

# 27104A

QUAD-CHANNEL  
BRIDGE CONDITIONER

 PRECISION  
FILTERS, INC.

±10 V Common Mode; 255 or 510 Cutoff Frequencies

## SYSTEM 27000 FEATURES

- Graphical User Interface (GUI) for system control
- Intelligent gain and system scaling algorithms
- Test input and output monitor busses
- Go/no-go test with diagnostics to be used before tests
- Rigorous factory acceptance test for maintenance

## 27000 SIGNAL CONDITIONING WIZARD

The 27000 Signal Conditioning Wizard™ provides all the power you need to manage your test measurements:

- Mix transducers in a single system
- Condition signals for immediate data conversion
- Manage hundreds of channels and a mix of sensors
- Assure system integrity before performing measurements
- Reduce life-cycle costs
- Upgrade and expand equipment as requirements change
- Count on unsurpassed performance and reliability

The Precision 27000 makes it easy to manage a test with hundreds of channels and a mix of transducers. Choose charge, voltage (filter amplifier), strain, thermocouple, RTD, potentiometer, current, frequency, or other transducers. There are 27000 cards to condition them.

The Wizard employs a management system of structured data bases (sensors and equipment), a graphical user interface, and a collection of algorithms to help you manage your measurements. The data bases keep records of the sensors and equipment which can be imported when you are designing or setting up a test. The GUI provides control panels for configuration, setup, operation, and tests. And the Wizard's algorithms transmute tedious and complex engineering calculations into simple setup entries. It's as simple as using a spreadsheet. Just change one parameter and the algorithm makes all other relevant calculations. System scaling becomes easy. Best of all, you won't have to pore over filter plots to calculate the tradeoffs between cutoff frequency, sampling rate, and attenuation of aliases. The filter algorithm does it for you, in the blink of an eye.

The built-in test hardware and software (optional) provide quick go/no-go tests which can be run before each test, and rigorous factory acceptance tests to assure you that the 27000 meets your most stringent requirements for critical applications. It won't be long before these tests earn a permanent place in your maintenance routine. And since they are traceable to NIST, they eliminate the need for off-site calibration.

In every phase of your tests—record keeping, installation, design, setup, operation, maintenance and upgrading—the Wizard has thought of ways to help you save time and money over the life of the system.

## PRECISION 27104A APPLICATIONS

- Strain gage conditioner
- Load cell conditioner
- Pressure transducer conditioner
- Potentiometer conditioner
- Low level AC or DC amplifier (<1 mV to 10 V inputs)
- Anti-aliasing filter/amplifier

## PRECISION 27104A FEATURES

- 4 channels per card, 64 channels per chassis
- Balanced programmable constant voltage source with remote sense
- Up to 20 V excitation delivered to the bridge
- ±10 V<sub>cm</sub> operation
- Up to 51 kHz bandwidth
- 2 to 10 wire plus shield transducer input interface
- Automatic bridge balance
- 4096 step bipolar shunt cal or single step bipolar resistive shunt cal; Shunt any bridge arm
- Selectable bridge configuration (1-arm, 2-arm, or 4-arm) with read back
- Programmable AC/DC input coupling
- Programmable amplifier: x1/16 to x8,192 with 0.05% vernier
- 4, 6 or 8-pole anti-alias filters with filter bypass (wide-band)
- 1° phase matching between any channels, DC to F<sub>c</sub>
- Overload detection
- Precise automatic calibration
- Hot swap

## 27104A DESCRIPTION

The 27104A is a member of the Precision 27000 family of signal conditioners. The 27104 provides four channels of conditioning for transducers requiring a Wheatstone bridge. Up to sixteen 27104A cards may reside in the 27000 system to provide up to 64 channels per chassis or 512 channels per system. In addition, the 27104A may be mixed with other conditioners in the 27000 family to meet your unique signal conditioning requirements.

The 27104A provides constant voltage excitation and conditioning for 1-, 2-, and 4-arm resistive bridges. The 27104A features automatic calibration of gain and offset for the entire channel, including the amplifier, filter, and excitation supply. The 2- to 10-wire input connection provides 6 wires for the bridge, 2 wires for shunt calibration, 1 wire for the shield, and 1 wire for single-arm bridges.

## 27104A DESCRIPTION (Continued)

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Precision bridge configuration resistors are contained on a plug-on module located on each 27104A card. The resistors may be set to complete the bridge for quarter, half, or full bridge configurations. ID registers are provided to read back bridge configuration and resistance.

