Model 7265

DSP Lock-in Amplifier

SIGNAL RECOVERY

FEATURES

- **0.001 Hz to 250 kHz operation**
- **Voltage and current mode inputs**
- **Direct digital demodulation without down-conversion**
- **10 µs to 100 ks output time constants**
- **Quartz crystal stabilized internal oscillator**
- **Synchronous oscillator output for input offset reduction**
- **Harmonic measurements to 65,536F**
- **Dual reference, Dual Harmonic and Virtual Reference modes**
- **Spectral display mode**
- **Built-in experiments**

APPLICATIONS

- **Scanned probe microscopy**
- **Optical measurements**
- **Audio studies**
- **AC impedance studies**
- **Atomic force microscopy**

DESCRIPTION

The ***SIGNAL RECOVERY*** model 7265 uses the latest digital signal processing (DSP) technology to extend the operating capabilities of the lock-in amplifier to provide the researcher with a very versatile unit suitable both for measurement and control of experiments. At the same time due consideration has been given to the needs of those users wishing only to make a simple measurement quickly and easily.

Operating over a frequency range of 1 mHz to 250 kHz, the model 7265 offers full-scale voltage sensitivities down to 2 nV and current sensitivities to 2 fA. The instrument has a choice of operating modes, signal recovery or vector voltmeter, for optimum measurement accuracy under different conditions, and the use of DSP techniques ensures exceptional performance.

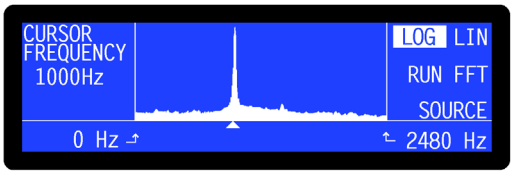
The instrument performs all of the normal measurements of a dual phase lock-in amplifier, measuring the in-phase and quadrature components, vector magnitude, phase angle and noise of the input signal.

Several novel modes of operation are also include to give greater levels of versatility than ever before, for example:

◆ Virtual Reference™
Under suitable conditions, this mode allows measurements to be made in the absence of a reference signal

◆ Dual Reference
In this mode the instrument can make simultaneous measurements on two signals at different reference frequencies, which is ideal, for example, for use in source compensated optical experiments

◆ Spectral Display
This allows the spectrum of the signals present at the input to be calculated and displayed, which can help when choosing the reference frequency



Spectral Display

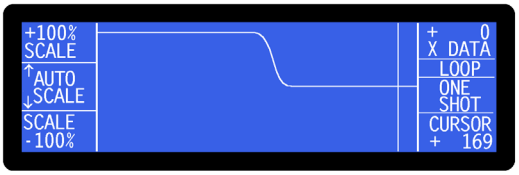
◆ Transient Recorder
In this mode, the auxiliary ADC inputs can be used as a 40 kSa/s (25 µs/point) transient recorder, with the captured transient being displayed graphically

◆ Frequency Response
This built-in experiment allows the internal oscillator frequency to be swept between preset frequencies, while simultaneously measuring the input signal magnitude and phase. The mode is ideal for determining the frequency and phase response of external networks

◆ Harmonic Analysis

Most lock-in amplifiers will measure signals at the applied reference frequency or its second harmonic. In the 7265, operation is possible at harmonics up the 65,536th, and in Dual Harmonic mode, simultaneous measurements can be made on two harmonics

Three auxiliary ADC inputs, one of which is a special integrating converter, four DAC outputs and eight output logic lines are provided. These can be used to record the magnitude of external signals associated with the experiment, such as temperature or pressure, or to generate voltages to control or switch other equipment. Information from the ADCs together with the lock-in amplifier's output data can be stored in the 32k point buffer memory, and even displayed graphically on screen.



Graphical Display

The model 7265 is extremely easy to use. All instrument controls are adjusted using soft-touch, front panel push-buttons, with the present settings and measured outputs being displayed on the centrally located, cold fluorescent backlit dot-matrix LCD. A particularly convenient feature is the pop-up keypad which is used when setting controls that need adjusting to a large number of significant figures.

Pop-up Keypad to set Controls

Control selection and adjustment is aided by the logical structure of on-screen menus and sub-menus, supported by a series of context-sensitive help screens. A number of built-in automatic functions are also provided to simplify instrument operation.

External control of the unit is via either the RS232 or GPIB interfaces, using simple mnemonic-type ASCII commands. A second RS232 port allows up to sixteen 7265 or compatible instruments to be operated from a single RS232 computer port by connecting them in a “daisy-chain” configuration.

