Model 7270

DSP Lock-in Amplifier

- 1 mHz - 250 kHz frequency range
- 2 nV/2 fA - 1 V/1 µA FS sensitivity
- Main ADC and analog outputs update rate of 1 MSa/s
- Large, easy to use color display with comprehensive range of operating modes
- USB, Ethernet and RS232 computer interfaces

...all in a compact benchtop enclosure

SIGNAL RECOVERY

...part of **AMETEK**® Advanced Measurement Technology

Model 7270 DSP Lock-in Amplifier

The new standard for general purpose DSP lock-in amplifiers

Overview

The model 7270 sets a new standard for general-purpose DSP lock-in amplifiers. We've taken advantage of the developments in technology since the first DSP lock-in amplifiers were introduced in the early 1990's to update the core design, but made sure that we've included all the best features of our model 7265 and 7280 instruments. What's more, the new architecture has allowed us to offer even better specifications in an instrument that is physically much more compact than older designs. The result is a lock-in amplifier of outstanding performance that is easy to use and suitable for all measurements over a frequency range extending from 1 mHz to 250 kHz.

Versatility

In common with other models in our range, the 7270 offers much more than just dual phase lock-in detection at the reference frequency of an applied signal. We've included features unique to ***SIGNAL RECOVERY*** instruments such as dual reference and dual harmonic detection, which allow signals at two different frequencies to be measured simultaneously. The spectral display mode shows the power spectral density of the input signal, making it easy to avoid interfering signals when selecting a reference frequency. It is now even possible to perform tandem demodulation. In this mode an amplitude-modulated signal at a (high) “carrier” frequency is first demodulated at that frequency. The resulting in-phase output, at short time constant settings, is a signal at the modulating frequency which is then passed forward for detection by a second set of demodulators running at the same modulating frequency. Such detection techniques, which can be used in pump-probe measurements, have until now required two separate instruments with an analog connection between them.

Fast Data Processing

The main ADC sampling rate and the rate at which the analog signal outputs are updated is 1 MSa/s, giving excellent performance when used at short output filter time constant settings, such as in scanned probe measurements. But we've also increased the maximum rate at which data can be stored to the internal curve buffer to 1 µs per point, allowing for the first time direct capture of instrument outputs when using these short time constants. The buffer length has also been increased to 100,000 sets of points, giving recording times of 100 ms at the fastest sampling rates. What's more, in the fast capture mode the length does not need to be divided by the number of outputs being stored, making it possible, for example, to store the full 100,000 points of X, Y and auxiliary ADC1 values at the same time.

Remote Control

The built-in RS232, USB and Ethernet connections allow full operation from a controlling computer. We offer a comprehensive software package, Acquire, that can operate the instrument via any of these interfaces and makes it easy to set up and run complex experiments, such as frequency response measurements, as well as allowing remote control of every instrument function. Users who wish to do their own programming can use our ActiveX control and toolkit (SRInstComms), or free LabVIEW driver, to simplify the task.

See what you've been missing...

In summary, if you're looking for a general purpose lock-in to work in the range 1 mHz to 250 kHz then you need look no further - you've found it in the ***SIGNAL RECOVERY*** model 7270.

- **1 mHz to 250 kHz operating frequency range**
- **Voltage and current mode inputs**
- **1.0 MHz main ADC sampling rate**
- **10 µs to 100 ks output filter time constants**
- **Precision DDS sinewave oscillator with adjustable amplitude and frequency**
- **Oscillator output can be amplitude or frequency modulated**
- **Harmonic measurements up to 127 × F**
- **Dual Reference, Dual Harmonic and Virtual Reference operating modes**
- **Easy manual operation using large full-color display, soft keys, and numeric keypad**
- **Built-in on-screen context sensitive help**
- **Auxiliary analog and digital inputs and outputs**
- **Internal data buffer for recording instrument outputs at rates down to 1 µs per point**
- **USB, RS232, and Ethernet computer interfaces**

Instrument Format

The 7270 is packaged as a compact, benchtop unit with a color display, keys for accessing menus and adjusting controls, and a keypad for entry of numeric values. It uses powerful DSP algorithms running in a dedicated field programmable gate array (FPGA), supported by a ColdFire processor, to deliver the best possible performance.