Automatic balance of the bridge is accomplished by inserting a voltage ratiometric with the excitation supply to the amplifier input stage. This balance method provides outstanding stability without loading the bridge. A wide range of unbalanced conditions may be accommodated.

Two methods of shunt calibration are available. The 27104A BC1 voltage insertion technique provides 4096 steps of bipolar shunt calibration that may be used to simulate a bridge unbalance. The 27104A BC2 shunt calibration supports the use of precision resistors for bipolar single-step shunt cal. For either technique, the 27104A supports the use of dedicated shunt cal lines to the bridge that allow the user to perform the shunt cal on non-current carrying leads. Single shunt calibration of any arm of the bridge and the double shunt calibration of opposing bridge arms are supported. Also, since the bridge balance technique is non-invasive to the bridge, shunt calibration results are unaffected by bridge balance circuitry.

### Balanced Voltage Excitation

The 27104A features a programmable constant voltage excitation supply that can source up to 20 volts to the bridge. Balanced constant voltage excitation offers a number of advantages over single-ended excitation. It enables a true balanced instrumentation amplifier input for outstanding rejection of high frequency common-mode signals. Single-ended voltage excitation to balanced bridges produces a relatively large common-mode voltage at half the excitation supply. The instrumentation amplifier must reject this signal. Balanced voltage excitation applied to balanced bridges results in lower common mode input voltages to the amplifier input stage.

The excitation supply has automatic amplitude and offset correction that may be run on the unit in place at any time. Dedicated remote sense lines allow the excitation supply regulator to deliver an accurate voltage to the bridge.

### Input Stage

The 27104A input stage has 120 dB of common-mode rejection, low DC drift and ultra-low noise ( $< -163$  dBV/ $\sqrt{\text{Hz}}$ ). The input can be equipped with programmable AC/DC coupling. AC coupling is useful in applications where DC levels that limit dynamic range can be coupled out of the signal.

A programmable switch at the input stage is provided to connect the amplifier to the 27000 system test bus. The test bus is used to inject signals for performance verification. In addition, the excitation supply may be connected to the input stage for direct verification of the excitation supply level.

## 27104A DESCRIPTION (Continued)

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### Amplifier and Filter

Programmable pre- and post-filter amplifiers provide an overall gain of 8192. Gain is distributed both before and after the filter to provide protection from large out-of-band energy or transients that could cause clipping before the filter, distorting the data. The Gain Wizard in the GUI allows the user to set a gain reserve and then apportions the gain between the input and output. This provides input gain for best noise performance yet conforms to the limitations of the user's worst case estimate of out-band or transient signals. Overload detectors alert the user to over-voltage conditions.

The post-filter gain has resolution of better than 0.05% to enable precise system scaling of 27104A outputs to match the full-scale input of the external recording device, given the transducer sensitivity and fullscale input in measurement units. A fully buffered output having over 20 mA of drive capability may be used to drive long output cable runs.

The 27104A has a wide range of anti-alias filter characteristics available including 4-, 6-, and 8-pole Butterworth, Bessel, Elliptic and time delay filters. Choose from a wide selection of cutoff frequency settings to 51 kHz. These real anti-alias filters make the 27104A data acquisition system ready.

## 27104A PROGRAMMABLE FEATURES

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- Excitation level (0 to 20.475 V in 5 mV steps)
- Excitation sense (local or remote)
- Bridge configuration (1-arm, 2-arm, and 4-arm)
- Automatic balance
- AC/DC coupling
- Test Modes: Amp Short, Excitation Off, Voltage Substitution, Shunt Calibration, Excitation Monitor, Output Monitor
- Gain (x1/16 to x8192 with 0.05% resolution)
- Cutoff frequency (1 Hz to 51 kHz)
- Wide-band or filtered operation
- Shield (driven, open, grounded)

## GRAPHICAL USER INTERFACE DISPLAY

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All programmable features in addition to:

- Bridge configuration and resistance readback
- Balance status
- Input wiring
- Gage sensitivity
- System scaling in engineering units
- Overload status
- Gain Wizard
- Filter Wizard
- Group Control

## 27104A CONDITIONER CARDS

The detailed description and specifications for the 27104A card are organized as follows in the sections below.

