2 MHz Lock-In Amplifier

SR865 — 2 MHz dual phase lock-in amplifier

SR865 2 MHz Lock-In Amplifier

- **1 mHz to 2 MHz frequency range (operates to 2.5 MHz)**

- **Dual reference mode**

- **Low-noise current and voltage inputs**

- **Touchscreen data display - large numeric answers, chart recordings, & FFT displays**

- **10 MHz timebase input and output**

- **GPIB, RS-232, Ethernet and USB**

- **HDMI video output**

- **SR865 ... $7950** (U.S. list)

The SR865 2 MHz Lock-In Amplifier delivers the performance needed in the most demanding synchronous detection applications. This FPGA based instrument offers a wide frequency range (0.001 Hz to 2 MHz), high dynamic reserve (>120 dB), excellent stability (<5 ppm/°C), and high phase resolution (0.1 µDeg.). Building on the industry standard SR830, this next-generation lock-in amplifier has several analog enhancements and many new features not found in other instruments. A built-in touchscreen display shows the instantaneous results of your measurement, as well as its complete time history. The instrument is also easy to use — all instrument function have dedicated buttons and knobs.

Signal Inputs

The SR865 has state-of-the-art voltage and current inputs. The voltage input is a single-ended/differential FET preamplifier that has less than 2.5 nV/√Hz input noise at 1 kHz, and less than 10 nV/√Hz at 10 Hz. It has 10 MΩ input impedance and can be AC or DC coupled. The current input offers a choice of 10^6 or 10^8 V/A gain, and has up to 400 kHz of bandwidth and as little as 13 fA/√Hz input current noise. The SR865 can operate in either Ground or Float mode.

There are several SRS preamplifiers including the SR550 (FET input), SR552 (BJT input), SR554 (transformer input), SR555 (120 kHz current amp) and SR556 (low noise current amp) which can all be powered directly from the SR865's rear-panel preamp power port. Each preamp is optimized for different experimental conditions, and when used with the SR865, they can often significantly improve your measurements.

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Input Range

On the front panel of the SR865, an input range button replaces the sensitivity and dynamic reserve buttons found on older digital lock-in amplifiers. You simply choose the lowest range that doesn't cause an overload. Small LED bar graphs indicate the percentage of full scale for each of the five range settings.

Output Time Constants

Output time constants from 1 μs to 30 ks with 6, 12, 18 or 24 dB/oct rolloff let you optimize the signal-to-noise ratio of your measurements. Synchronous filters are available below 4 kHz which notch out multiples of the reference frequency and can be extremely useful for low frequency measurements. Unlike previous models, there is no output resolution trade-off for using the synchronous filters.

Advanced Filters

The SR865 also provides advanced filtering in place of the traditional 6 dB/oct RC filters. These filters can provide digital filtering that has no analog filter counterpart.

At time constants of 3 s and faster, these advanced filters are pass the same amount of noise as the corresponding RC filter but have much faster settling times. If the input signal is changing rapidly, or if there is significant noise away from the reference frequency, then the advanced filters often provide better signal to noise with faster output response.

For time constants of 10 s and longer, the advanced filters are implemented to align the stop band with the corresponding classical RC analog filter. These filters settle to their final values nearly twice as fast as the RC filter.

Reference Channel

The reference source of the SR865 can set to Internal, External, Dual or Chop modes. In Internal mode, the reference frequency is set from 0.001 Hz to 2 MHz. In External mode, an external sine wave or square wave determines the reference frequency, and there is a choice of 50 Ω or 1 MΩ input termination. In either mode, the SR865 can also detect harmonics of the reference frequency. Any harmonic, from the fundamental up to the 99th harmonic, can be detected.

In Dual F Reference mode (Dual), the SR865 detects at the difference between the internally set reference frequency and an external reference frequency. In this mode, the SR865 provides direct recovery of a double-modulated signal.

In Chopper Reference mode (Chop), the SR865 uses PID control to synchronize a remote SR540 Optical Chopper to the high-stability internal reference of the lock-in. The excessive frequency drift of the chopper is virtually eliminated.

External 10 MHz Timebase Input and Output

The SR865 has a reference 10 MHz timebase input and output on the rear panel. This allows the SR865 to be locked to an external reference (like the FS725 10 MHz Rubidium Frequency Standard), or to synchronize several SR865s and/or other test equipment with a 10 MHz reference input.

Source Output

A spectrally clean source (-80 dB) with DC offset is a standard feature of the SR865. The sine output source can be operated in standard single-end mode or differentially — new to lock-ins. In differential mode you can have signals as small as 1 nV or as large as 2 volts with up to 5 volts of DC offset. Frequency can be set with up to 6 digits of resolution.