Signal and Reference Connections

The front-panel signal input connectors can be switched to operate in single ended or differential voltage mode, or in current mode with a choice of two transimpedance settings. They can also be used to switch between two single-ended voltage signals, for simple sequential measurement under computer control of two inputs. In cases where further preamplification is needed then one of the ***SIGNAL RECOVERY*** remote preamplifiers can be used, with its output connected to the 7270's "A" input connector. This flexible choice of input modes allows the best possible connection to be made to the experiment.

If using an external reference signal then either the front-panel general purpose analog or rear-panel TTL logic reference inputs can be used. For internal reference work, a precision DDS oscillator generates a sinewave signal of adjustable frequency and amplitude that is available at the front panel OSC OUT connector..

Signal Path

Following input amplification the signal can optionally be passed through an analog line-frequency rejection filter, with configurable center frequency and mode, before reaching the main anti-aliasing filter. It is then applied to the signal channel precision ADC. This operates at 1 MHz, delivering an accurate digital representation of the signal to be measured and the noise accompanying it to the signal inputs of the in-phase and quadrature demodulators, which are implemented in an FPGA.

Reference Channel

The reference channel signal drives a phase locked loop which in turn drives the reference channel. When the instrument is set to internal reference mode, the internal precision quartz stabilized oscillator is used to generate the sinewave output at the OSC OUT connector.

When set to the harmonic detection mode, an internal frequency multiplier permits measurement of signals at frequencies up to 127 times the reference frequency, allowing distortion measurements to be easily made.

The reference channel also includes a precision phase shifter, to permit the phase of the reference inputs to the demodulator to be adjusted.

The output of the reference channel is a series of digital phase values, updated at the same 1 MHz rate as the signal channel ADC sampling rate. These are used to derive digital representations of cosinusoidal and sinusoidal waveforms, which are applied to the reference channel inputs of the in-phase and quadrature demodulators respectively.

Digital Demodulators

At the heart of the instrument are the demodulators, implemented using DSP techniques. Unlike the analog multipliers or switches used in older lock-in amplifiers, this type of demodulator does not use DC coupled electronics. Hence it is immune from the potential errors caused by DC drift and offset introduced by such designs.

Output Channels

Following the demodulators, the first stage of output filtering, providing time constants in the range 10 µs to 500 ms, is carried out using digital finite impulse response (FIR) filters implemented within the FPGA and updated at the 1 MHz signal sampling rate. Further filtering, if required, is provided using similar filters implemented in the instrument's main microprocessor.

After filtering, the output signals are potentially further modified by offset and expansion controls, before being displayed either as basic X-output and Y-output values or being processed to give derived outputs, including signal vector magnitude and phase. The instrument can also be used to measure the noise accompanying the signal and the ratio or logarithm of the ratio of the X-channel output to other signals, such as the voltage at the auxiliary ADC inputs.

There are four rear-panel DAC outputs that can be set to convert the internal digital output values back to analog signals, at the same 1 MHz update rate, thereby making them usable down to the shortest possible output filter time constant settings.

- **Dual Reference - Simultaneously measure two signals at different frequencies**
- **Spectral Display - See the power spectral density of the input signal plus noise**
- **Dual Harmonic - Simultaneously measure two harmonics of the reference frequency**
- **Virtual Reference - Make reference-free measurements even on noisy signals**
- **VCO - Use external analog signal to control the frequency or amplitude of the precision internal oscillator**
- **Synchronous Oscillator Output - Access the sinewave being used for demodulation, including any frequency multiplication and/or phase shift**

Extended Operating Modes

The instrument includes the extended operating modes made popular by other ***SIGNAL RECOVERY*** lock-in amplifiers, such as the 7265 and 7280.

In normal **Single Reference** mode, harmonic analysis can be performed on harmonics up to 127 × F, while in **Dual Harmonic** mode the signals at two harmonics of the reference signal can be simultaneously measured. The instrument can therefore be used to measure a fundamental frequency and one harmonic of it at the same time.

Dual Reference mode permits measurement of two signals at two unrelated frequencies to be performed simultaneously. For example, in an optical experiment the signals passing through two different paths can be independently measured if they are modulated at two different modulation frequencies.

The instrument also includes a “tandem” demodulation mode which allows an amplitude-modulated signal to be first demodulated at a carrier frequency, with the output from this demodulation being processed by a second demodulator running at a lower frequency.

