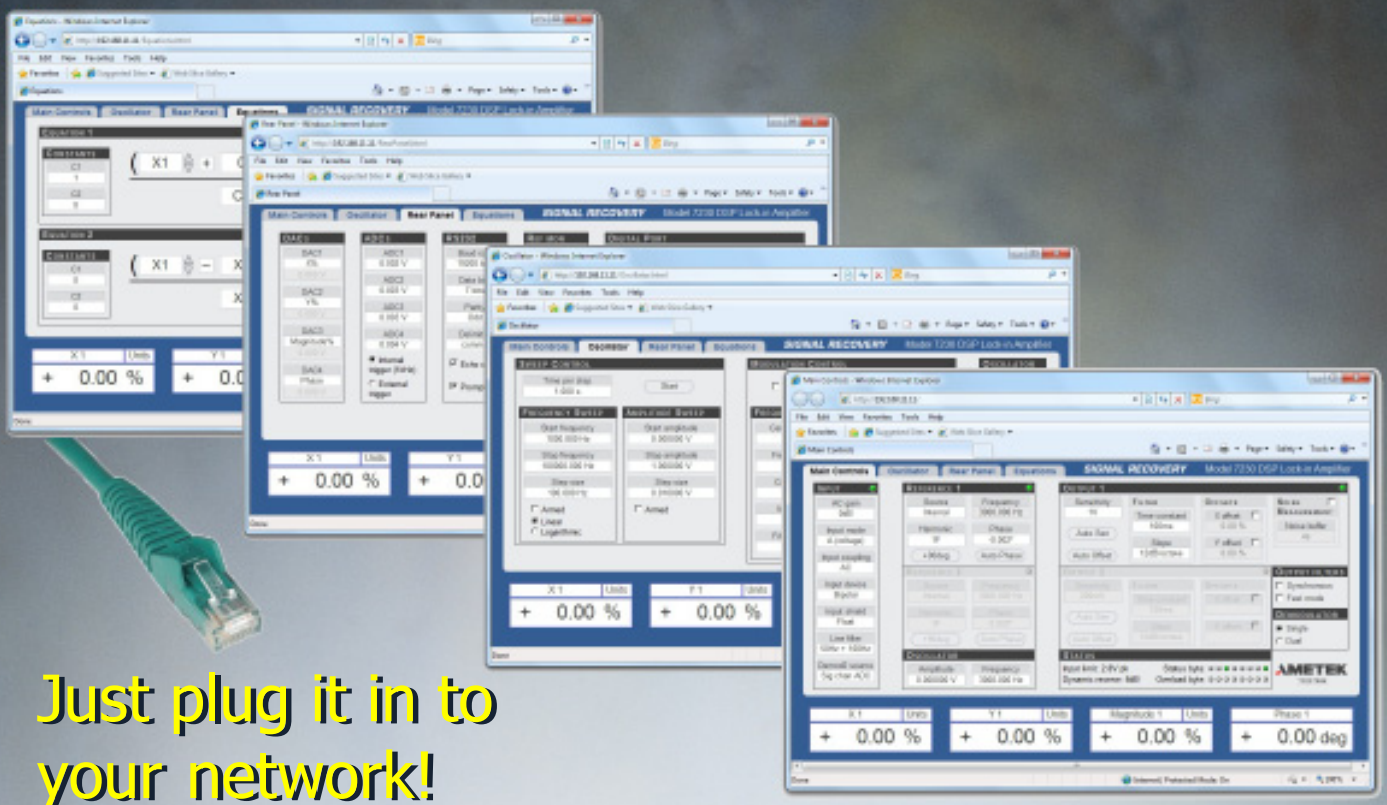
Model 7230

DSP Lock-in Amplifier

...as easy to use as your favorite web browser



Just plug it in to your network!

SIGNAL RECOVERY

...part of AMETEK® Advanced Measurement Technology

Model 7230 DSP Lock-in Amplifier

Outstanding performance at a surprisingly low price

Overview

The model 7230 is a new concept in general-purpose DSP lock-in amplifiers. It offers the excellent signal recovery performance that users expect from our instruments but at a lower price than many competitive models. We've achieved this improvement in price/performance ratio by replacing traditional control buttons and display with easy-to-use control panels that can be operated from any computer via your favorite browser. No longer do you need to be in front of the instrument to operate it - now you can set up your experiment in the lab but return to the office while it runs, monitoring what is happening via your computer. And if you need to make a change to a setting then it's as easy as clicking a button on a web page.

You can use any web compatible device to operate the model 7230, ranging from a simple netbook to the most powerful development machine, from an Android smartphone to the latest iPad. No special software is needed, since the panels work directly through the device's browser. All that is necessary is that the computer and instrument be connected to the same Ethernet network.