Compatible software is available in the form of a LabVIEW driver supporting all instrument functions, and the Acquire lock-in amplifier applications software. The driver and a free demonstration version of the software, DemoAcquire, are available for download from our website at **www.signalrecovery.com**

Specifications

General

Dual-phase DSP lock-in amplifier operating over a reference frequency range of 0.001 Hz to 250 kHz.

Wide range of extended measuring modes and auxiliary inputs and outputs.

User-upgradeable firmware.

Measurement Modes

The instrument can simultaneously show any four of these outputs on the front panel display:

X	In-phase
Y	Quadrature
R	Magnitude
θ	Phase Angle
Noise	

Harmonic *n*F, $n \leq 65{,}536$

Dual Harmonic

Simultaneously measures the signal at two different harmonics F_1 and F_2 of the reference frequency

Dual Reference

Simultaneously measures the signal at two different reference frequencies, F_1 and F_2 where F_1 is the external and F_2 the internal reference

Frequency Range for Dual Harmonic and Dual Reference Modes: F_1 and $F_2 \leq 20$ kHz

Virtual Reference

Locks to and detects a signal without a reference (100 Hz ≤ F ≤ 250 kHz)

Noise

Measures noise in a given bandwidth centered at the reference frequency F

Spectral Display

Gives a visual indication of the spectral power distribution of the input signal in a user-selected frequency range lying between 1 Hz and 60 kHz. Note that although the display is calibrated in terms of frequency, it is not calibrated for amplitude. Hence it is only intended to assist in choosing the optimum reference frequency

Display

240 × 64 pixel cold fluorescent backlit LCD panel giving digital, analog bar-graph and graphical indication of measured signals. Menu system with dynamic key function allocation. On-screen context sensitive help

Signal Channel

Voltage Input

Modes	A only, -B only or Differential (A-B)
Full-scale Sensitivity	2 nV to 1 V in a 1-2-5 sequence
Max. Dynamic Reserve	> 100 dB
Impedance	
FET Input	10 MΩ // 30 pF
Bipolar Input	10 kΩ // 30 pF
Maximum Safe Input	20 V pk-pk
Voltage Noise	
FET Input	5 nV/√Hz @ 1 kHz
Bipolar Input	2 nV/√Hz @ 1 kHz
C.M.R.R.	> 100 dB @ 1 kHz
Frequency Response	0.001 Hz to 250 kHz
Gain Accuracy	±0.2% typ
Distortion	-90 dB THD (60 dB AC gain, 1 kHz)
Line Filter	attenuates 50, 60, 100, 120 Hz
Grounding	BNC shields can be grounded or floated via 1 kΩ to ground

Current Input

Mode	Low Noise or Wide Bandwidth
Full-scale Sensitivity	
Low Noise	2 fA to 10 nA in a 1-2-5 sequence
Wide Bandwidth	2 fA to 1 μA in a 1-2-5 sequence
Max. Dynamic Reserve	> 100 dB
Frequency Response (-3 dB)	
Low Noise	≥ 500 Hz
Wide Bandwidth	≥ 50 kHz
Impedance	
Low Noise	< 2.5 kΩ @ 100 Hz
Wide Bandwidth	< 250 Ω @ 1 kHz
Noise	
Low Noise	13 fA/√Hz @ 500 Hz
Wide Bandwidth	1.3 pA/√Hz @ 1 kHz
Gain Accuracy	± 0.6% typ, midband
Line Filter	attenuates 50, 60, 100, 120 Hz
Grounding	BNC shield can be grounded or floated via 1 kΩ to ground

Model 7265 Specifications (continued)

Reference Channel

TTL Input (rear panel)
- Frequency Range: 0.001 Hz to 250 kHz

Analog Input (front panel)
- Impedance: 1 MΩ // 30 pF
- Sinusoidal Input
  - Level: 1.0 V rms*
  - Frequency Range: 0.3 Hz to 250 kHz
- Squarewave Input
  - Level: 250 mV rms*
- Frequency Range: 2 Hz to 250 kHz

*Note: Lower levels can be used with the analog input at the expense of increased phase errors

Phase Set Resolution: 0.001° increments

Phase Noise at 100 ms TC, 12 dB/octave slope
- Internal Reference: < 0.0001° rms
- External Reference: < 0.01° rms @ 1 kHz

Orthogonality: 90° ±0.0001°

Acquisition Time
- Internal Reference: instantaneous acquisition
- External Reference: 2 cycles + 50 ms

Reference Frequency Meter Resolution: 1 ppm or 1 mHz, whichever is the greater

Demodulator and Output Processing

Output Zero Stability
- Digital Outputs: No zero drift on all settings
- Displays: No zero drift on all settings
- Analog Outputs: < 5 ppm/°C

