Fast Gated Integrators and Boxcar Averagers

The System

The Stanford Research Systems' Gated Integrator and Box-car Averager System is a versatile instrument designed to recover and process fast analog signals. The system consists of a NIM-compatible mainframe and modules which can be selected to tailor the system to your specific needs.

Compatibility

The system mainframe provides regulated power to each of the modules. Because the mainframe is NIM compatible, you are able to use modules from other manufacturers or ones that you build yourself. A wide variety of modules are available in the NIM format including amplifiers, counters, discriminators, and pulse height analyzers. Each of the SRS modules is NIM compatible and may be used in NIM standard crates from other manufacturers.

Versatility

The Boxcar System has been designed to operate in a wide range of configurations:

1. Stand-alone analog data acquisition.
2. Interfaced to virtually any computer via the RS-232 or GPIB interfaces, or to the computer's A/D and D/As.
3. "Turn-key" data acquisition, storage, graphics and analysis on IBM PC or compatible computers using SRS application programs.

Convenient, Simple Operation

Unlike other boxcar averagers, this one is easy to operate. Look at the front panel of the Gated Integrator Module —operation of this unit is very simple. For example, you specify the boxcar averaging in number of samples, and the Gate Output lets you see the exact (±1 nS) position of the sample gate with respect to the input signal. No guesswork is involved.

Shot by Shot

An important feature of the Gated Integrator and Fast Sampler Modules is the Last Sample Output. The analog voltage at this output is proportional to the average of the input signal during the most recent gate. This output may be digitized by the computer interface module to allow shot-by-shot analysis of the experimental data.

Computer Interface and PC Software

The SR245 Computer Interface Module provides 12 Bit A/D and D/A at eight analog input/output ports. The module allows your computer to read outputs from your gated integrator, to scan gates, and to interface with other analog or digital equipment in your lab.

While the SR245 can operate with virtually any computer via its RS-232 and GPIB interfaces, a complete data acquisition package for IBM PC computers is also available.

The Solution

The Stanford Research Systems Boxcar Averager System is the answer to your fast analog data acquisition problems. The system provides the speed, accuracy, flexibility and convenience that are needed in your research laboratory.

Model SR250 Gated Integrator

The Model SR250 Gated Integrator and Boxcar Averager is a versatile, high speed, low cost NIM module designed to recover fast analog signals from noisy backgrounds.

The SR250 consists of a gate generator, a fast gated integrator, and exponential averaging circuitry. The gate generator, triggered internally or externally, provides an adjustable delay from a few nanoseconds to 100 milliseconds, before it generates a continuously adjustable gate from 2 nanoseconds to 15 microseconds (a minor modification allows gates to 150μs). The delay may be set by a front panel potentiometer, or automatically scanned by a rear panel input voltage in order to record entire waveforms.

The fast gated integrator integrates the input signal during the gate. The output from the integrator is then normalized by the gate width to provide a voltage which is proportional to the average of the input signal during the sampling gate.

This signal is further amplified (according to the front panel sensitivity setting) and then sampled by a low droop sample and hold amplifier, and output via a front panel BNC connector. This LAST SAMPLE output allows the experimenter to do a shot-by-shot analysis of the signal being studied, and makes the instrument a particularly useful component in a computer data acquisition system.

In addition to the traditional boxcar averaging technique, the averaging circuitry may be used to actively subtract a baseline drift or background from the signal of interest. This is accomplished by taking input samples at twice the experiment's repetition rate, inverting the baseline sample acquired when the signal is not present, and adding it to the moving average. This method of canceling baseline drift is analogous to phase sensitive detection which is used in frequency domain measurements.