The instrument is also much more compact than traditional designs, making it easier to accommodate in crowded laboratories, and as it does not include any cooling fans it is completely silent, which is especially useful for acoustic research.

It is normally configured for operation over a frequency range extending from 1 mHz to 120 kHz. However, for a small extra charge it can also be delivered, or upgraded via a firmware update pack, to allow operation at frequencies of up to 250 kHz.

Versatility

In common with other models in our range the 7230 offers much more than just dual phase lock-in detection at the reference frequency of an applied signal. It includes 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, and tandem demodulation. It also includes virtual reference mode, allowing reference-free measurement of suitable signals.

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. The maximum rate at which data can be stored to the internal curve buffer is 1 µs per point, allowing direct capture of instrument outputs when using these short time constants. The buffer length of 100,000 sets of points gives a recording time of 100 ms at the fastest sampling rate.

Remote Control

The built-in web control pages allow full operation via the Ethernet interface, which with the USB and RS232 connections, can also be used to operate the instrument from our comprehensive software package, Acquire, from our ActiveX control and toolkit (SRInstComms), or using the free LabVIEW driver.

See what you've been missing...

In summary, the Model 7230 offers a very cost-effective solution to users who need a lock-in amplifier suitable for straightforward applications but with the versatility to also be used in complex experiments.

- **Built-in web pages for control from any computer on the same network**
- **1 mHz to 120 kHz (250 kHz with 7230/99 option) 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**
- **Auxiliary analog and digital inputs and outputs**
- **Internal data buffer for recording instrument outputs at rates down to 1 µs per point**
- **Ethernet, USB, and RS232 computer interfaces**
- **Free LabVIEW driver**

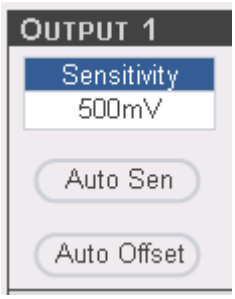
Instrument Format

The 7230 is packaged as a very compact benchtop unit with separate power supply module. 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

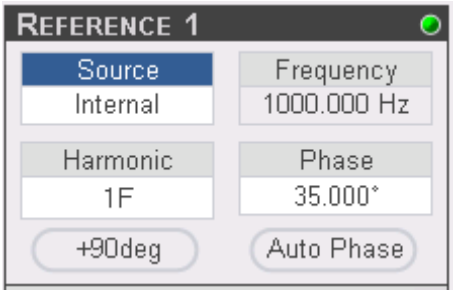
The front-panel signal input connectors can be switched to operate in single ended or differential voltage mode, or in current mode with a choice of two transimpedance settings. They can also be used to switch between two single-ended voltage signals, for simple sequential measurement under computer 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 7230'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 analog or TTL logic signals 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 via the web panels 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**
- **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, 7124, 7270 and 7280.

In normal **Single Reference** mode, measurements can be made at harmonics of 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 frequencies.

A variant of the dual reference mode is tandem demodulation, which allows an amplitude-modulated signal at a (high) "carrier" frequency to be 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 to a second set of demodulators to give an output proportional to the amplitude of the modulation.

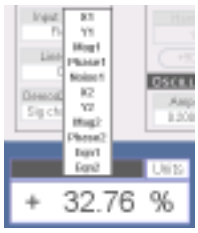
In **Virtual Reference** mode the instrument extracts a reference from the applied signal, allowing reference-free measurements where signals are derived from stable frequency sources.

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.

Browser Operation

Just like other ***SIGNAL RECOVERY*** instruments, the 7230 is exceptionally easy to use. Plug it in to your network and if a DHCP server is present (most networks include one) then it will be allocated an IP address; simply type this address into any browser on a device on the same network, and the main display panel will be shown. It is also possible to set the instrument to a manual IP address.

The web pages use tabbed panels containing both drop-down selectors and text boxes to set the instrument controls, and four digital indicators to show selected outputs

