lock-ins.

Digital Precision

At the input of the SR850 is a precision 18-bit A/D converter which digitizes the input signal at 256 kHz. The A/D converter, together with a high-speed DSP chip, replace the analog demodulator (mixer), low-pass filters and DC amplifiers found in conventional lock-ins. Instead of using analog components, the SR850 is implemented by a series of precise mathematical calculations which eliminate the drift, offset, non-linearity and aging inherent in analog components. The same DSP chip digitally synthesizes the reference oscillator, providing a source with less than –80 dBc distortion, 100 mHz frequency resolution, and 2 mV of amplitude resolution.

Digital Flexibility

The SR850 has a 7" CRT display which supports a large selection of display options. Data can be viewed numerically or graphically in bar graph, polar plot and strip chart formats. With 65,536 points of memory and data acquisition rates up to 512 Hz, you are able to see exactly how your data changes in time—not just what the current output value is. After the data has been acquired, the SR850 offers a variety of data reduction options, such as Savitsky-Golay smoothing, curve-fitting and statistical analysis. A built-in 3.5” disk drive, along with standard RS-232 and GPIB interfaces, makes it easy to transfer data to your computer.



Large numeric readout with bar graph

Input Channel

The SR850 has a differential input with 6 nV/√Hz input noise. The input impedance is 10 MΩ, and minimum full-scale input voltage sensitivity is 2 nV. The input can also be configured for current measurements with selectable current gains of 10^6 and 10^8 V/A. A line filter (50 Hz or 60 Hz) and a 2× line filter (100 Hz or 120 Hz) are provided to eliminate line related interference. However, unlike conventional lock-in amplifiers, no tracking band-pass filter is needed at the input of the SR850. This filter is used by conventional lock-ins to increase dynamic reserve. Unfortunately, band-pass filters also introduce noise, amplitude and phase error, and drift. The DSP based design of the SR850 has such inherently large dynamic reserve that no tracking band-pass filter is needed.

Reference Channel

The reference source for the SR850 can be an externally applied sine wave or square wave, or its own digitally synthesized reference source. Because the internal reference source is synthesized from the same digital signal that is used to multiply the input, there is virtually no reference phase noise when using the internal reference. The internal reference can operate at a fixed frequency or can be swept linearly or logarithmically over the entire operating range of 1 mHz to 102.4 kHz. Harmonic detection can be performed at any integer harmonic of the reference frequency—not just the first few harmonics.

The DSP approach also offers considerable advantages when working with an external reference. The time to acquire an external reference is only 2 cycles + 5 ms (or 40 ms, whichever is greater)—about ten times faster than conventional lock-ins.

Because the SR850 uses a digital phase-shifting technique rather than analog phase-shifters, the reference phase can be adjusted with one millidegree resolution. In addition, the X and Y outputs are orthogonal to within one millidegree.

Outputs and Time Constants

The output time constants on the SR850 are implemented digitally. Low-pass-filter rolloffs of 6, 12, 18 and 24 dB/octave are available, with time constants ranging from 10 µs to 30 ks. Below 200 Hz, the SR850 can perform synchronous filtering. Synchronous filters notch out multiples of the reference frequency—an especially useful feature at low frequencies where the proximity of the 2f component would otherwise require a long time constant for effective filtering. The SR850 makes working at low frequencies a far less time consuming task.

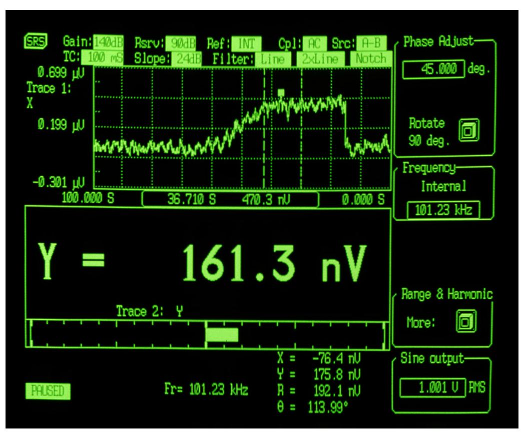
High Dynamic Reserve

The dynamic reserve of a lock-in amplifier at a given full-scale input voltage is the ratio (in dB) of the largest interfering signal to the full-scale input voltage. The largest interfering signal is defined as the amplitude of the largest signal at any frequency that can be applied to the input before the lock-in cannot measure a signal with its specified accuracy.

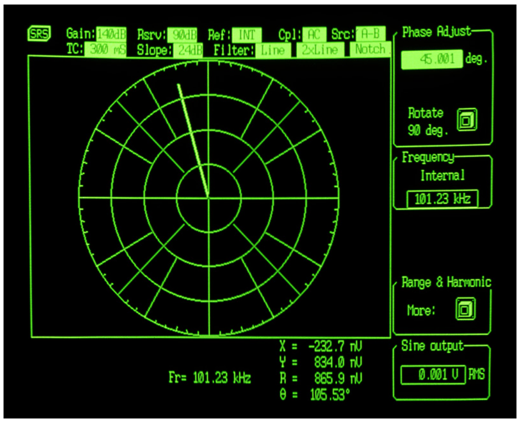
The SR850 has the highest dynamic reserve (>100 dB) of any lock-in available. In conventional lock-in amplifiers, dynamic reserve is increased at the expense of stability. Because of the digital nature of the filtering and gain process in the SR850, the ultra-high dynamic reserve is obtained without any sacrifice in stability or accuracy. In addition, the SR850’s high dynamic reserve is obtained without the use of analog band-pass filters, eliminating the noise and error that such filters introduce.

Traces and Displays

Data acquired by the SR850 is stored in up to four user-defined traces. Each trace can be configured as (A × B) / C, where A, B and C are selected from X, Y, R, θ, noise, frequency or any of the four rear-panel auxiliary inputs. Common operations, such as ratioing, can be performed in real time by



Graphical, numerical, and bar-graph display defining an appropriate trace. Trace values can be displayed as a bar graph with an associated large numerical display, or as a strip chart showing the trace values as a function of time. Additionally, you can display polar plots showing the phasor formed by the in-phase and quadrature components of the signal. All displays can be easily scaled from the front panel or over the computer interfaces, and an auto-scale feature is available to quickly optimize the display. The screen can be configured as a single large display, or as two horizontally-split displays.