The **Synchronous Oscillator** output is an analog sinusoidal signal equivalent to that being used to drive the in-phase demodulator, and available in both internal and external reference modes. Hence, for example, if the instrument is set to 2F reference mode and a 1 kHz reference is applied, then this output will be a 2 kHz sine wave.

Manual Operation

Just like other ***SIGNAL RECOVERY*** instruments, the 7270 is exceptionally easy to use, both manually and when operated from a remote computer.

In manual use, the color TFT display panel is used in conjunction with the keys grouped around it and the numeric keypad to adjust the instrument’s controls, with the selected outputs being shown both on the display and being available as analog signals from four rear-panel connectors.

The keypad makes it simple to set controls, such as the oscillator frequency, that can be adjusted over a wide range and to a high precision. But once at the desired setting, the corresponding “increment/decrement” keys make it simple to change the set value by the required amount.

The Main Display is used in normal operation and shows four user-selected instrument controls on the left-hand side and four user-selected outputs, output offset status, and the present reference frequency, on the right.

Main Display

The output display selections include digital and bar-graph displays in a variety of formats. Error information, such as input and output overload, and reference unlock indication, is clearly shown along the top edge of the display, while soft keys along the bottom edge are used for selecting controls and to initiate numerical keypad data entry.

Pressing the Menu key accesses the Main Menu, from which other menus may be reached. Some, such as those affecting the communications interface settings, occupy the full display. Others, such as the Signal Channel menu, occupy only the left-hand side of the display, with the right-hand side continuing to show the selected outputs. This feature gives instant feedback on the effect of adjusting the controls.

User Settings

Sophisticated instruments such as the model 7270 are often used by several users for different types of experiment, and setting all the controls to the required state each time the unit is moved can waste precious time. The instrument therefore includes the ability to store up to eight complete records of all control settings, which can be recalled when required.

Auto Functions

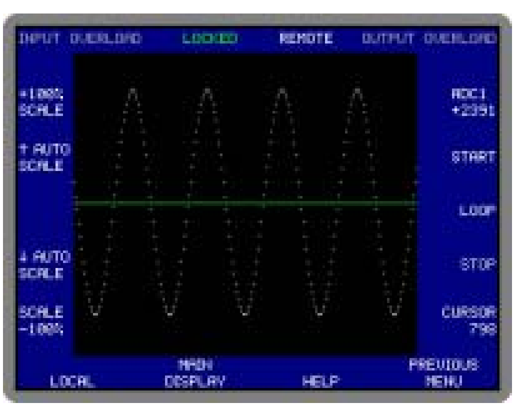
Any one of the five auto functions can be reached with just two key presses from the Main Display, and on completion of the selected function the Main Display returns. When activated, these functions adjust the associated control to the optimum setting for the present input signal.

Data Storage

An internal, 100k-point buffer memory can be used to store selected outputs. Digitized information from the auxiliary ADCs can also be stored, which is especially useful when using the highest ADC sampling rates. If required, the data buffer can be sub-divided to allow several outputs to be stored

simultaneously giving, for example, the ability to store lock-in amplifier outputs and auxiliary ADC input signals on the same time axis.

The resulting data curves can be shown graphically on the display as they are acquired in a "strip chart" mode, which can



Graphical Output Display

prove very useful while making adjustments to the experiment. The instrument also includes a **Spectral Display** mode (unique to ***SIGNAL RECOVERY*** lock-in amplifiers), which shows the power spectral density of the input signal plus accompanying noise, and which can prove an invaluable aid to selecting a reference frequency that is away from interfering signals.

Remote Operation

The model 7270 includes USB, RS232 and Ethernet bidirectional control interfaces, allowing controls to be set or interrogated, and instrument outputs to be read.

The command set is based on the use of simple ASCII mnemonics, making user written source code very easy to read and understand. In addition, a Communications Monitor display menu is available that shows all commands received and responses generated by the instrument. This is invaluable during program development and debugging.

Auxiliary Features

The model 7270 is much more than just a lock-in, since it includes a number of auxiliary inputs and outputs to further increase its versatility.

Four sampled ADC inputs on the rear panel of the instrument can be used to digitize external voltage signals, such as those from transducers measuring variables like temperature, pressure, flow rate, optical intensity or liquid level. Various trigger modes are provided. For example, the instrument can function as a 15-bit ADC 200 kSa/s transient recorder with a 100k-point data memory.