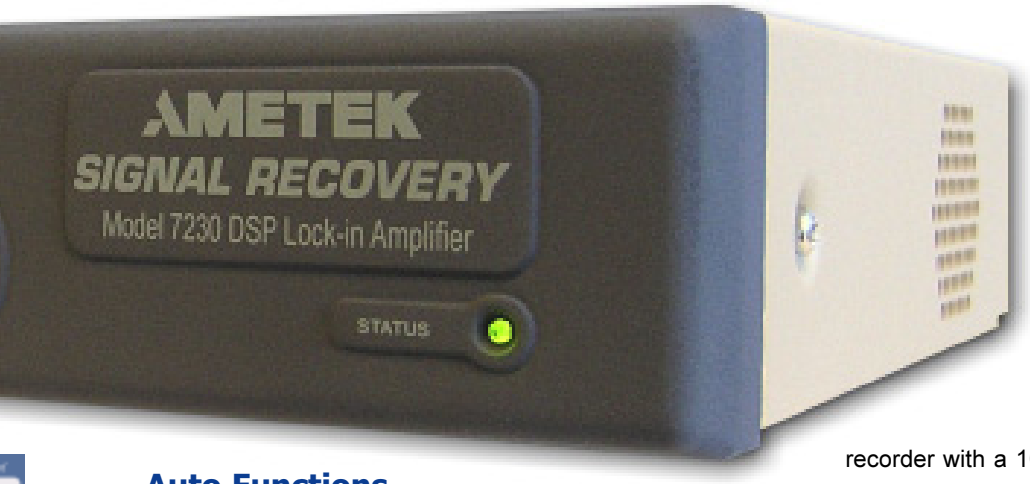


The **Main Controls** panel is used to configure the signal channel input settings, the reference source and mode, the output filter settings, and the internal oscillator frequency and amplitude. Status indicators give an immediate indication of conditions such as input or output overload, or loss of reference lock.

More complex control of the internal oscillator, such as frequency or amplitude sweeps, is possible via the **Oscillator** panel. The **Rear Panel** tab includes controls for setting the voltages at the DAC outputs, and for reading the voltages present at the auxiliary ADC inputs.

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. These are specified on the **Equations** tab.

Control from your iPad...

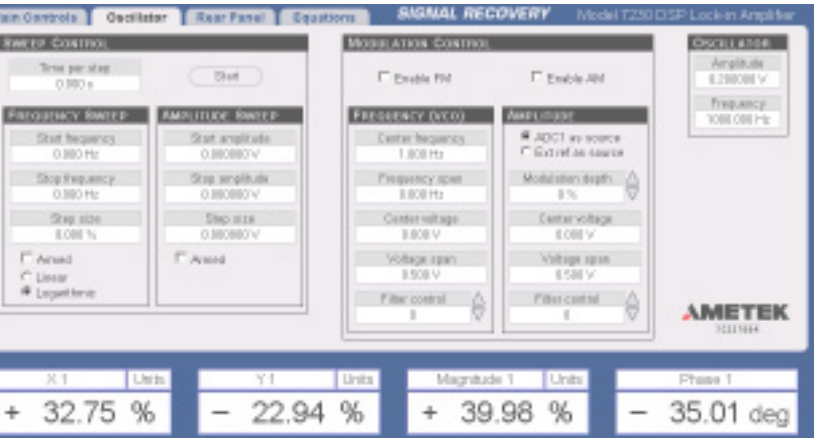


Auto Functions

Any one of the four auto functions can be reached with just a single click on a button on the **Main Controls** tab. When activated, these functions adjust the associated control to the optimum setting for the present input signal, and the effect is immediately visible on the digital indicators.

Remote Operation

There are some situations where the built-in web control panels do not offer sufficient flexibility. This is typically when data from the instrument needs to be stored to a disk file, or where the model 7230 needs to be used in conjunction with other instruments. It therefore also includes USB and RS232, as well as the Ethernet, 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.

An internal, 100,000 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 transferred via the interfaces to the controlling computer for storage or further manipulation

Auxiliary Features

The model 7230 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 analog-to-digital (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 100,000 point data memory.

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.

...or your desktop

User-Upgradeable Firmware

In common with most other ***SIGNAL RECOVERY*** instruments, the 7230'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.

Specifications

Note:

† In the following specifications, the upper frequency limit for the standard model 7230 is 120 kHz; when fitted with the model 7230/99 it is 250 kHz

Measurement Modes

X In-phase **Y** Quadrature **R** Magnitude **θ** Phase Angle **Noise**	The instrument can simultaneously show any four of these outputs via the web control pages
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 one is the internal and the other the external reference
Tandem Demodulation	Demodulates the signal using the internal reference frequency, and then passes the resulting X channel output to a second demodulator running at an external reference frequency
Virtual Reference	Locks to and detects a signal without a reference (100 Hz ≤ F ≤ 120/250 kHz†)
Noise	Measures noise in a selected bandwidth centered at the reference frequency F

Display

Four web control pages showing four selected outputs and controls for all instrument functions

Signal Channel

Voltage Input

Modes	A only, –B only or Differential (A–B)
Frequency Response	1 mHz ≤ F ≤ 120/250 kHz†
Full-scale Sensitivity	10 nV to 1 V in a 1-2-5 sequence (e.g. 10 nV, 20 nV, 50 nV, 100 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	
FET Input	5 nV/√Hz @ 1 kHz
Bipolar Input	2 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	10 fA to 10 nA in a 1-2-5 sequence
Wide Bandwidth	10 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 ≤ 50 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 @ 50 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 setting	
Frequency Range	1 mHz to 120/250 kHz†
Analog setting	
Impedance	1 MΩ // 30 pF
Sinusoidal Input	
Level	1.0 V rms
Frequency Range	0.5 Hz to 120/250 kHz†
Squarewave Input	
Level	250 mV rms
Frequency Range	2 Hz to 120/250 kHz†