Polar plot display

Convenient Auto Measurements

Common measurement parameters are available as single-key “auto” functions. The gain, phase, dynamic reserve and display scaling can all be set with a single key press. For many measurements, the instrument can be completely configured simply by using the auto functions.

Auxiliary A/Ds and D/As

Four rear-panel A/D inputs allow you to measure external signals with millivolt resolution. The measured values can be incorporated into one of the SR850’s trace definitions, or can be displayed on the front panel, or read via either computer interface. Four D/A outputs can provide either fixed output voltages or a voltage level which scans synchronously with the SR850’s frequency scans. Both the A/D inputs and the D/A outputs have a ±10 V range.

Analysis Features

The SR850’s performance doesn’t stop once data has been acquired—a full set of data processing features is also included. Multiple-range Savitsky-Golay smoothing can be applied to any of the trace arrays, and statistical information (mean, variance, sum) can be calculated for a selected trace region. A curve fitting routine calculates best fits to lines, exponential curves, and Gaussian curves for any portion of your data. And a trace “calculator” lets you perform a variety of simple arithmetic and trigonometric operations on trace data.

Interfaces and Hardcopies

The SR850 comes standard with RS-232 and GPIB interfaces. All instrument functions can be queried and controlled via the interfaces. For convenient debugging, characters received and sent via the interfaces can be viewed on the front panel. Several hardcopy options are available on the SR850. Screens can be dumped to a dot-matrix or LaserJet compatible printer through the standard Centronics printer interface. Displays can also be plotted on any HP-GL compatible plotter via GPIB or RS-232.

Ordering Information

SR850	DSP dual phase lock-in amplifier
SR550	Voltage preamplifier (100 MΩ, 3.6 nV/√Hz)
SR552	Voltage preamplifier (100 kΩ, 1.4 nV/√Hz)
SR554	Transformer preamplifier (0.091 nV/√Hz)
SR555	Current preamplifier
SR556	Current preamplifier
SR540	Optical chopper

SR850 rear panel

SR850 Specifications

Signal Channel

Voltage inputs	Single-ended or differential
Sensitivity	2 nV to 1 V
Current input	10^6 or 10^8 V/A
Input impedance	
Voltage input	10 MΩ + 25 pF, AC or DC coupled
Current input	1 kΩ to virtual ground
Gain accuracy	±1 % (±0.2 % typ.)
Noise (typ.)	6 nV/√Hz at 1 kHz 0.13 pA/√Hz at 1 kHz (10^6 V/A) 0.013 pA/√Hz at 100 Hz (10^8 V/A)
Line filters	50/60 Hz and 100/120 Hz (Q = 5)
CMRR	100 dB at 10 kHz, decreasing by 6 dB/oct above 10 kHz
Dynamic reserve	>100 dB (without prefilters)

Reference Channel

Frequency range	0.001 Hz to 102.4 kHz
Reference input	TTL or sine (400 mVpp min.)
Input impedance	1 MΩ, 25 pF
Phase resolution	0.001°
Absolute phase error	<1°
Relative phase error	<0.001°
Orthogonality	90° ± 0.001°
Phase noise	
Int. reference	<0.0001° rms at 1 kHz
Ext. reference	0.005° rms at 1 kHz, 100 ms, 12 dB/oct
Phase drift	<0.01°/°C below 10 kHz, <0.1°/°C, 10 kHz to 100 kHz
Harmonic detection	2F, 3F, ... nF to 102.4 kHz
Acquisition time	(2 cycles + 5 ms) or 40 ms, whichever is greater

Demodulator

Stability	
Digital outputs	no drift
Analog outputs	<5 ppm/°C for all dynamic reserves
Harmonic rejection	–90 dB
Offset/Expand	±100 % offset, expand up to 256×
Time constants	10 µs to 30 ks (6, 12, 18, 24 dB/oct rolloff) Sync. filtering available below 200 Hz

Internal Oscillator

Range	1 mHz to 102.4 kHz
Accuracy	25 ppm + 30 µHz
Resolution	0.01 % or 0.1 mHz (whichever is greater)
Distortion	–80 dBc (f < 10 kHz) –70 dBc (f > 10 kHz) at 1 Vrms
Amplitude	0.004 Vrms to 5 Vrms into 10 kΩ (2 mV resolution)
Output impedance	50 Ω
Amplitude accuracy	1 %
Amplitude stability	50 ppm/°C
Outputs	Sine and TTL (both can be phase-locked to an external reference)
Sweeps	Linear and log

Inputs and Outputs

Interfaces	IEEE-488.2, RS-232 and Centronics interfaces standard. All instrument functions can be controlled and read though the interfaces.
X, Y outputs	±10 V, updated at 256 ksamples/s
CH1 output	±10 V output of X, R or Trace 1 to 4
CH2 output	±10 V output of Y, θ or Trace 1 to 4
Aux. A/D inputs	4 BNC inputs, 1 mV res., ±10 V
Aux. D/A outputs	4 BNC outputs, 1 mV resolution, ±10 V (fixed or swept amplitude)
Sine out	Internal oscillator analog output
TTL out	Internal oscillator TTL output
Trigger In	TTL signal starts internal oscillator sweep or triggers instrument data taking (rates to 512 Hz).
Remote pre-amp	Provides power to the optional SR55X preamps

Displays

Screen format	Single or dual display
Displayed quantities	Each display shows one trace. Traces are defined as $A \times B / C$ or $A \times B / C^2$ where A, B, C are selected from X, Y, R, θ, X-noise, Y-noise, R-noise, Aux 1 to 4 or frequency.
Display types	Large numeric readout, bar graph, polar plot and strip chart
Data buffer	64k data points. Buffer is configured as a single trace with 64k points, two traces with 32k points each, or four traces with 16k points each.
Sample rate	0.0625 to 512 Hz, external to 512 Hz