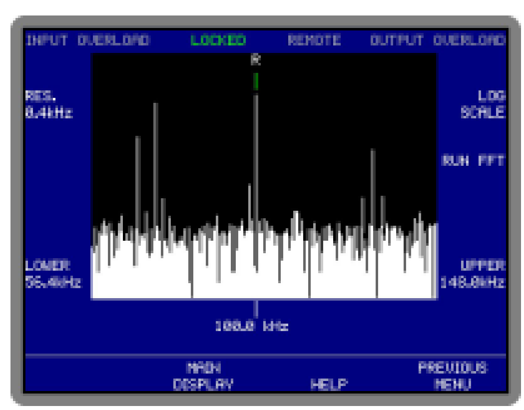
Calculations can be performed between any of the instrument's outputs and the digitized ADC inputs, allowing corrections for such variations as signal strength and standing offsets to be made.

The instrument also has four digital-to-analog converter (DAC) outputs that can be used to generate analog signals representing the instrument outputs (e.g. X, Y, Magnitude and Phase values) and voltages for the control of external equipment, such as motor speed, lamp intensity, or fluid flow rate.

The instrument includes an eight bit bidirectional TTL port that can be used to switch external equipment, such as relay input or output multiplexers.

User-Upgradeable Firmware

In common with most other ***SIGNAL RECOVERY*** instruments, the 7270's operating firmware can be updated via the USB or RS232 port simply by downloading new code into it using a firmware update pack, which can be obtained free of charge from our website. You can therefore be sure you are always using the latest code. No other lock-in manufacturer offers this capability.



Spectral Display Mode

Specifications

Measurement Modes

X In-phase **Y Quadrature** **R Magnitude** **θ Phase Angle** **Noise**	The instrument can simultaneously show any four of these outputs on the front panel display
Harmonic	n × F, n ≤ 127
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 internal and F_2 the external reference
Tandem Demodulation	Demodulates the signal using the internal reference frequency F_1, and then passes the resulting X channel output to a second demodulator running at an external reference frequency F_2
Virtual Reference	Locks to and detects a signal without a reference (100 Hz ≤ F ≤ 250 kHz)
Noise	Measures noise in a selected 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 250 kHz. The display is calibrated for frequency, but not amplitude, and is intended to assist in choosing the best reference frequency

Display

320 × 240 pixel color TFT display panel giving digital, analog bar-graph and graphical indication of measured signals. Menu system with dynamic key function allocation.

Signal Channel

Voltage Input	
Modes	A only, –B only or Differential (A–B)
Frequency Response	1 mHz ≤ F ≤ 250 kHz (–3dB)
Full-scale Sensitivity	2 nV to 1 V in a 1-2-5 sequence (e.g. 2 nV, 5 nV, 10 nV, 20 nV, etc.)
Input Impedance	
FET Input	10 MΩ // 25 pF, AC or DC coupled
Bipolar Input	10 kΩ // 25 pF, input must be DC coupled
Maximum Safe Input	±12.0 V
Voltage Noise	5 nV/√Hz @ 1 kHz
C.M.R.R.	> 100 dB @ 1 kHz degrading by no more than 6 dB/octave with increasing frequency
Gain Accuracy	±0.5% typ, ±1.0% max.
Distortion	-90 dB THD (60 dB AC gain, 1 kHz)
Current Input	
Mode	Low Noise (10^8 V/A) or Wide Bandwidth (10^6 V/A)
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
Frequency Response (-3dB)	
Low Noise	1 mHz ≤ F ≤ 500 Hz minimum
Wide Bandwidth	1 mHz ≤ F ≤ 5 kHz minimum
Impedance	
Low Noise	< 2.5 kΩ @ 100 Hz
Wide Bandwidth	< 250 Ω @ 1 kHz
Noise	
Low Noise	13 fA/√Hz @ 500 Hz
Wide Bandwidth	130 fA/√Hz @ 1 kHz
Gain Accuracy	± 2.0% typ, midband
Either Input Mode:	
Max. Dynamic Reserve	> 100 dB
Line Filter	Filter can be set to attenuate 50/60 Hz, 100/120 Hz, or both frequency bands
Grounding	BNC shields can be grounded or floated via 1 kΩ to ground
Signal Monitor	
Amplitude	±1 V FS. This is the signal after preamplification and filtering immediately prior to conversion by the main ADC
Output Impedance	1 kΩ