Sync Output / BlazeX

In addition to the sine source, there is a logic level sync signal available on the rear panel. This output also serves as the BlazeX output which is a low latency output (<2 μs delay) ideal in control loop applications.

Front-Panel Operation and Touchscreen Data Display

For the seasoned lock-in user, the SR865 front panel will seem quite familiar. All instrument controls have dedicated front-panel buttons and knobs — there is no obscure menu tree to navigate. So changing a time constant or adjusting the source amplitude is trivial.

In addition, there is a colorful 640×480 touchscreen data display. Four controllable data channels display and graph 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 f_{ref}. You can also scan and display the internal reference frequency, the sine out amplitude and offset, or the AUX 1 and 2 outputs. All data sources are continually stored at all chart display time scales (17 scales from 0.5 seconds per division to 2 days per division) and available at any time to the user.

There are several ways to view your data. There are large numbers that can easily be read from across the lab, chart recordings for a complete time history of your data, and FFT displays of your signal input and the signal output.

For situations where a dark lab is required, the touchscreen display and all front-panel LEDs can be turned off with the push of a button.

Communication

The SR865 comes standard with GPIB (IEEE488.2), RS-232, USB device, and Ethernet interfaces. All instrument functions can be queried and controlled using any of the interfaces.

A convenient front-panel USB flash storage port lets you quickly save/export your data and graphical screen shots. Data is stored as a comma separated text file or as a MatLab file, and screen shots are stored as bit maps. Getting screen shots and data into reports or spreadsheets couldn't be easier.

Other Useful Features

The Offset/Expand feature is useful for examining small fluctuations in a measurement. X, Y, and R may be manually offset up to ±999 %, or you can use the auto offset feature to quickly null the signal. The relative signal can then be amplified by a factor of 10 or 100.

The SR865 has several auto features including auto range, auto scale, and auto phase which are provided to simplify operation.

The SR865 also has an embedded web server which allows you to monitor and control your instrument from your office, home or anywhere there is internet access. And there is an HDMI video output port available on the rear panel of the SR865 to connect large monitors and TVs to the instrument for presentations and long distance viewing.

Lastly, the SR865 design uses linear power supplies rather than switching power supplies, so switching frequency interference can never be a problem.

SR865 front panel

SR865 rear panel

Signal Channel

Voltage inputs	Single-ended or differential
Voltage input range	10 mV to 1 V (peak)
Current input range	1 µA or 10 nA (peak)
Max input	1 V (peak) or 10 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 2 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 detection	−80 dB (<100 kHz), −60 dB (>100 kHz)
CMRR	90 dB to 100 kHz (DC coupled), decreasing by 6 dB/oct above 100 kHz
Dynamic reserve	>120 dB

Reference Channel

Frequency range	0.001 Hz to 2 MHz (specified)
	(operates to 2.5 MHz)
Timebase	10 MHz In/Out (phase locks the internal frequency to other SR865s)
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	<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 $f_{dual} = abs(f_{int} - f_{ext})$
Chopper reference	SR865 drives SR540 Chopper (via Aux Out 4) to lock the chopper to f_{int}

Demodulator

DC stability	Digital output values have no drift
Analog outputs	<5 ppm/°C
Time constants	1 µs to 30 k s
Low pass filters	Typical RC-type filters or Advanced FIR/BiQuad filters
Filter slope	6, 12, 18 or 24 dB/oct rolloff
Synchronous filter	Available below 2 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 2 MHz (specified)
	(operates to 2.5 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
Amplitude stability	50 ppm/°C
Sync	Logic level sync on rear panel (via BlazeX output)
Distortion	<−80 dBc (f<1 kHz)

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 f_{ref}.
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
Data buffer	8 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.
Scanning	One of the following parameters may be scanned: f_{int}, Sine Out Amplitude, Sine Out DC Level, Aux Out 1 or 2

Inputs and Outputs

CH1 output	Proportional to X or R (±10 V full scale thru 50 Ω)
CH2 output	Proportional to X and Y (rear panel) (±10 V full scale thru 50 Ω)
X and Y outputs	Proportional to Y or θ (±10 V full scale thru 50 Ω)
BlazeX	Low latency ouput of X, ±2.5 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, 1 MΩ input
Trigger input	TTL input triggers storage into the internal data buffer
Monitor output	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	30 lbs.
Warranty	One year parts and labor on defects in materials and workmanship

Ordering Information

SR865	2 MHz lock-in amplifier	$7950
SR550	Voltage preamplifier (100 MΩ, 3.6 nV/√Hz)	$750
SR552	Voltage preamplifier (100 kΩ, 1.4 nV/√Hz)	$750
SR554	Transformer preamplifier (0.091 nV/√Hz)	$1200
SR555	Current preamplifier	$1095
SR556	Current preamplifier	$1095
SR540	Optical chopper	$1195

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