Model SR250 Gated Integrator and Boxcar Averager

FEATURES

- Gate Widths from 2 nsec to 15 μsec (expandable to 150 μsec)
- Independent rate generator, gate control, and averaging
- Shot-by-Shot Output
- Trigger to gate delay <25 nsec
- Low drift . . . <0.5 mV/hr
- Jitter less than 20 psec +0.01%
- Active Baseline Subtraction
- Gate Out shows precise timing
- DC to 20 KHz repetition rate
- Inputs protected to 100 VDC
- Average 1 to 10,000 samples
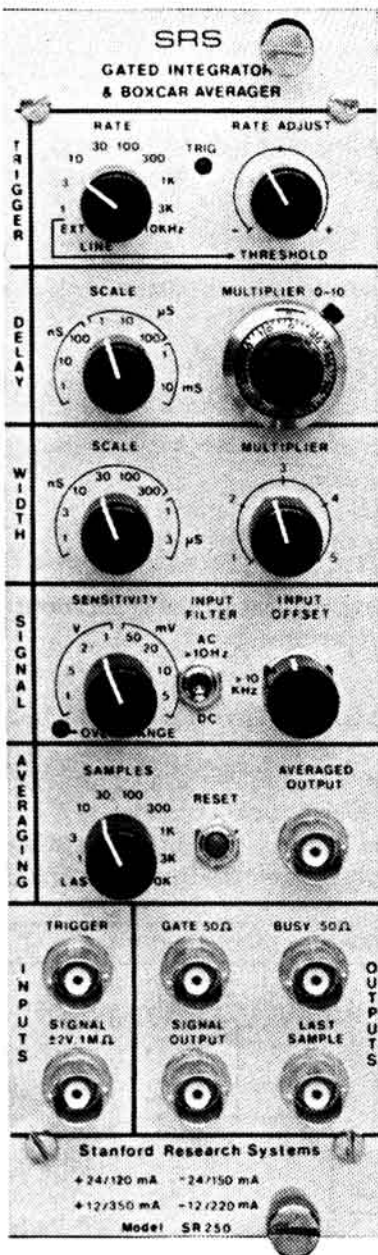
SPECIFICATIONS

TIMING CIRCUITS

Trigger	Int: 0.5 Hz to 20 KHz, Single Shot, or Line. Ext: ±0.5 to ± 2V. 5 nS minimum pulse. 1 M Ohm input impedance, protected to 100 VDC. Max trig rate=1/(50 μS+Width+Delay+Full Scale Delay).
Delay	Gate Delay=25 nS+(Delay Range)×(Delay Multiplier). Accuracy is 2 nS or 5% of the full scale delay. Jitter is less than 20 pS or 0.01% of full scale. Gate Delay may be scanned by a rear panel input. (0–10 volts gives 0–100% of full scale delay.)
Width	Gate Width=(Width Scale)×(Width Multiplier). Gate Width: 2 nS–15 μS (150 μS with modification).
Gate Output	200 mV pulse shows the position of the sample gate with respect to the Signal Output with 1 nS accuracy.
Busy Output	TTL Output goes high from the trigger until ready for the next trigger. Busy time is approximately 50 μS+Delay+Width+Full Scale Delay.

SIGNAL CHANNEL

Signal Input	Zin=1 M Ohm. (50 Ohms with Signal Out Terminated). Input Offset Drift <0.5 mV/hr. Shot noise <0.5 mVrms. Coherent Pickup: <8 mV in first 100 nS, <1 mV after 100 nS, <100 μV when using Baseline Subtraction.
Signal Filter	DC, AC above 10 Hz, or AC above 10 KHz.
Sensitivity	(Volts Out)/(Volts In) from 1 V/V to 1 V/5 mV in a 1,2,5 sequence.
Accuracy	±3% for gate widths greater than 10 nS. Sensitivity decreases to about 50% at 2 nS gate width.
Offset	10 turn control adds offsets of ±0.4 V to the input. The offset may need adjustment when the gate width is changed.

OUTPUTS

Last Sample	±10 VDC full scale. Polarity set on rear panel.
Output Impedance	<1 Ohm with 10 mA drive capacity.
Droop	<0.2% of full scale per second.
Responsivity	>95% (no more than 5% of the previous sample remains).
Average Out	Exponential moving average over 1 to 10,000 samples. May be reset by pushbutton or logic input. ±10 V full scale, polarity set on rear panel.
Output Impedance	<1 Ohm with 10 mA drive capacity.
Droop	<1%/minute on 1 to 30 samples, <0.01%/minute on 100 to 10,000 samples. All droop errors <1% of full scale for trigger rates greater than 1 Hz.