Analysis Functions

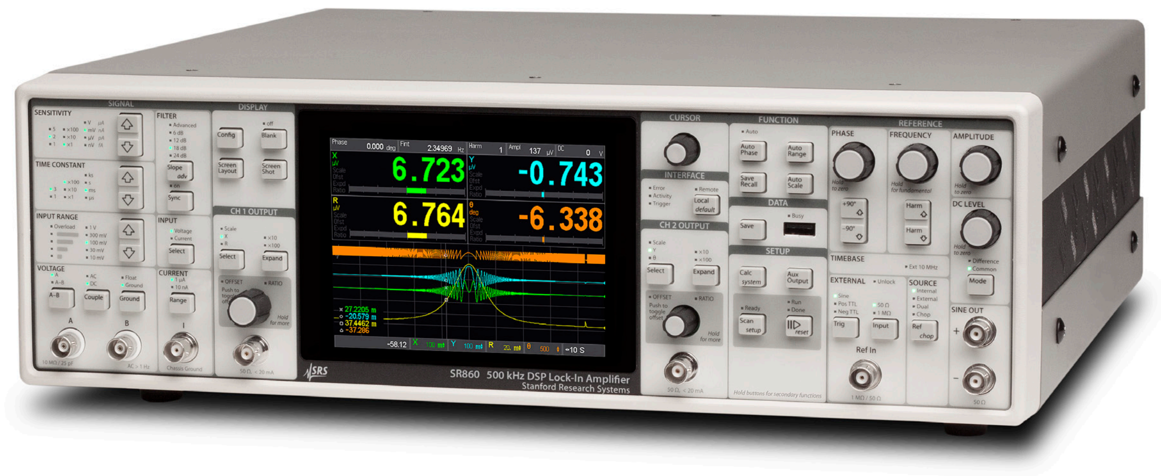
Smoothing	5, 9, 17, 21, 25 pt. (Savitsky-Golay)
Curve fitting	Linear, exponential or Gaussian
Calculator	Arithmetic, trigonometric and logarithmic calculations
Statistics	Mean and standard deviation

General

Hardcopy	Screen dumps to dot-matrix or LaserJet printers. Plots to HP-GL plotters (RS-232 or GPIB).
Disk drive	USB drive. Storage of data and instrument setups (binary or ASCII). Screens can be saved as PCX files.
Power	60 W, 100/120/220/240 VAC, 50/60 Hz
Dimensions	17" × 6.25" × 19.5" (WHD)
Weight	40 lbs.
Warranty	One year parts and labor on defects in materials and workmanship

500 kHz Lock-In Amplifier

SR860 — 500 kHz dual phase lock-in amplifier



SR860 500 kHz Lock-In Amplifier

- **1 mHz to 500 kHz frequency range**
- **Low-noise current and voltage inputs**
- **Touchscreen data display - large numeric results, chart recordings, & FFT displays**
- **10 MHz timebase input and output**
- **Dual reference mode**
- **GPIB, RS-232, Ethernet and USB**
- **HDMI video output**

Superb performance. Outstanding value. They're what you've come to expect from a Stanford Research Systems lock-in amplifier. And they're delivered by the new SR860 500 kHz Lock-in Amplifier, the latest in a line of innovative lock-ins from SRS. With unparalleled analog performance, sophisticated new digital signal processing features, a thoroughly modern, intuitive user interface, and a wide range of computer connectivity options, the SR860 is the ideal choice for any synchronous detection application.

With over 30 years of lock-in design experience SRS has made every effort to optimize each detail of the SR860. From a hefty toroidal transformer that eliminates switch-mode noise to iOS connectivity that brings the lock-in to your cell phone to advanced DSP filters that eliminate more noise while speeding up your experiment, the SR860 is truly the ultimate lock-in amplifier.

Signal Inputs

Lock-in performance starts at the front end. The SR860 front end offers both state-of-the art voltage and current input amplifiers. The voltage input is a switchable single-ended/ differential JFET-pair amplifier with 2.5 nV/√Hz of noise at 1 kHz and under 10 nV/√Hz of noise at 10 Hz. The voltage input has a 10 MΩ input impedance and can be AC or DC coupled. Input connector shields can be connected to the instrument ground through a user selectable 10 Ω (Ground) or 10 kΩ (Float) resistor.

SRS current source and several SRS preamplifiers

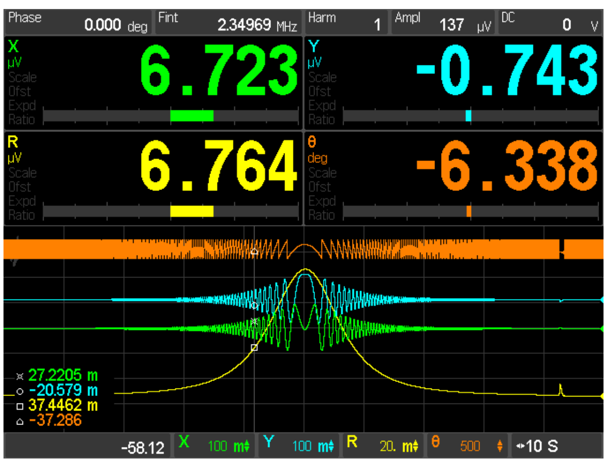
The SR860's built-in current amplifier represents a significant improvement over previous designs. The current input range is selectable from 1 µA or 10 nA. The 1 µA range has 400 kHz of bandwidth and 130 fA/√Hz of noise, while the 10 nA range offers 2 kHz of bandwidth and 13 fA/√Hz of noise.

While the built in voltage and current amplifiers are suitable for most applications, the SR860 is also compatible with the complete range of specialized pre-amplifiers offered by SRS. The SR550 (FET input), SR552 (BJT input), SR554 (transformer input), SR555 (120 kHz current amp), and SR556 (low-noise current amp) can all be powered directly from the SR860's rear-panel preamp power port. The SRS website shows you how each of these preamps can be used to optimize measurements in a wide variety of experimental situations.

Sensitivity and Input Range

As with previous instruments, the Sensitivity setting of the SR860 is the voltage (or current) which produces a full scale output. But unlike previous designs, the input range of the SR860 can be explicitly set from the front panel without having to consult a confusing "dynamic reserve" equation. Simply choose the sensitivity required by your experiment and then select the smallest input range that doesn't overload. That's it.

The SR860's effective dynamic reserve is simply the ratio of these two settings. For instance with a 10 nV sensitivity setting and a 300 mV input range the effective dynamic reserve of the SR860 is 3×10^7, or nearly 150 dB.



Large numeric readout with strip chart recording

Output Time Constants and Filtering

The SR860 offers traditional RC-response output time constants from 1 µs to 30 ks with rolloffs of 6, 12, 18, and 24 dB/oct. But in addition, the SR860 also offers advanced digital filters which can significantly reduce measurement time while increasing signal to noise. Below 3 s, the advanced filters are Gaussian FIR filters which at the same noise bandwidth as an RC filter have significantly better rise-time and stopband attenuation. These filters also have symmetric rise and fall profiles which preserves feature shapes while scanning in frequency. At time constants longer than 3 s, the advanced filters are linear phase IIR filters which settle nearly twice as fast as their RC counterparts for equivalent stopband attenuation.