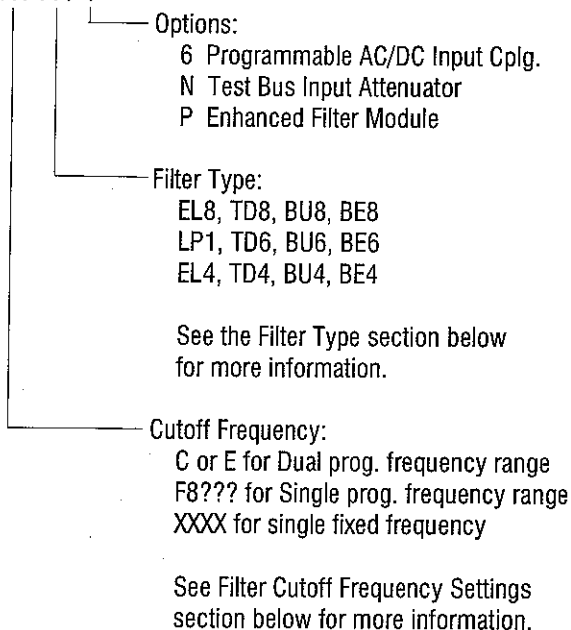
- Card Model Number Structure
- Bridge Configuration and Shunt Cal Options (Option BC?/???)
- Bridge Resistor Modules
- Bridge Wiring
- Excitation Supply
- Input Characteristics and Options
- Amplifier Characteristics
- Test Modes
- Filter Type Characteristics
- Filter Cutoff Frequency Settings
- Filter Specifications
- Output Characteristics
- Mainframes and Accessories

### 27104A CARD MODEL NUMBER

The 27104A card model number describes the configuration of the four channels on the card. The model number identifies:

- The cutoff frequency, fixed or programmable, of the filters.
- The filter characteristic, or filter type, of the low-pass filters.
- Options included on the card, including the identification of the installed Bridge Completion configuration option.

27104A-X-YYY-?\*



## BRIDGE CONFIGURATION AND SHUNT CAL MODULE

One plug-on bridge configuration and shunt cal module must be specified as an option in the 27104A model number (except that bridge configuration modules are not required for 4-arm bridge configurations with no shunt calibration).

The bridge configuration cards provide selectable or hard-wired bridge configuration. Three versions are available: BC1 for 4096-step shunt cal, BC2 for resistive shunt cal, and BC0 for no shunt cal. The GUI reads back and reports the model number from the plug-on card.

BC1 Shunt Cal provides shunt calibration utilizing voltage insertion at the bridge, providing 4096 steps of shunt calibration. Single shunt of any bridge arm or double shunt of opposing arms may be selected. The shunt may be applied at the gage (if additional cable wires are used) or at the signal conditioner via program control. Double shunt sensitivity is set by a precision resistor on the 27104A-BR1 resistor completion card and is programmable to  $\pm 16$  mV/V in steps of  $7.8125 \mu\text{V/V}$ . This simulates compression or tension on the gage.

BC2 Shunt Cal provides single-step bipolar shunt cal using a precision resistor installed on the 27104A-BR2 resistor completion card. Programmable GUI selections allow the shunt to be applied at the gage (if additional cable wires are used) or at the signal conditioner. Single shunt of any bridge arm, or double shunt of opposing bridge arms may be selected. Upscale (tension) and downscale (compression) calcs are selectable from the GUI.

The standard BC2 shunt cal supplied with  $120\Omega$ ,  $350\Omega$  and  $1K\Omega$  cards produces 5 mV/V single shunt or 10 mV/V double shunt in bridge output with accuracy better than 0.01%. Custom shunt resistor values may be specified, or the user can install shunt resistor values.

Note: Bridge configuration modules are not required for 4-arm bridge configurations with no shunt calibration.

### Modules without Shunt Cal Options

27104A-BC0/124	Selectable bridge configuration, no shunt cal
27104A-BC0/1	Hardwired for 1-arm (R1) bridge, no shunt cal
27104A-BC0/2	Hardwired for 2-arm (R1/R2) bridge, no shunt cal

### Modules with Shunt Cal Options

27104A-BC1/124	4096-step shunt cal with selectable bridge configuration
27104A-BC1/1	4096-step shunt cal, hardwired for 1-arm (R1) bridge
27104A-BC1/2	4096-step shunt cal, hardwired for 2-arm (R1/R2) bridge
27104A-BC1/4	4096-step shunt cal, hardwired for 4-arm bridge

## BRIDGE CONFIGURATION ... Continued

- 27104A-BC2/124 Single-step bipolar resistive shunt with selectable bridge configuration
- 27104A-BC2/1 Single-step bipolar resistive shunt, hardwired for 1-arm (R1) bridge
- 27104A-BC2/2 Single-step bipolar resistive shunt, hardwired for 2-arm (R1/R2) bridge
- 27104A-BC2/4 Single-step bipolar resistive shunt, hardwired for 4-arm bridge

## 27104A BRIDGE RESISTOR MODULE

Optional plug-on bridge resistor completion modules provide high stability completion resistors for standard bridges. This plug-on also provides the shunt cal scaling resistor for models with 4096-step shunt for BC1 models, or the precision shunt resistor for BC2 models. Resistor values can be read back and displayed on the GUI.