Reference Channel

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 + 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/°C
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	≤ 0.01°
Reference Monitor	TTL signal at current reference frequency, internal or external

Oscillator

Frequency	
Range	1 mHz to 120/250 kHz†
Setting Resolution	1 mHz
Absolute Accuracy	± 50 ppm

Specifications - continued

Amplitude

Range	1 µV to 5 V
Max Setting Resolution	1 µV
Output Impedance	50 Ω

Sweep

Frequency	
Output Range	1 mHz to 120/250 kHz†
Law	Linear or Logarithmic
Step Rate	1000 Hz maximum (1 ms/step)
Amplitude Sweep	
Output Range	0.000 to 5.000 V rms
Law	Linear
Step Rate	20 Hz maximum (50 ms/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

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

Interfaces

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

General

Power	Via external model PS0110 universal power supply
Voltage	100 - 250 VAC
Frequency	50/60 Hz
Power	40 VA max
Dimensions	
Width	15½" (390 mm)
Depth	10" (250 mm)
Height	
With feet	3" (75 mm)
Without feet	2½" (64 mm)
Weight	6.6 lb (3.0 kg)

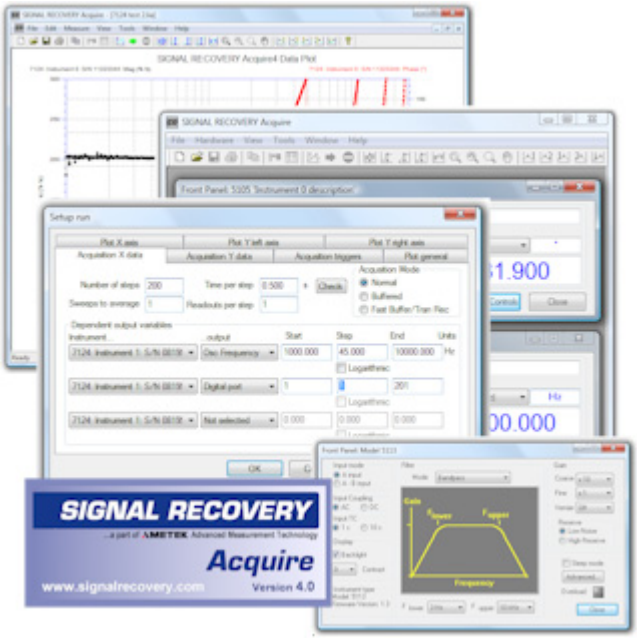
Preliminary specifications subject to change without notice

Model PS0110 Power Supply

Model 7230 Rear Panel

Software and Ordering Information
ACQUIRE Applications Software

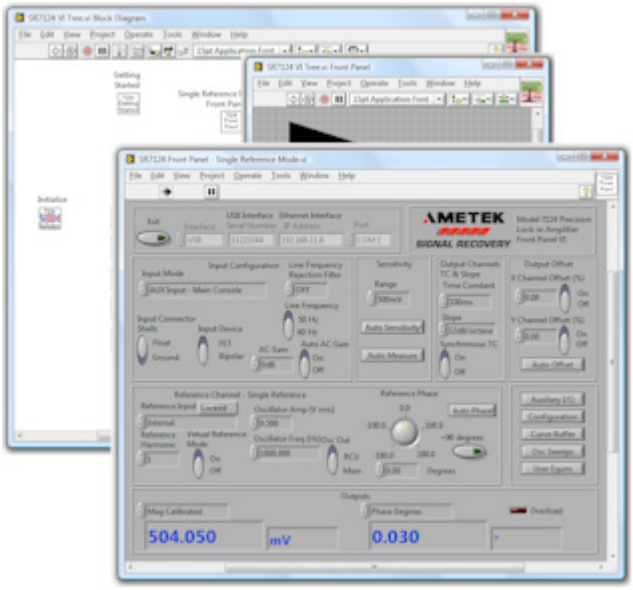
The Acquire Data Acquisition Software significantly extends the capabilities of the instrument by, for example, adding the ability to make swept frequency measurements. The software is suitable for Windows XP and later operating systems and allows up to ten compatible ***SIGNAL RECOVERY*** instruments 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.



Free LabVIEW Driver

Ordering Information

Each model 7230 is supplied complete with model PS0110 power supply, line power cord, and comprehensive instruction manual

Optional Accessories

7230/99	Extends upper reference frequency limit to 250 kHz
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 7/Vista/XP operating systems
Model K02006	Rack mount to mount one model 7230 in a 19" rack

External Preamplifiers

The model 7230 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

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