Synchronous filtering may also be selected at reference frequencies below 4 kHz. The synchronous filter notches out multiples of the reference frequency and is extremely useful in making low frequency measurement where multiples of the reference frequency would otherwise show up in the lock-in output. Unlike previous designs the synchronous filter in the SR860 can be selected with no loss of output resolution.

SR540 Optical Chopper

Reference Channel

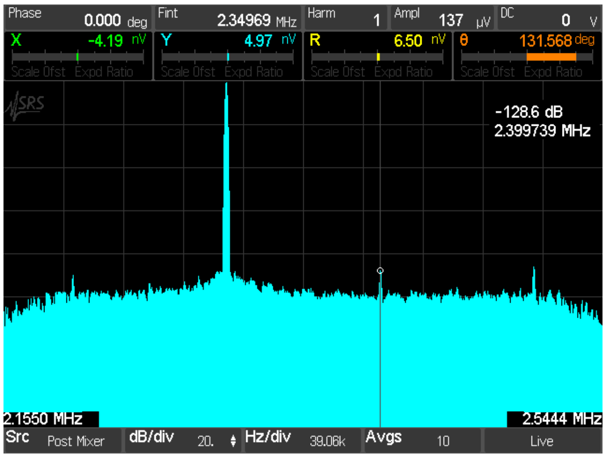
The SR860 has a specified reference frequency range of 1 mHz to 500 kHz. Detection can be done at the fundamental of the reference frequency, or at up to the 99th harmonic. Several reference modes are available: Internal mode uses the SR860's precision internal oscillator as the reference. External mode locks to an external sine or TTL signal. In Dual Mode, the lock-in detects at the difference frequency between the internally set reference frequency and an externally applied sync signal allowing direct recovery of a double-modulated signal. Finally, in Chop mode, the SR860 provides a digital PID (Proportional-Integral-Derivative) controller signal to synchronize an SR540 Optical Chopper to the internal oscillator of the lock-in. By having the lock-in directly control the chopper, frequency drift can be virtually eliminated.

Sine Output

The SR860 offers a precision sine wave output which can be set with 6 digits of frequency resolution and an amplitude range from 1 nV to 2 V. The SR860 output is unique in that it can be configured as a single-ended or as a differential (balanced) signal. A DC offset of up to ±5 V can be applied to the sine output. A rear-panel logic-level sync signal synchronized to the sine output is also provided.

Timebase

Rear-panel 10 MHz inputs and outputs are provided allowing the SR860 to be locked to an external frequency reference (such as the FS725 10 MHz Rubidium Frequency Standard). Alternatively, the 10 MHz output from the SR860 can be used to synchronize several lock-ins or other test equipment with a 10 MHz timebase input.



FFT display

FFT Displays

Lock-in amplifiers are traditionally time-domain instruments but sometimes it's easier to understand a signal in the frequency domain. The SR860 is at home in both worlds. An FFT display shows the spectrum of the input signal at the front end, the post-mixer signal, or the spectrum of the signal after the time-constant filters. Using the FFT displays can simplify tracking down sneaky noise sources that would otherwise get lost in the "one-number" output of a conventional lock-in amplifier.

Trend analysis

Front-Panel Touchscreen Display

The center of the SR860's front panel is a full-color 640 × 480 touchscreen which can be set to display up to 4 channels of data. (When a dark lab is required, the LCD screen can be blanked from the front panel or from the remote interface.) Each data channel can be configured to display X, Y, R, Θ, Aux In (1-4), Aux Out (1-2), X noise, Y noise, Sine Amplitude, Sine Out DC Level, Reference Phase, or Reference Frequency. The screen can be set up to show the data channels as large numbers, easily visible from across the room, or as a "strip-chart" display showing a complete history of each channel with selectable time scales from 0.5 s/div to 2 days/div. Even when not displaying a measurement, all measurements are always being saved by the SR860 insuring that no data is ever lost. The touchscreen also continually displays key lock-in setup parameters such as phase, reference frequency, and sine amplitude. And a rear-panel HDMI port allows the LCD screen to be viewed on any HDMI monitor or TV.

It should be emphasized that as useful as the touchscreen display is for displaying data, it's not necessary to use the touchscreen to control common instrument functions on the SR860. All commonly used controls: time constant, reference frequency, sine amplitude and offset, input configuration, and more, are controllable with dedicated front panel knobs or buttons. Infrequently accessed configuration settings, such as the TCP/IP settings and other communication settings, are accessed through menus shown on the touchscreen.

Computer Connectivity

The SR860 comes standard with virtually every remote interface imaginable. GPIB (IEEE488.2) and RS-232 are of course provided, as well as USB (Test and Measurement Class) and Ethernet (VXI-11 and telnet). The SR860 hosts its own webserver allowing the instrument to be monitored and controlled remotely with just a browser.

A front-panel USB port allows data and screen-shots to a USB flash drive. Data can be saved either as comma delimited files or MATLAB compatible .MAT files. Incorporating screen shots and data into reports or spreadsheets has never been easier.

SR860 Specifications

Signal Channel

Voltage inputs	Single-ended or differential
Sensitivity (output scale)	1 nV to 1 V (voltage input) 1 fA to 1 µA (current input)
Voltage input range	10 mV to 1 V (peak)
Current input range	1 µA or 10 nA (peak)
Max input	1 V (peak) or 1 µA (peak)
Input impedance	
Voltage input	10 MΩ + 25 pF, AC or DC coupled
Current input	1 kΩ or 100 Ω to virtual ground
Gain accuracy	±1 % (<200 kHz) Signal amplitude must be less than 30 % of input range
Noise (rms)	2.5 nV/√Hz at 1 kHz (10 mV input range, typ.)
Harmonic distortion	–80 dB (<100 kHz), –60 dB (>100 kHz)
CMRR	90 dB to 1 kHz (DC coupled, 10 mV to 100 mV input range)
Dynamic reserve	120 dB (typ)