Harmonic Rejection: -90 dB

Output Filters

X, Y and R outputs only
- Time Constant: 10 µs to 640 µs in a binary sequence
- Slope (roll-off): 6 dB/octave

All outputs
- Time Constant: 5 ms to 100 ks in a 1-2-5 sequence
- Slope: 6, 12, 18 and 24 dB/octave

Synchronous Filter: Available for F < 20 Hz

Offset: Auto and Manual on X and/or Y: ±300% full-scale

Absolute Phase Measurement Accuracy: ≤ 0.01°

Oscillator

Frequency
- Range: 0.001 Hz to 250 kHz
- Setting Resolution
  - 1 mHz ≤ *F* ≤ 900 Hz: 1 mHz
  - *F* > 900 Hz: 4 mHz
- Absolute Accuracy: ± 50 ppm

Distortion (THD): -80 dB @ 1 kHz and 100 mV rms

Amplitude (rms)
- Range: 1 µV to 5 V rms
- Setting Resolution
  - 1 µV to 4 mV: 1 µV
  - 4 mV to 500 mV: 125 µV
  - 500 mV to 2 V: 500 µV
  - 2 V to 5 V: 1.25 mV
- Accuracy
  - > 1 mV: ±0.3%, *F* ≤ 60 kHz, ±0.5%, *F* > 60 kHz
  - 100 µV - 1 mV: ±1%, *F* ≤ 60 kHz, ±3%, *F* > 60 kHz
- Stability: 50 ppm/°C

Output Impedance: 50 Ω

Sweep

Amplitude Sweep
- Output Range: 0.000 to 5.000 V rms
- Law: Linear
- Step Rate: 20 Hz maximum (50 ms/step)

Frequency Sweep
- Output Range: 0.001 Hz to 250 kHz
- Law: Linear or Logarithmic
- Step Rate: 20 Hz maximum (50 ms/step)

Auxiliary Inputs

ADC 1 & 2
- Maximum Input: ±10 V
- Resolution: 1 mV
- Accuracy: ±20 mV
- Input Impedance: 1 MΩ // 30 pF
- Sample Rate
  - ADC 1 only: 40 kHz max.
  - ADC 1 and 2: 17.8 kHz max.
- Trigger Mode: Internal, External or burst
- Trigger Input: TTL compatible

ADC 3
- Maximum Input: ±10 V
- Resolution: 12 to 20 bit, depending on sampling time
- Input Impedance: 1 MΩ // 30 pF
- Sampling Time: 10 ms to 2 s, variable

Outputs

Fast Outputs
- Function: X and Y or X and Mag
- Amplitude: ±2.5 V full-scale; linear to ±300% full-scale
- Impedance: 1 kΩ
- Update Rate: 166 kHz

Main Analog (CH1 and CH2) Outputs
- Function: X, Y, R, θ, Noise, Ratio, Log Ratio and User Equations 1 & 2.
- Amplitude: ±10.0 V full-scale; linear to ±120% full-scale
- Impedance: 1 kΩ
- Update Rate: 200 Hz

Signal Monitor
- Amplitude: ±10 V FS
- Impedance: 1 kΩ

Auxiliary D/A Outputs 1, 2, 3 and 4
- Maximum Output: ±10 V
- Resolution: 1 mV
- Accuracy: ±10 mV
- Output Impedance: 1 kΩ

8-bit Digital Output Port
- 8 TTL-compatible lines that can be independently set high or low to activate external equipment

Reference Output
- Waveform: 0 to 5 V rectangular wave
- Impedance: TTL-compatible

Power - Low Voltage: ±15 V at 100 mA rear panel 5-pin 180° DIN connector for powering ***SIGNAL RECOVERY*** preamplifiers

Data Storage Buffer
- Size: 32k × 16-bit data points, may be organized as 1×32k, 2×16k, 3×10.6k, 4×8k, etc.
- Max Storage Rate
  - From LIA: up to 1000 16-bit values per second
  - From ADC1: up to 40,000 16-bit values per second

User Settings

Up to 8 complete instrument settings can be saved or recalled from non-volatile memory

Interfaces

RS232 and GPIB (IEEE-488). A second RS232 port is provided to allow “daisy-chain” connection and control of up to 16 compatible instruments from a single RS232 computer port

General

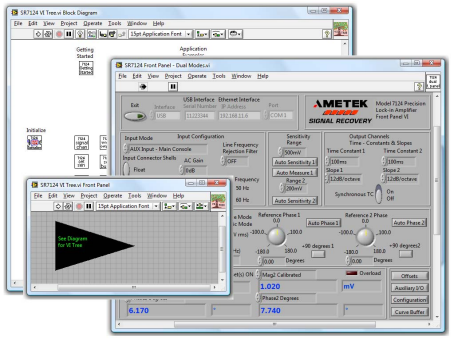
Power Requirements
- Voltage: 110/120/220/240 VAC
- Frequency: 50/60 Hz
- Power: 40 VA max

