Digital Lock-In Amplifiers

SR830 — DSP lock-in amplifier

SR830 DSP Lock-In Amplifier

- 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

SR830 DSP Lock-In Amplifiers

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

Input Channel

The SR830 has 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

The SR830 has 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. It has a second, user-defined output that measures Y, θ, Y-noise, Aux 3, Aux 4 or ratio. The instrument also has 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 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 SR830 is 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
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
SR542	Optical chopper

SR830 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	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	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 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

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