GENERAL SPECIFICATIONS

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Power	+24V/120 mA, +12V/350 mA, −12V/220 mA, −24V/150 mA. About 14 Watts total. Power from a NIM-standard crate or from SRS NIM mainframe model SR280.

SR255 Fast Sampler Module

The SR255 Fast Sampler is an important tool for short pulse duration experiments. It provides four user-selectable gate widths from 100 psec to 1 nsec. All of the electronics are built into the module including A/D, D/A and a PROM correction circuit to eliminate the inherent non-linearities in the sampling bridge. Output is provided in both digital and analog form. Input sensitivity can be set from 100 mV/V to 1 V/V and trigger level selection is provided for broad trigger source compatibility. The gate view allows you to see precisely when the sample is being taken. The gate can be scanned by a rear panel voltage input from the SR200 Gate Scanner or SR245 Computer Interface. The signal out aids in sample timing and special applications such as time domain reflectometry or shorted-cable baseline subtraction. This module can be used alone, combined with the SR245 Computer Interface Module for computer data acquisition, or operated with the SR200 Gate Scanner for waveform recovery.

FEATURES

- Gate Widths from 100 psec to 1 nS
- Droopless analog output
- Linear over full range
- Jitter less than 2 psec rms
- 20 nsec trigger to gate delay
- Trigger rates up to 50 KHz
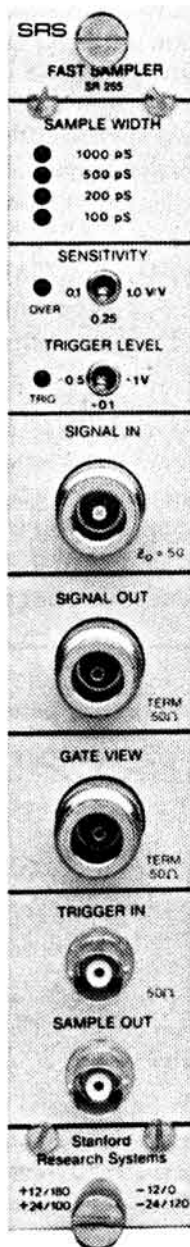
SPECIFICATIONS

TIMING CIRCUITS

Trigger Input	BNC, 50 Ohm termination. Thresholds: -0.5, $+0.1$, or $+1$ VDC. Trigger Rate: DC to 50 KHz.
Gate Delay	20 nS + (Delay Range) × (Control Voltage). Delay Range: 1, 10, 100 or 1000 nS/Volt. (Control voltage input is on the rear.) Delay Jitter: 2 pS rms.
Gate Width	100, 200, 500, or 1000 pS.
Gate View	N-type connector. Leading edge indicates when gate opens. Accuracy ± 50 pS with respect to signal out. Risetime < 50 pS.

SIGNAL CHANNEL

Signal Input	N-type connector. Characteristic impedance is 50 Ohms. Protected to 5 VDC. The full scale input level equals the sensitivity setting.
Shot Noise (typical)	200 μV rms on 1000 pS gate 350 μV rms on 500 pS gate 600 μV rms on 200 pS gate 800 μV rms on 100 pS gate.
Sensitivity	0.1, 0.25 or 1.0 Volts full scale. Overrange LED indicates signal greater than full scale.
Signal Out	The Signal In is passed to the Signal Out for termination, gate timing, and for special applications such as time domain reflectometry.

OUTPUTS

Sample Out	±1 V full scale analog output. Linearized and latched representation of the signal input as sampled during the gate. Resolution is ½% of full scale. Output impedance <1 Ohm. 10 mA drive capacity.
Digital Out	Rear panel 8-bit digital interface is addressed as two bytes, an 8-bit data byte for amplitude, an 8-bit status byte for sign, gate width sensitivity, data ready, rate error, and overrun status.

GENERAL SPECIFICATIONS

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Power	+24 V/100 mA, −24 V/120 mA, +12 V/180 mA. About 8 Watts total.
Connectors	Three N-type to BNC transitions are provided.

SR200 Gate Scanner Module

The SR200 is designed to automate the recovery of waveforms with the SR250 and SR255. A waveform is recorded by plotting the 'Average Output' vs. the 'Delay Multiplier' setting as the Delay Multiplier is slowly scanned. The SR200 module will scan the delay multiplier (to scan the sample gate through the waveform) and control an X–Y chart recorder, strip chart recorder or oscilloscope.