Reference Input

TTL Input (rear panel)	
Frequency Range	1 mHz to 250 kHz
Analog Input (front panel)	
Impedance	1 MΩ // 30 pF
Sinusoidal Input	
Level	1.0 V rms
Frequency Range	0.5 Hz to 250 kHz
Squarewave Input	
Level	250 mV rms
Frequency Range	2 Hz to 250 kHz

Reference Channel

Phase Set Resolution	0.001º increments
Phase Noise at 100 ms TC, 12 dB/octave slope	
Internal Reference	< 0.0001º rms
External Reference	< 0.01º rms @ 1 kHz
Orthogonality	90º ±0.0001º
Acquisition Time	
Internal Reference	instantaneous acquisition
External Reference	2 cycles + 1 s
Reference Frequency Meter Resolution	4 ppm or 1 mHz, whichever is the greater

Demodulators and Output Processing

Output Zero Stability	
Digital Outputs	No zero drift on all settings
Displays	No zero drift on all settings
DAC Analog Outputs	< 100 ppm/ºC
Harmonic Rejection	-90 dB
Output Filters	
Time Constant	10 µs to 100 ks in a 1-2-5 sequence
Slope (roll-off)	
TC < 5 ms	6 or 12 dB/octave
TC ≥ 5 ms	6, 12, 18 or 24 dB/octave
Synchronous Filter	Available for F < 20 Hz
Offset	Auto/Manual on X and/or Y: ±300% F.S.
Phase Measurement Resolution	≤ 0.01º
Reference Monitor	TTL signal at current reference frequency, internal or external

Oscillator

Frequency	
Range	1 mHz to 250 kHz
Setting Resolution	1 mHz
Absolute Accuracy	± 50 ppm
Amplitude	
Range	1 µV to 5 V
Max Setting Resolution	1 µV
Output Impedance	50 Ω
Sweep	
Frequency	
Output Range	1 mHz to 250 kHz
Law	Linear or Logarithmic
Step Rate	1000 Hz maximum (1 ms/step)

Specifications - continued

Amplitude Sweep	
Output Range	0.000 to 1.000 V rms
Law	Linear
Step Rate	
Main Console	20 Hz maximum (50 ms/step)
RCU	1 Hz maximum (1 s/step)

Auxiliary Inputs

ADC 1, 2, 3 and 4

Maximum Input	±11 V
Resolution	1 mV
Accuracy	±20 mV
Input Impedance	1 MΩ // 30 pF
Sample Rate	200 kHz maximum (one ADC only)
Trigger Mode	Internal, External or burst
Trigger Input	TTL compatible, rising or falling edge

Outputs

Analog Outputs

DAC1	X, X1, Mag2, User DAC1, Output function
DAC2	Y, Y1, Pha2, User DAC2, Output function
DAC3	X2, Mag, Mag1, User DAC3, Output function
DAC4	Y2, Pha, Pha2, User DAC4, Output function
Output Functions	Noise, Ratio, Log Ratio and User Equations 1 & 2.
Amplitude	
X(1), Y(1), Mag(1), Pha(1)	±2.5 V full-scale; linear to ±300% F.S.
User DACs and Output Functions	±10.0 V full-scale
Impedance	1 kΩ
Update Rate	
X(1/2), Y(1/2), Mag(1/2), Pha(1/2) @ TC < 1 s	1 MHz
User DACs, Output Functions and TC's ≥ 1 s	1 kHz

8-bit Digital Port

Mode	0 to 8 lines can be configured as inputs, with the remainder being outputs
Status	Each output line can be set high or low and the status of each input line read

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

Data Storage Buffer

Size	100,000 data points
Max Storage Rate	
Fast Mode	1 MHz (X1, Y1, X2, Y2, ADC1, Demod I/P 1, Demod I/P 2)
Normal Mode	1 kHz

User Settings

Up to 8 complete instrument settings can be saved or recalled from memory as required

Interfaces

USB 2.0, Ethernet, and RS232 allow complete control of instrument settings, and data readout.