Dimensions
- Width: 13¼" (350 mm)
- Depth: 16½" (415 mm)
- Height
  - With feet: 4¼" (105 mm)
  - Without feet: 3½" (90mm)

Weight: 18 lb (8.1 kg)

LabVIEW Driver Software

A LabVIEW driver for the instrument is available from the **www.signalrecovery.com** website, offering example VIs for all its controls and outputs, as well as the usual Getting Started and Utility VIs. It also includes example soft-front panels built using these VIs, demonstrating how you can incorporate them in more complex LabVIEW programs.

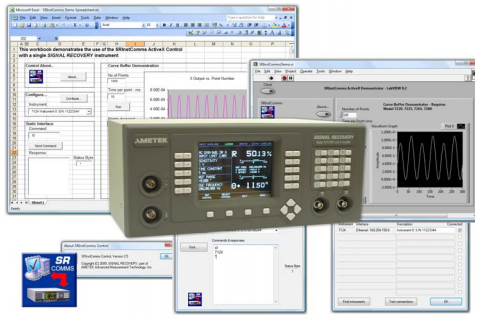


SIGNAL RECOVERY Acquire Software (see page 56)

Users who do not wish to write their own control code but who still want to record the instrument's outputs to a computer file will find the ***SIGNAL RECOVERY*** Instruments Acquire Lock-in Amplifier Applications Software, available at a small extra cost, useful. This 32-bit package, suitable for Windows XP/Vista, extends the capabilities of the instrument by, for example, adding the ability to record swept frequency measurements. It also supports the internal curve buffer, allowing acquisition rates of up to 1000 points per second independent of the computer's processor speed.

SRInstComms Software (see page 59)

Control up to ten ***SIGNAL RECOVERY*** instruments directly from Visual Basic, Visual C++, LabVIEW, Visual Basic for Applications (included in Word, Excel, Outlook, Access and other Microsoft products) and VBScript (supported by Internet Explorer 3 and later) without having to worry about low-level communications routines. The SRInstComms control handles all the communications between your software and the instrument(s) via the RS232 and/or GPIB interfaces, leaving you free to develop the code to run your experiment.

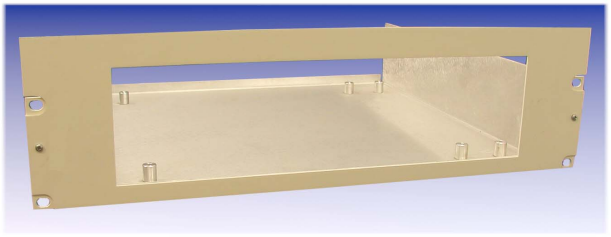


Ordering Information

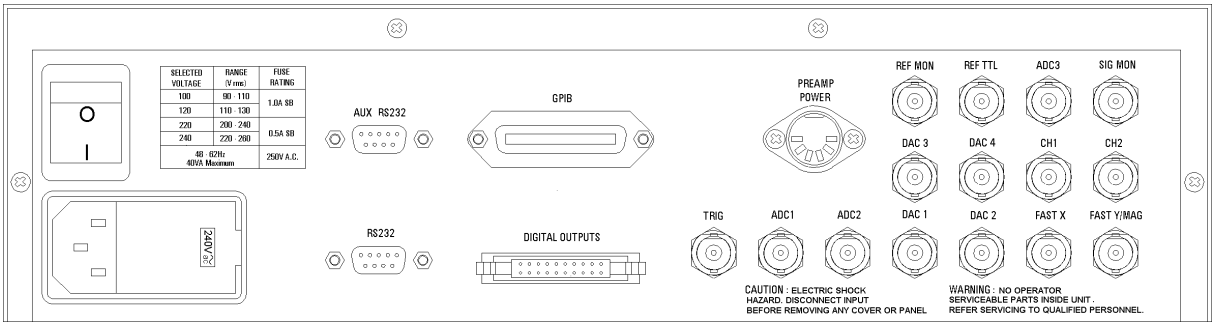
Each model 7265 is supplied complete with a comprehensive instruction manual. Users may download the instrument's LabVIEW driver software and a free demonstration copy, DemoAcquire, of the ***SIGNAL RECOVERY*** lock-in amplifier applications software package, from the **www.signalrecovery.com** website.

Optional Accessories

Model K02003 Rack mount to mount one model 7265 in a 19" rack



Model K02003 Rack Mount Kit



Model 7265 Rear Panel Layout