The SR200 provides delay control for the SR255 and overrides the delay multiplier dial on the SR250. The SR200 electronically scans the delay multiplier over a range specified by 10 turn dials on its front panel. Single or repeated scans may be done in the forward or reverse direction over any portion of the waveform.
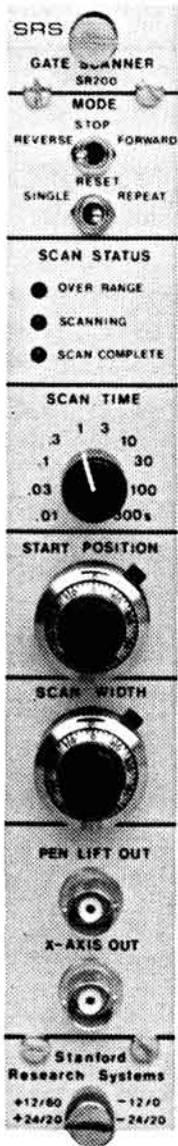
SPECIFICATIONS

CONTROLS

Reverse/Stop/Forward	Selects the scan direction or stops the scan.
Single/Reset/Repeat	Selects single or repeated scans or resets to start.
Scan Time	Selects time to complete one scan. 10 msec to 5 minutes.
Start Position	Specifies the smallest Delay Multiplier in the scan.
Scan Width	Specifies the range of Delay Multipliers in the scan.

INDICATORS

Over Range LED	Indicates if the delay multiplier exceeds 10.0.
Scanning LED	Indicates that a scan is in progress.
Scan Complete LED	Indicates when a single scan has been completed.

OUTPUTS

Control Voltage	Rear panel output connects to the SR250 or SR255 External Delay Multiplier Input. This output has an output impedance of less than 1 Ohm and current limits at 20 mA.
Pen Lift	Logic Signal to lift chart recorder pen or blank an oscilloscope trace.
X-Axis	Analog voltage output scans between 0 and 10.0 VDC regardless of the start position and scan width dial settings.

GENERAL SPECIFICATIONS

Power Supplies	+24 V/20 mA, +12 V/60 mA, −12 V/0 mA, −24 V/20 mA. 2 Watts total.

WAVEFORM RECOVERY

SAMPLING OSCILLOSCOPE
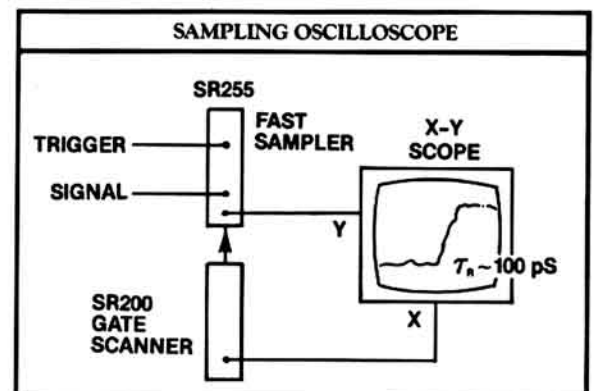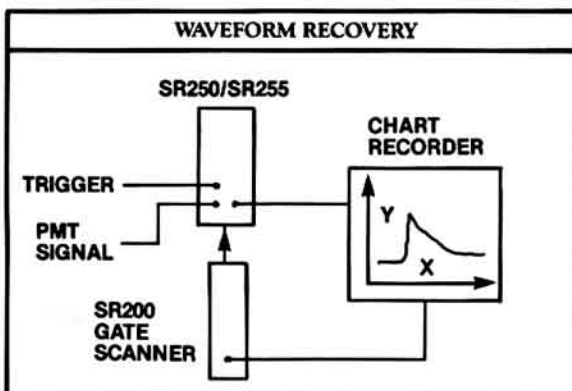
SR235 Analog Processor Module

Often, additional processing of a Gated Integrator output is needed in an experiment. For example, in pulsed laser experiments, one may wish to normalize a laser-induced signal to the laser's intensity, and so eliminate the noise introduced by the laser's intensity fluctuations. Many other types of analog processing may be needed in other experiments.