The Bridge Resistor modules are not included with the 27104A card and must be specified separately. The module provides the completion and shunt cal resistors for four channels.

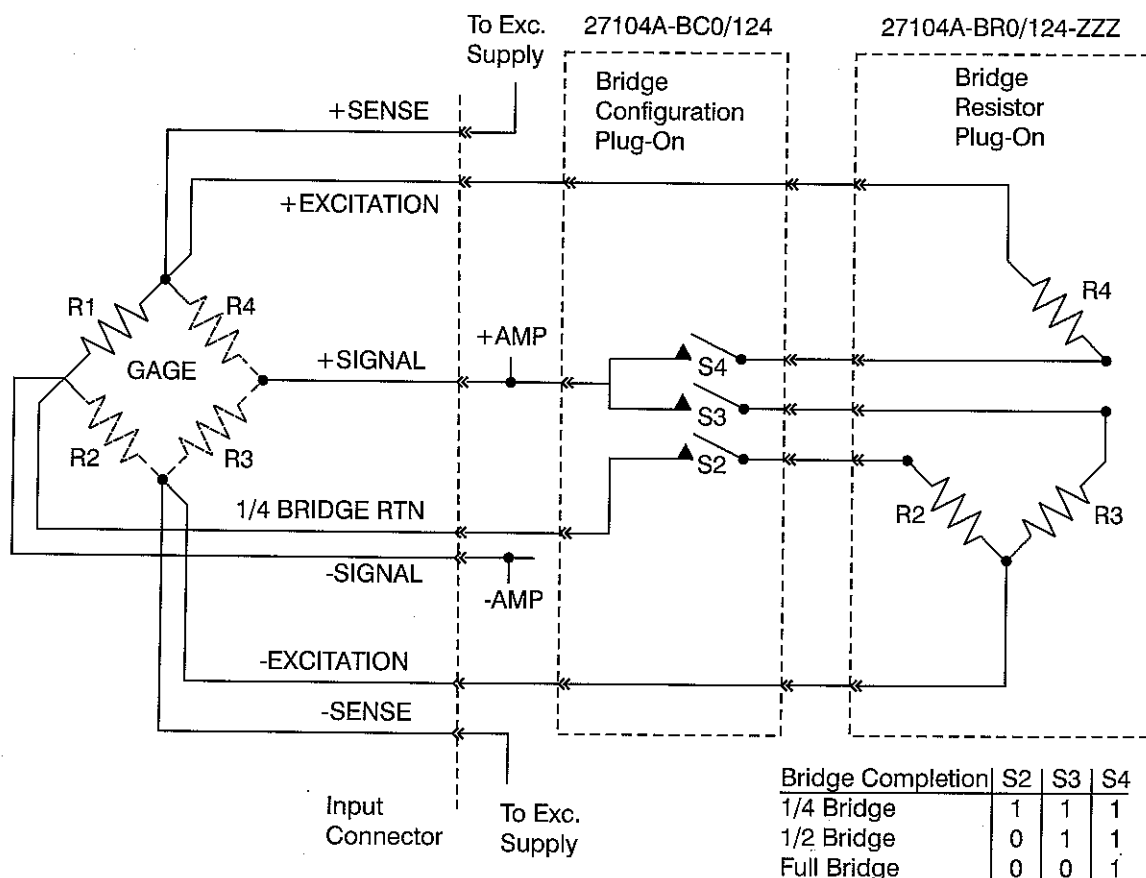
There are three base models: BR1 for use with BC1 configuration cards, BR2 for use with BC2 configuration cards, and BR0 for configuration with no shunt cal.

Note: Bridge resistor modules are not required for hardwired 4-arm bridge configurations with no shunt calibration.