General

Power

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

Dimensions

Width	15½" (390 mm)
Depth	7¼" (185 mm)
Height	
With feet	7¼" (185 mm)
Without feet	6½" (170 mm)

Weight 12.8 lb (5.8 kg)

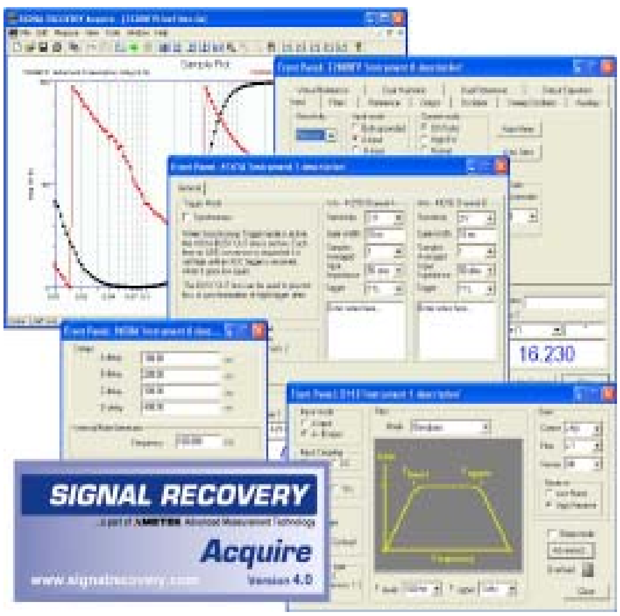
Preliminary specifications subject to change without notice

Model 7270 Rear Panel

Software and Ordering Information

ACQUIRE Applications Software

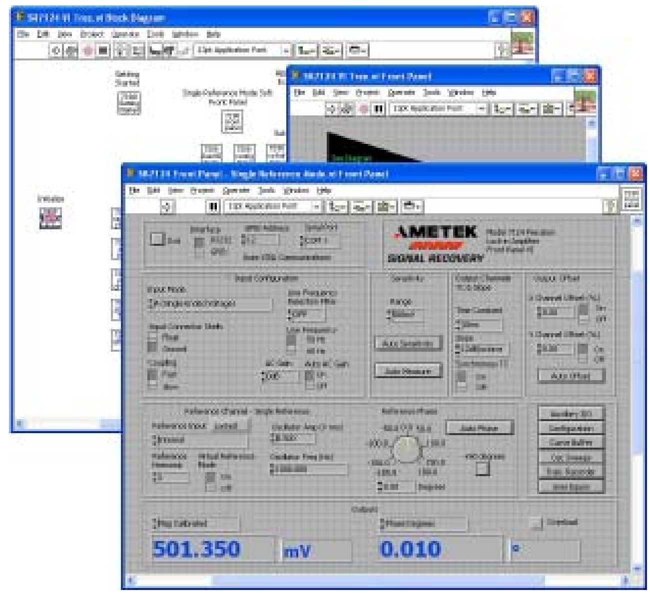
The Acquire Data Acquisition Software significantly extends the capabilities of the instrument by, for example, adding the ability to make swept frequency measurements. The software is suitable for Windows XP and later operating systems and allows up to ten compatible ***SIGNAL RECOVERY*** instruments to be controlled at the same time. A free demonstration version is available from the **www.signalrecovery.com** website, which can be upgraded to the full version by purchase of an activation key.



Acquire Software

LabVIEW® Driver Software

A free LabVIEW® driver is available for the instrument, 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.



LabVIEW Driver

Ordering Information

Each model 7270 is supplied complete with comprehensive instruction manual and line power cord

Optional Accessories

SRInstComms	ActiveX Control and Software Toolkit for simple instrument control from a PC. Includes sample programs in C#, C++, Visual Basic, HTML, etc.
Acquire™	Comprehensive control and acquisition software for use with Windows XP/Vista operating systems
Model K02005	Rack mount to mount one model 7270 in a 19" rack

External Preamplifiers

The model 7270 may also be used in conjunction with ***SIGNAL RECOVERY*** model 5113, 181, 5182, 5183, 5184, and 5186 preamplifiers, and with the model 1900 impedance matching transformer.

SIGNAL RECOVERY

SIGNAL RECOVERY is part of **AMETEK** Advanced Measurement Technology, Inc

801 SOUTH ILLINOIS AVENUE
OAK RIDGE
TN 37831-2011
USA
Phone: (865) 483 2118
Fax: (865) 481 2410

SPECTRUM HOUSE
1 MILLARS BUSINESS CENTRE, FISHPONDS CLOSE
WOKINGHAM, BERKS RG41 2TZ
UNITED KINGDOM
Phone: +44 (0)118 936 1210
Fax: +44 (0)118 936 1211

info@signalrecovery.com   www.signalrecovery.com

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