Reference Channel

Frequency range	0.001 Hz to 500 kHz
Timebase	10 MHz In/Out (phase locks the internal frequency to other SR860s)
Input impedance	1 MΩ or 50 Ω
Phase setting resolution	$360/2^{32}$ degrees
Phase noise	
Int. ref	<0.0001° rms at 1 kHz (100 ms, 12 dB/oct)
Ext. ref (typ)	<0.001° rms at 1 kHz (100 ms, 12 dB/oct)
Phase drift (typ)	<0.002°/°C below 20 kHz (DC coupled) <0.02°/°C below 200 kHz <0.2°/°C below 2 MHz
Harmonic detection	Detect at $N \times f_{ref}$ ($N<99$ and $(N \times f_{ref})<2$ MHz)
Dual F reference	Detect at $f_{dual} = \lvert f_{int} - f_{ext} \rvert$
Chopper reference	SR860 drives SR540 Chopper (via Aux Out 4) to lock the chopper to f_{int}

Demodulator

DC stability	Digital output values have no drift
Time constants	1 µs to 30 ks
Low pass filters	Typical RC-type filters or advanced Gaussian/Phase-Linear filters
Filter slope	6, 12, 18 or 24 dB/oct rolloff
Synchronous filter	Available below 4 kHz
Harmonic rejection	–80 dB
Low latency output	Rear-panel BlazeX output with <2 µs delay (plus LPF rise/fall times).

Internal Oscillator

Frequency range	0.001 Hz to 500 kHz
Frequency accuracy	25 ppm + 30 µHz (with internal timebase)
External timebase	10 MHz timebase input/output (on rear panel)
Frequency resolution	6 digits or 0.1 mHz, whichever is greater

Sine Output

Outputs	Single-ended or differential
Output impedance	50 Ω source
Amplitude	1 nVrms to 2 Vrms (amplitude is differential into 50 Ω loads). Output is halved when using in single-ended mode. Output is doubled when driving a high impedance load.
Amplitude resolution	3 digits or 1 nV, whichever is greater
DC offset	±5 V, differential or common mode
Offset resolution	3 digits or 0.1 mV, whichever is greater
Output limit	±6 V, sum of DC offset and peak amplitude
Sync	Logic level sync on rear panel (via BlazeX output)

Data

Data channels	Four data channels are displayed and graphed (green, blue, yellow, orange)
Data sources	Each data channel can be assigned any of these data sources: X, Y, R, θ, Aux In 1 to 4, Aux Out 1 to 2, X noise, Y noise, Sine Out Amplitude, Sine Out DC Level, Reference Phase, or Reference Frequency.
Data history	All data sources are continually stored at all chart display time scales. The complete stored history of any data source can be displayed sat any time.
Offset	X, Y and R may be offset up to ±999 % of the output scale
Expand	X, Y and R may be expanded by × 10 or × 100
Ratio	X and Y may be ratioed by Aux In 3. R may be ratioed by Aux In 4.
Capture buffer	1 Mpoint internal data storage. Store (X), (X and Y), (R and θ), or (X, Y, R and θ) at sample rates up to 1.25 MHz. This is in addition to the data histories for the chart display.
Data streaming	Realtime streaming of data, either (X), (X and Y), (R and θ), or (X, Y, R and θ) at sample rates up to 1.25 MHz over the Ethernet interface.
Scanning	One of the following parameters may be scanned: f_{int}, Sine Out Amplitude, Sine Out DC Level, Aux Out 1 or 2

FFT

Source	Input ADC, demodulator output, or filter output
Record length	1024 bins
Averaging	Exponential rms

Inputs and Outputs

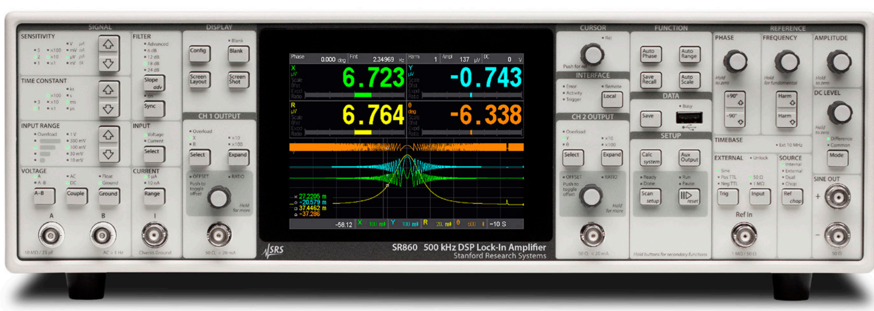
CH1 output	Proportional to X or R (±10 V full scale thru 50 Ω)
CH2 output	Proportional to Y and θ (±10 V full scale thru 50 Ω)
X and Y outputs	Proportional to X and Y (rear panel) (±10 V full scale thru 50 Ω)
BlazeX	Low latency ouput of X, ±2.0 V full scale or logic level reference sync output, either thru 50 Ω
Aux outputs	4 BNC D/A outputs, ±10.5 V thru 50 Ω, 1 mV resolution
Aux inputs	4 BNC A/D inputs, ±10.5 V, 1 mV resolution, 1MΩ input
Trigger input	TTL input triggers storage into the internal capture buffer
Signal monitor	Analog output of the signal amplifier
HDMI	Video output to external monitor or TV (640 × 480, 60 Hz)
Timebase I/O	1 Vrms, 10 MHz clock to synchronize internal reference to other units

General

Interfaces	GPIB (IEEE-488.2), RS-232, USB and Ethernet
USB flash	Front-panel slot for USB flash storage of screen shots and data
Preamp power	9-pin D connector to power SRS preamps
Power	60 W, 100/120/220/240 VAC, 50/60 Hz
Dimensions	17” × 5.25” × 17” (WHD)
Weight	22 lbs.
Warranty	One year parts and labor on defects in materials and workmanship

Ordering Information

SR860	500 kHz lock-in amplifier
SR550	Voltage preamplifier (100 MΩ, 3.6 nV/√Hz)
SR552	Voltage preamplifier (100 kΩ, 1.4 nV/√Hz)
SR554	Transformer preamplifier (0.091 nV/√Hz)
SR555	Current preamplifier
SR556	Current preamplifier
SR540	Optical chopper