## 27104A BRIDGE RESISTOR MODULE (Cont.)

Resistor Temp. Coeff.:  $\pm 4$  ppm/ $^{\circ}$ C  
 Resistor Accuracy:  $\pm 0.01\%$

- 27104A-BR0/124-120 120 $\Omega$  completion for 1, 2, or 4-arm bridges. No shunt cal.
- 27104A-BR0/124-350 350 $\Omega$  completion for 1, 2, or 4-arm bridges. No shunt cal.
- 27104A-BR0/124-1000 1 k $\Omega$  completion for 1, 2, or 4-arm bridges. No shunt cal.
- 27104A-BR0/124-ZZZ Custom completion for 1, 2, or 4-arm bridges. No shunt cal.
- 27104A-BR1/4-XXX-3K690 4-arm bridge config. (no completion resistors). 4096-step shunt cal scaling resistor.
- 27104A-BR1/4-XXX-10K762 4-arm bridge config. (no completion resistors). 4096-step shunt cal scaling resistor.
- 27104A-BR1/4-XXX-30K750 4-arm bridge config. (no completion resistors). 4096-step shunt cal scaling resistor.
- 27104A-BR1/4-XXX-YYY 4-arm bridge config. (no completion resistors).  
 YYY = Custom 4096-step shunt cal scaling resistor.



## 27104A BRIDGE RESISTOR MODULE (Cont.)

- 27104A-BR1/124-120-3K690 120Ω completion for 1, 2, or 4-arm bridges. 4096-step shunt cal scaling resistor.
- 27104A-BR1/124-350-10K762 350Ω completion for 1, 2, or 4-arm bridges. 4096-step shunt cal scaling resistors.
- 27104A-BR1/124-1000-30K750 1 kΩ completion for 1, 2, or 4-arm bridges. 4096-step shunt cal scaling resistors.
- 27104A-BR1/124-ZZZ-YYY Custom completion for 1, 2, or 4-arm bridges.  
YYY = custom 4096-step shunt cal scaling resistors.
- 27104A-BR2/4-XXX-5K940 4-arm bridge config. (no completion resistors). Single-step shunt resistors.
- 27104A-BR2/4-XXX-17K325 4-arm bridge config. (no completion resistors). Single-step shunt resistors.
- 27104A-BR2/4-XXX-49K500 4-arm bridge config. (no completion resistors). Single-step shunt resistors.
- 27104A-BR2/4-XXX-YYY 4-arm bridge config. (no completion resistors).  
YYY = Custom single-step shunt resistors.

## 27104A BRIDGE RESISTOR MODULE (Cont.)

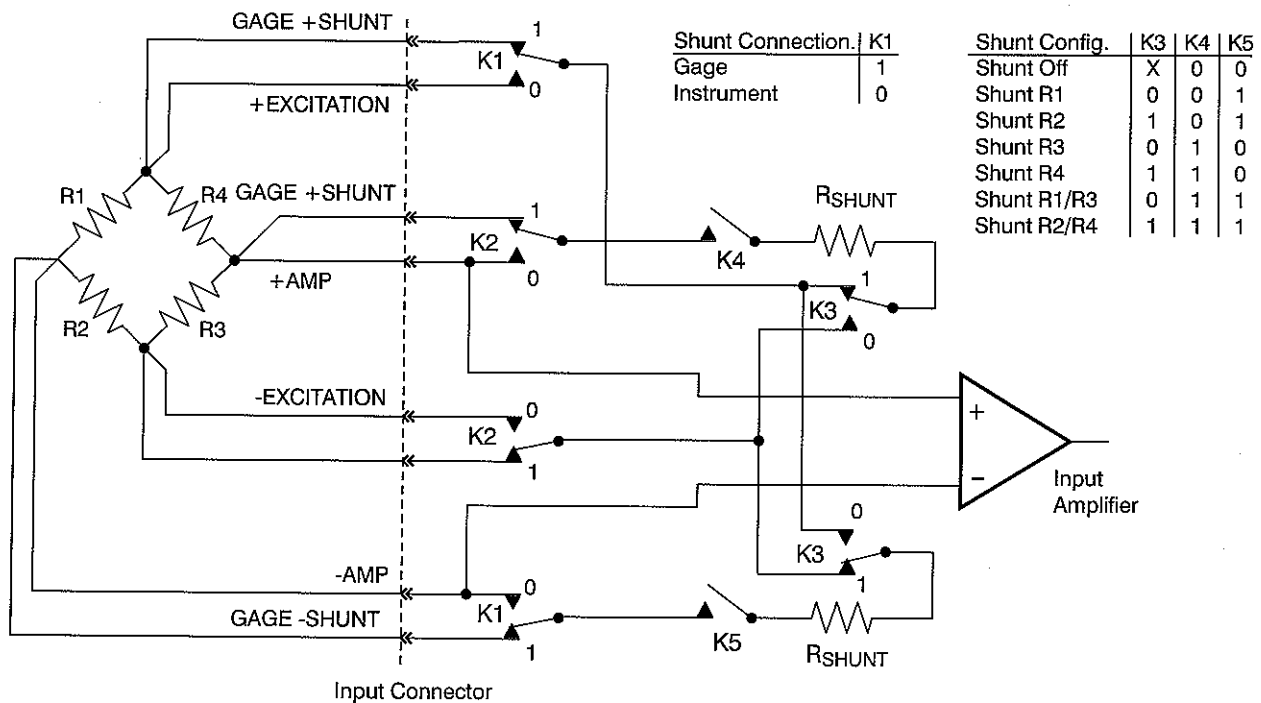
- 27104A-BR2/124-120-5K940 120Ω completion for 1, 2, or 4-arm bridges. Single-step shunt cal resistors.
- 27104A-BR2/124-350-17K325 350Ω completion for 1, 2, or 4-arm bridges. Single-step shunt cal resistors.
- 27104A-BR2/124-1000-49K500 1 kΩ completion for 1, 2, or 4-arm bridges. Single-step shunt cal resistors.
- 27104A-BR2/124-ZZZ-YYY Custom completion for 1, 2, or 4-arm bridges.  
YYY = Custom single-step shunt resistors.