The SR235 Analog Processor is a convenient and flexible instrument which is capable of a wide variety of operations. The Analog Processor module provides an analog output F(x) which is formed from its analog inputs A and B. The argument, x, can be A, B, A–B, A×B, A/B or $\sqrt{A^2+B}$. The argument may be filtered with a time constant from 0.3 mS to 30 S, or left unfiltered. The function may be any of x, x^2, $\sqrt{x}$, ln(x), dx/dt or (dx/dt)/100. Finally, an output gain from 0.1 to 20 may be selected. The result, $5\ln(10A/B)$ for example, is available at the output.

The Instrument may be used to normalize Boxcar outputs, find peaks in experimental scans, linearize exponential decay curves, compress analog signals in order to increase dynamic range, or simply to amplify a signal.

FEATURES

- 36 functions
- Gain Control
- Averaging of products and ratios
- Noise Reduction
- Normalization
- 2% Basic Accuracy
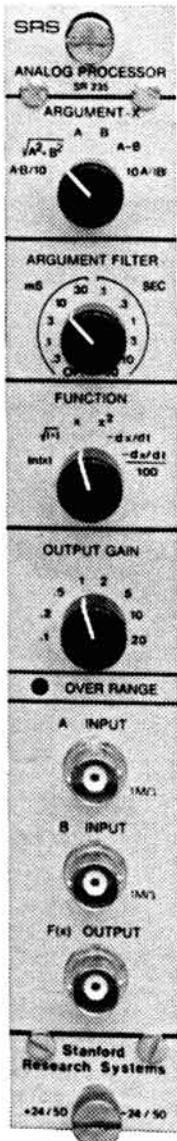
SPECIFICATIONS

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A and B Inputs	Input impedance of 1 M Ohm. Operating range of ±10 VDC, protected to 100 VDC. Input offset voltage is less than 2 mV.
Argument X	Select A, B, $\sqrt{A^2+B^2}$, A–B, A×B/10 or 10A/B.
Filter	Select time constants from 0.3 mS to 30 S or none.
Function	Select x, x^2, $\sqrt{x}$, ln(x), –dx/dt or –(dx/dt)/100.
Gain Select	Selectable gains of 0.1 to 20 in a 1,2,5 sequence.
F(x) Output	±10 VDC linear range. Output impedance is less than 1 Ohm. Short circuit limits at 20 mA.
Frequency Response	dx/dt to 10 Hz, (dx/dt)/100 to 1 KHz, all other from DC to 50 KHz.
Accuracy	Gain 2%; Vector Sum 3%; Difference 1%; Multiplication 2% of full scale; Division (with denominator >0.1) 3% of full scale; ln(x), x^2, and $\sqrt{x}$ are accurate to ±20 mV referenced to the input or at the output, whichever is less; dx/dt and (dx/dt)/100 5%.
Power	+24/120 mA, –24/80 mA. 5 Watts total.

DUAL CHANNEL WITH NORMALIZATION
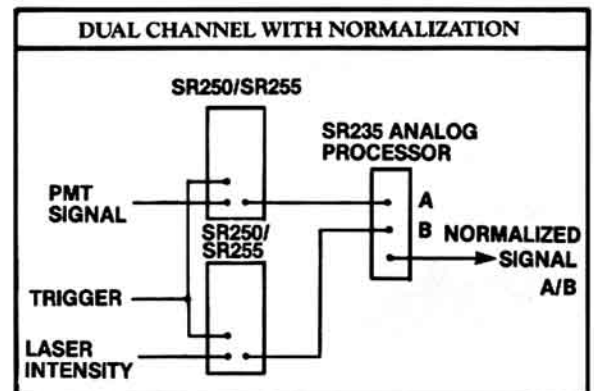
SR245 Computer Interface Module

The SR245 Computer Interface module is a powerful addition to your data acquisition capabilities. The unit provides both an analog and a digital interface between your computer and your experiment.

The eight analog I/O channels can be designated as inputs, outputs, or a combination, under software control. Both inputs and outputs have 13 bits of resolution over ±10.24 VDC full scale range, and 0.05% accuracy.