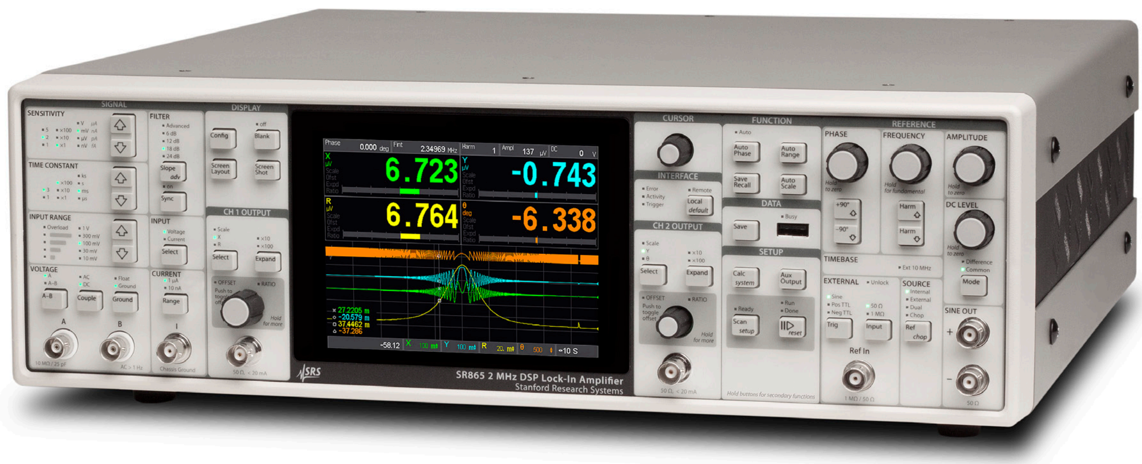


SR860 front panel

SR860 rear panel

4 MHz Lock-In Amplifier

SR865A — 4 MHz dual phase lock-in amplifier



SR865A 4 MHz Lock-In Amplifier

- **1 mHz to 4 MHz frequency range**
- **Low-noise current and voltage inputs**
- **Touchscreen data display - large numeric results, chart recordings, & FFT displays**
- **10 MHz timebase input and output**
- **Dual reference mode**
- **GPIB, RS-232, Ethernet and USB**
- **HDMI video output**
- **SR865A ... $7950** ***(U.S. list)***

Superb performance. Outstanding value. They're what you've come to expect from a Stanford Research Systems lock-in amplifier. And they're delivered by the new SR865A 4 MHz Lock-in Amplifier, the latest in a line of innovative lock-ins from SRS. With unparalleled analog performance, sophisticated new digital signal processing features, a thoroughly modern, intuitive user interface, and a wide range of computer connectivity options, the SR865A is the ideal choice for any synchronous detection application.

With over 30 years of lock-in design experience SRS has made every effort to optimize each detail of the SR865A. From a hefty toroidal transformer that eliminates switch-mode noise to iOS connectivity that brings the lock-in to your cell phone to advanced DSP filters that eliminate more noise while speeding up your experiment, the SR865A is truly the ultimate lock-in amplifier.

Signal Inputs

Lock-in performance starts at the front end. The SR865A front end offers both state-of-the art voltage and current input amplifiers. The voltage input is a switchable single-ended/differential JFET-pair amplifier with 2.5 nV/√Hz of noise at 1 kHz and under 10 nV/√Hz of noise at 10 Hz. The voltage input has a 10 MΩ input impedance and can be AC or DC coupled. Input connector shields can be connected to the instrument ground through a user selectable 10 Ω (Ground) or 10 kΩ (Float) resistor.

SRS current source and several SRS preamplifiers

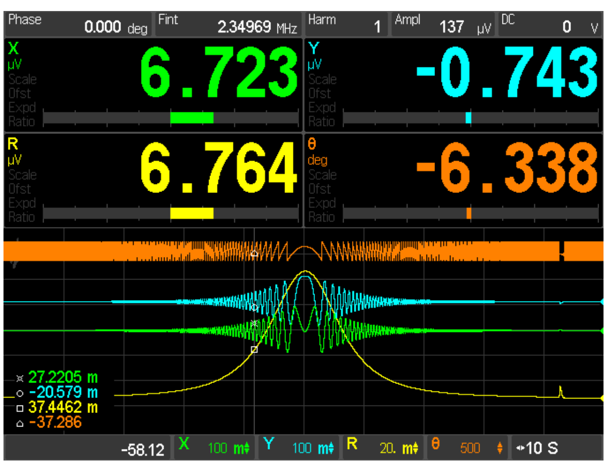
The SR865A's built-in current amplifier represents a significant improvement over previous designs. The current input range is selectable from 1 µA or 10 nA. The 1 µA range has 400 kHz of bandwidth and 130 fA/√Hz of noise, while the 10 nA range offers 2 kHz of bandwidth and 13 fA/√Hz of noise.

While the built in voltage and current amplifiers are suitable for most applications, the SR865A is also compatible with the complete range of specialized pre-amplifiers offered by SRS. The SR550 (FET input), SR552 (BJT input), SR554 (transformer input), SR555 (120 kHz current amp), and SR556 (low-noise current amp) can all be powered directly from the SR865A's rear-panel preamp power port. The SRS website shows you how each of these preamps can be used to optimize measurements in a wide variety of experimental situations.

Sensitivity and Input Range

As with previous instruments, the Sensitivity setting of the SR865A is the voltage (or current) which produces a full scale output. But unlike previous designs, the input range of the SR865A can be explicitly set from the front panel without having to consult a confusing "dynamic reserve" equation. Simply choose the sensitivity required by your experiment and then select the smallest input range that doesn't overload. That's it.

The SR865A's effective dynamic reserve is simply the ratio of these two settings. For instance with a 10 nV sensitivity setting and a 300 mV input range the effective dynamic reserve of the SR865A is 3×10^7, or nearly 150 dB.



Large numeric readout with strip chart recording

Output Time Constants and Filtering

The SR865A offers traditional RC-response output time constants from 1 µs to 30 ks with rolloffs of 6, 12, 18, and 24 dB/oct. But in addition, the SR865A also offers advanced digital filters which can significantly reduce measurement time while increasing signal to noise. Below 3 s, the advanced filters are Gaussian FIR filters which at the same noise bandwidth as an RC filter have significantly better rise-time and stopband attenuation. These filters also have symmetric rise and fall profiles which preserves feature shapes while scanning in frequency. At time constants longer than 3 s, the advanced filters are linear phase IIR filters which settle nearly twice as fast as their RC counterparts for equivalent stopband attenuation.

Synchronous filtering may also be selected at reference frequencies below 4 kHz. The synchronous filter notches out multiples of the reference frequency and is extremely useful in making low frequency measurement where multiples of the reference frequency would otherwise show up in the lock-in output. Unlike previous designs the synchronous filter in the SR865A can be selected with no loss of output resolution.

SR540 Optical Chopper

Reference Channel

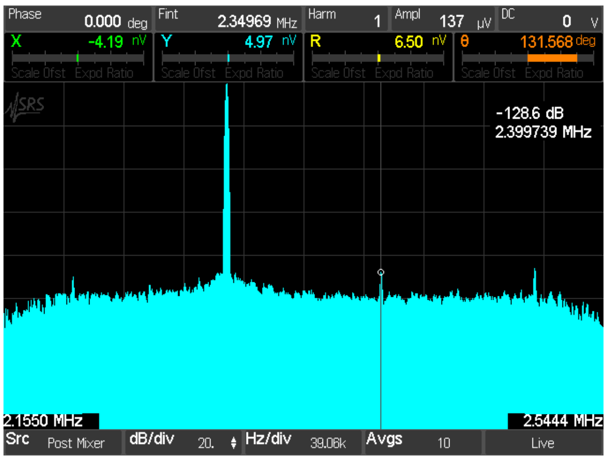
The SR865A has a specified reference frequency range of 1 mHz to 4 MHz. Detection can be done at the fundamental of the reference frequency, or at up to the 99th harmonic. Several reference modes are available: Internal mode uses the SR865A's precision internal oscillator as the reference. External mode locks to an external sine or TTL signal. In Dual Mode, the lock-in detects at the difference frequency between the internally set reference frequency and an externally applied sync signal allowing direct recovery of a double-modulated signal. Finally, in Chop mode, the SR865A provides a digital PID (Proportional-Integral-Derivative) controller signal to synchronize an SR540 Optical Chopper to the internal oscillator of the lock-in. By having the lock-in directly control the chopper, frequency drift can be virtually eliminated.

Sine Output

The SR865A offers a precision sine wave output which can be set with 6 digits of frequency resolution and an amplitude range from 1 nV to 2 V. The SR865A output is unique in that it can be configured as a single-ended or as a differential (balanced) signal. A DC offset of up to ±5 V can be applied to the sine output. A rear-panel logic-level sync signal synchronized to the sine output is also provided.

Timebase

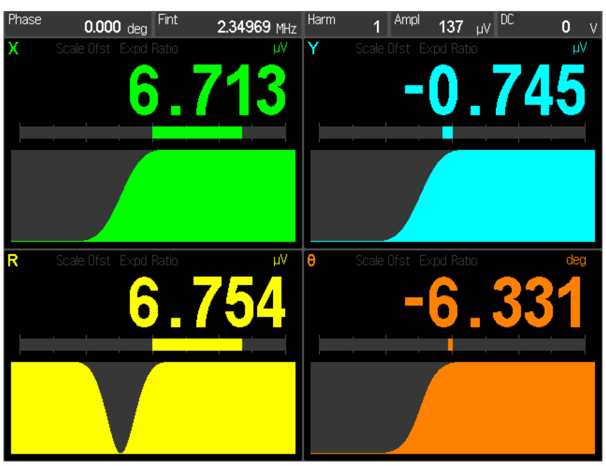
Rear-panel 10 MHz inputs and outputs are provided allowing the SR865A to be locked to an external frequency reference (such as the FS725 10 MHz Rubidium Frequency Standard). Alternatively, the 10 MHz output from the SR865A can be used to synchronize several lock-ins or other test equipment with a 10 MHz timebase input.



FFT display

FFT Displays

Lock-in amplifiers are traditionally time-domain instruments but sometimes it's easier to understand a signal in the frequency domain. The SR865A is at home in both worlds. An FFT display shows the spectrum of the input signal at the front end, the post-mixer signal, or the spectrum of the signal after the time-constant filters. Using the FFT displays can simplify tracking down sneaky noise sources that would otherwise get lost in the "one-number" output of a conventional lock-in amplifier.



Trend analysis

Front-Panel Touchscreen Display

The center of the SR865A's front panel is a full-color 640 × 480 touchscreen which can be set to display up to 4 channels of data. (When a dark lab is required, the LCD screen can be blanked from the front panel or from the remote interface.) Each data channel can be configured to display X, Y, R, Θ, Aux In (1-4), Aux Out (1-2), X noise, Y noise, Sine Amplitude, Sine Out DC Level, Reference Phase, or Reference Frequency. The screen can be set up to show the data channels as large numbers, easily visible from across the room, or as a "strip-chart" display showing a complete history of each channel with selectable time scales from 0.5 s/div to 2 days/div. Even when not displaying a measurement, all measurements are always being saved by the SR865A insuring that no data is ever lost. The touchscreen also continually displays key lock-in setup parameters such as phase, reference frequency, and sine amplitude. And a rear-panel HDMI port allows the LCD screen to be viewed on any HDMI monitor or TV.

It should be emphasized that as useful as the touchscreen display is for displaying data, it's not necessary to use the touchscreen to control common instrument functions on the SR865A. All commonly used controls: time constant, reference frequency, sine amplitude and offset, input configuration, and more, are controllable with dedicated front panel knobs or buttons. Infrequently accessed configuration settings, such as the TCP/IP settings and other communication settings, are accessed through menus shown on the touchscreen.

Computer Connectivity

The SR865A comes standard with virtually every remote interface imaginable. GPIB (IEEE488.2) and RS-232 are of course provided, as well as USB (Test and Measurement Class) and Ethernet (VXI-11 and telnet). The SR865A hosts its own webserver allowing the instrument to be monitored and controlled remotely with just a browser.

A front-panel USB port allows data and screen-shots to a USB flash drive. Data can be saved either as comma delimited files or MATLAB compatible .MAT files. Incorporating screen shots and data into reports or spreadsheets has never been easier.