Two digital I/O bits are provided on the front panel which may be used as counters, triggers, or may be set or read by your computer. In addition, an 8-bit input and an 8-bit output port are available on an internal connector for your own custom digital interfaces.

Both RS-232-C and IEEE-488 interfaces are included for connection to your computer. The module is simple to control from high level languages. For example, sending ?5 instructs the module to digitize and send (in ASCII) the voltage on the 5th analog input BNC. Other commands allow you to record scans in the module's buffer memory, or ramp an analog output at a specified rate (for gate scanning), or read the contents of a digital counter.

FEATURES

- Eight analog I/O Ports
- 12 bit+sign resolution
- 18 digital I/O Bits
- RS-232-C and IEEE-488
- 3500 Sample Memory
- Counter Channel
- IBM Software Available
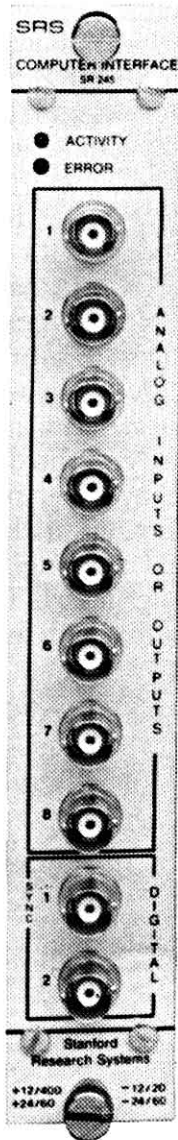
SPECIFICATIONS

ANALOG PORTS	Any number of the eight ports may be designated under program control as input ports, the rest will become output ports.
Inputs	1 Megaohm input impedance, ±10.24 VDC range, protected to 40 VDC. 13-bit resolution (2.5 mV). Accuracy: 0.05%. Input offset less than 2.5 mV. Maximum A/D rate is 2 KHz.
Outputs	Output impedance less than 1 Ohm. Short circuit current limit is 20 mA. 13 bit resolution (2.5 mV). Accuracy: 0.05%. Output offset less than 2.5 mV.
DIGITAL PORTS	Front Panel BNC digital bits may be configured as inputs or outputs under program control.
Front Panel Input Bits	Input impedance greater than 100 Kohms. Minimum pulse width is 200 nS. Maximum count rate is 4 MHz. Logic > 3 VDC. Logic zero < 0.7 VDC. Inputs protected to ±10 VDC.
Output Bits	Can drive loads up to 50 Ohms to TTL logic levels.
Internal 20 Pin Connector	8 latched TTL output bits with strobe bit. 8-bit TTL input port with strobe bit.
INTERFACES	Both IEEE-488 Std Port and RS-232-C (110 to 19.2 Kbaud). An Activity LED indicates when the unit is triggered, or when data is sent or commands received over the interfaces. The error LED indicates an overrange input or a bad command.
Power	+24/60 mA, −24/60 mA, +12/400 mA, −12/20 mA. Approximately 8 Watts total.

Abridged Command List

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MR	Master reset.
In	Designates first n analog ports as inputs.
?n	Returns the voltage at the nth analog port.
?Bn	Returns the logic level at the nth digital port.
?D	Returns the value at the 8-bit digital input port.
?C	Returns the pulse count at the 2nd digital input.
Sn=v	Sets the nth analog port to v volts.
SBn=m	Set the nth digital bit high (m=1) or low (m=0).
SD=m	Set the 8-bit digital output port to m.
SM=m	Set the GPIB service request mask to m.
Tn	Trigger on every nth pulse at the sync port.
SCi,j,.:n	Record analog ports i,j,.. for n triggers.
N	Send one data point from the stored scan.
X	Send all data points from the stored scan in binary.
An,m	Add n×2.5 mV to the voltage at port 8 on every nth trigger. (Provides ramp for waveform recovery.)

SR280 System Mainframe and Display Module

The SR280 is the Boxcar Averager System Mainframe. The Mainframe is NIM (Nuclear Instrumentation Module) compatible, which allows modules from other manufacturers to be used in the SRS system leaving nine NIM slots available. The three right-most slots are filled by the display module and by the unregulated power supplies. The DC power supply regulators are mounted on a heat sink on the rear of the mainframe.