SR865A Specifications

Signal Channel

Voltage inputs	Single-ended or differential
Sensitivity (output scale)	1 nV to 1 V (voltage input) 1 fA to 1 µA (current input)
Voltage input range	10 mV to 1 V (peak)
Current input range	1 µA or 10 nA (peak)
Max input	1 V (peak) or 1 µA (peak)
Input impedance	
Voltage input	10 MΩ + 25 pF, AC or DC coupled
Current input	1 kΩ or 100 Ω to virtual ground
Gain accuracy	±1 % (<200 kHz), ±2 % (to 4 MHz) Signal amplitude must be less than 30 % of input range
Noise (rms)	2.5 nV/√Hz at 1 kHz (10 mV input range, typ.)
Harmonic distortion	–80 dB (<100 kHz), –60 dB (>100 kHz)
CMRR	90 dB to 1 kHz (DC coupled, 10 mV to 100 mV input range)
Dynamic reserve	120 dB (typ)

Reference Channel

Frequency range	0.001 Hz to 4 MHz
Timebase	10 MHz In/Out (phase locks the internal frequency to other SR865As)
Input impedance	1 MΩ or 50 Ω
Phase setting resolution	$360/2^{32}$ degrees
Phase noise	
Int. ref	<0.0001° rms at 1 kHz (100 ms, 12 dB/oct)
Ext. ref (typ)	<0.001° rms at 1 kHz (100 ms, 12 dB/oct)
Phase drift (typ)	<0.002°/°C below 20 kHz (DC coupled) <0.02°/°C below 200 kHz <0.2°/°C below 4 MHz
Harmonic detection	Detect at $N \times f_{ref}$ ($N<99$ and $(N \times f_{ref})<4$ MHz)
Dual F reference	Detect at $f_{dual} = \|f_{int} - f_{ext}\|$
Chopper reference	SR865A drives SR540 Chopper (via Aux Out 4) to lock the chopper to f_{int}

Demodulator

DC stability	Digital output values have no drift
Time constants	1 µs to 30 ks
Low pass filters	Typical RC-type filters or advanced Gaussian/Phase-Linear filters
Filter slope	6, 12, 18 or 24 dB/oct rolloff
Synchronous filter	Available below 4 kHz
Harmonic rejection	–80 dB
Low latency output	Rear-panel BlazeX output with <2 µs delay (plus LPF rise/fall times).

Internal Oscillator

Frequency range	0.001 Hz to 4 MHz
Frequency accuracy	25 ppm + 30 µHz (with internal timebase)
External timebase	10 MHz timebase input/output (on rear panel)
Frequency resolution	6 digits or 0.1 mHz, whichever is greater

Sine Output

Outputs	Single-ended or differential
Output impedance	50 Ω source
Amplitude	1 nVrms to 2 Vrms (amplitude is differential into 50 Ω loads). Output is halved when using in single-ended mode. Output is doubled when driving a high impedance load.
Amplitude resolution	3 digits or 1 nV, whichever is greater
DC offset	±5 V, differential or common mode
Offset resolution	3 digits or 0.1 mV, whichever is greater
Output limit	±6 V, sum of DC offset and peak amplitude
Sync	Logic level sync on rear panel (via BlazeX output)

Data

Data channels	Four data channels are displayed and graphed (green, blue, yellow, orange)
Data sources	Each data channel can be assigned any of these data sources: X, Y, R, θ, Aux In 1 to 4, Aux Out 1 to 2, X noise, Y noise, Sine Out Amplitude, Sine Out DC Level, Reference Phase, or Reference Frequency.
Data history	All data sources are continually stored at all chart display time scales. The complete stored history of any data source can be displayed sat any time.
Offset	X, Y and R may be offset up to ±999 % of the output scale
Expand	X, Y and R may be expanded by × 10 or × 100
Ratio	X and Y may be ratioed by Aux In 3. R may be ratioed by Aux In 4.
Capture buffer	1 Mpoint internal data storage. Store (X), (X and Y), (R and θ), or (X, Y, R and θ) at sample rates up to 1.25 MHz. This is in addition to the data histories for the chart display.
Data streaming	Realtime streaming of data, either (X), (X and Y), (R and θ), or (X, Y, R and θ) at sample rates up to 1.25 MHz over the Ethernet interface.
Scanning	One of the following parameters may be scanned: f_{int}, Sine Out Amplitude, Sine Out DC Level, Aux Out 1 or 2

FFT

Source	Input ADC, demodulator output, or filter output
Record length	1024 bins
Averaging	Exponential rms

Inputs and Outputs

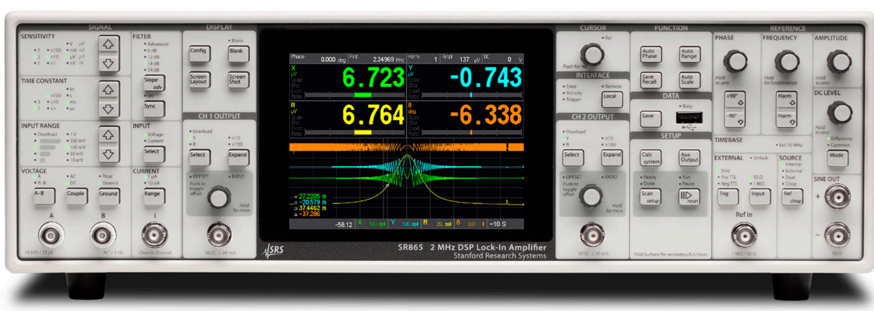
CH1 output	Proportional to X or R (±10 V full scale thru 50 Ω)
CH2 output	Proportional to Y and θ (±10 V full scale thru 50 Ω)
X and Y outputs	Proportional to X and Y (rear panel) (±10 V full scale thru 50 Ω)
BlazeX	Low latency ouput of X, ±2.0 V full scale or logic level reference sync output, either thru 50 Ω
Aux outputs	4 BNC D/A outputs, ±10.5 V thru 50 Ω, 1 mV resolution
Aux inputs	4 BNC A/D inputs, ±10.5 V, 1 mV resolution, 1MΩ input
Trigger input	TTL input triggers storage into the internal capture buffer
Signal monitor	Analog output of the signal amplifier
HDMI	Video output to external monitor or TV (640 × 480, 60 Hz)
Timebase I/O	1 Vrms, 10 MHz clock to synchronize internal reference to other units

General

Interfaces	GPIB (IEEE-488.2), RS-232, USB and Ethernet
USB flash	Front-panel slot for USB flash storage of screen shots and data
Preamp power	9-pin D connector to power SRS preamps
Power	60 W, 100/120/220/240 VAC, 50/60 Hz
Dimensions	17” × 5.25” × 17” (WHD)
Weight	22 lbs.
Warranty	One year parts and labor on defects in materials and workmanship

Ordering Information

SR865A	4 MHz lock-in amplifier
SR550	Voltage preamplifier (100 MΩ, 3.6 nV/√Hz)
SR552	Voltage preamplifier (100 kΩ, 1.4 nV/√Hz)
SR554	Transformer preamplifier (0.091 nV/√Hz)
SR555	Current preamplifier
SR556	Current preamplifier
SR540	Optical chopper



SR865A front panel

SR865A rear panel