The Display Module features three types of display meters. The analog meter is for 'peaking-up' an experimental signal. The digit voltmeter allows accurate measurements to be made. The 'Digital Hold' button may be used to hold the digital meter's reading. A 20-segment bargraph display meter may be used to show rapidly changing data. The Display Module is available separately for use in other mainframes (Model SR275).

GENERAL SPECIFICATIONS

Power Mains	115 or 230 VAC (50/60 Hz). The power lines are fused with 2A/1A for 115/230 VAC. The 115 VAC bin supply has a 1 Amp fuse.
Mechanical	NIM-compatible chassis, power supplies and busses. Nine NIM slots are available. The mainframe may be rack mounted (19.5"), but also has feet for tabletop use. Dimensions: 16.875" x 8.714" x 13.0".
DC Power	±12 VDC at 2A ±24 VDC at 1A 120 VAC is wired to each slot.
Display Module	Analog meter 2% accuracy. ±10 VDC. Zero center.
Digital Meter	0.25% accuracy. 3½ digit. ±10 VDC.
Bargraph	2% accuracy. 5% resolution. 20 segments. 50 KHz bandwidth. 0–10 V display. −10 to +10 V display. −10 to 0 V display.
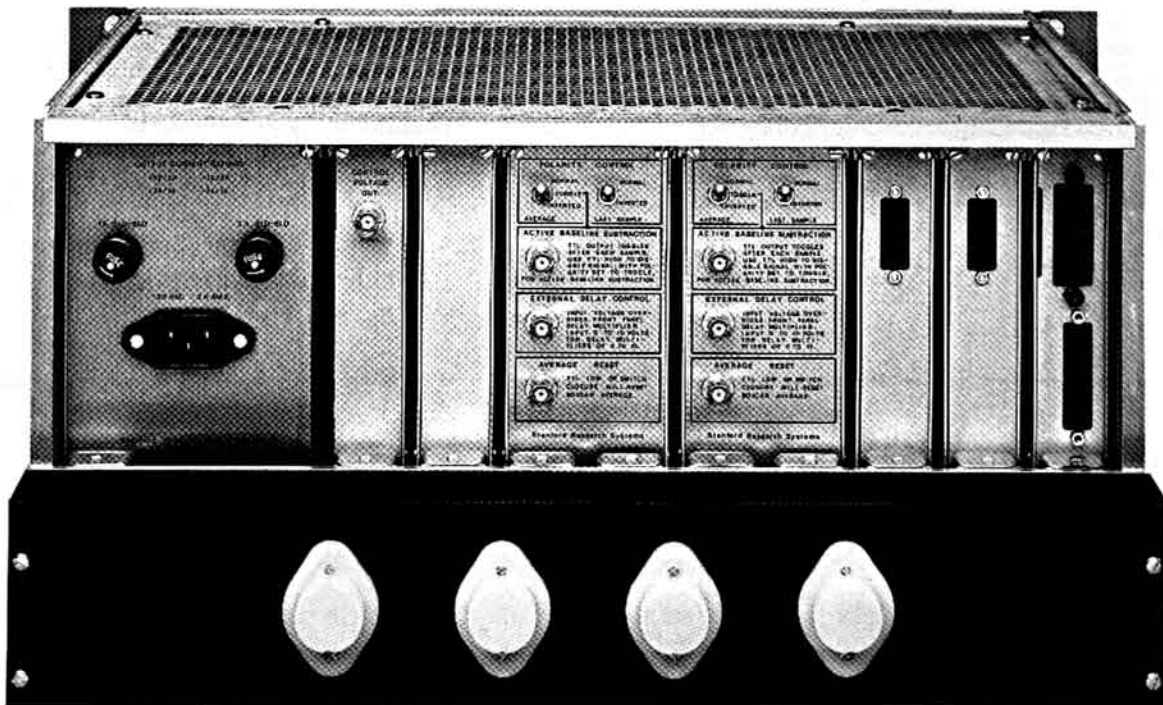
Rear view of the SR280 Mainframe, Gate Scanner, Analog Processor, two Boxcar Modules, two Fast Samplers, and a Computer Interface.

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