XXX = No completion resistors  
 ZZZ = Custom completion resistor, Consult factory  
 YYY = Custom shunt cal resistor, Consult factory

Shunt cal resistors specified for 16 mV/V of excitation fullscale range for double shunt on BC1 shunt cal or 10 mV/V for double shunt on BC2 shunt cal.

### BRIDGE WIRING

- Input Connector: 26-pin D-shell (2 ea.)  
 Input Wires: ±EXCITATION (2)  
 ±SENSE (2)  
 ±SIGNAL (2)  
 SHUNT CAL (2)  
 RETURN (1) Single Arm Bridge  
 SHIELD (1)



27104A BC2 Shunt Cal

## 27104A EXCITATION SUPPLY

### Programmable Constant Voltage Excitation

Maximum Output: 20.475 V, 30 mA (balanced)  
 Steps: Programmable from 0 to 20.475 in 5 mV steps  
 Excitation Sense: Programmable (local or remote sense)  
 Accuracy:  $\pm 5$  mV,  $\pm 0.01\%$   
 Current Limit: 60 mA, typical  
 Load Regulation:  $\pm 0.03\%$  or  $\pm 200 \mu\text{V}$ , whichever is greater, no load to full load  
 Line Regulation:  $\pm 0.01\%$  for 10% line variation  
 Noise:  $20 \mu\text{Vrms}$ , DC to 25 kHz  
 Temp. Drift:  $\pm 0.0025\%/^{\circ}\text{C}$  of setting or  $\pm 50 \mu\text{V}/^{\circ}\text{C}$ , whichever is greater  
 Sense Current: Less than  $10 \mu\text{A}$   
 Calibration: Automatically calibrated for gain and offset. Calibration initiated at the GUI panel.  
 Excitation Off: The excitation supply is programmed to 0 volts.

### Excitation Monitor (Standard)

Excitation Monitor: Under GUI control, the amplifier input is switched from the bridge to the excitation supply to monitor the excitation voltage. Excitation monitor gain is x0.5.

## 27104A INPUT CHARACTERISTICS

Common Mode Voltage:  $\pm 10$  V operating  
 CMRR: 120 dB, DC to 60 Hz, with a full bridge input and input gain of x8 or greater  
 Input Protection:  $\pm 50$  V  
 Input Impedance:  $15 \text{ M}\Omega//100 \text{ pF}$  per side  
 $30 \text{ M}\Omega//50 \text{ pF}$  differential  
 $1000 \text{ M}\Omega//24 \text{ pF}$  common mode  
 Max Level:  $\pm 10$  Vpk for  $f \leq 50$  kHz;  
 $\pm 10$  Vpk (50 kHz/f) for  $f > 50$  kHz  
 Offset Drift:  $1 \mu\text{V}/^{\circ}\text{C}$ , typical  
 Noise:  $7 \text{ nV}/\sqrt{\text{Hz}}$  RTI at 1 kHz and gain  $> \text{x}64$   
 Shield: Programmable (driven, open, or grounded)

**Option 6:** Programmable AC/DC input coupling  
 Note: Specs below are for AC coupled setting. Specs are unchanged from above for the DC-coupled setting.

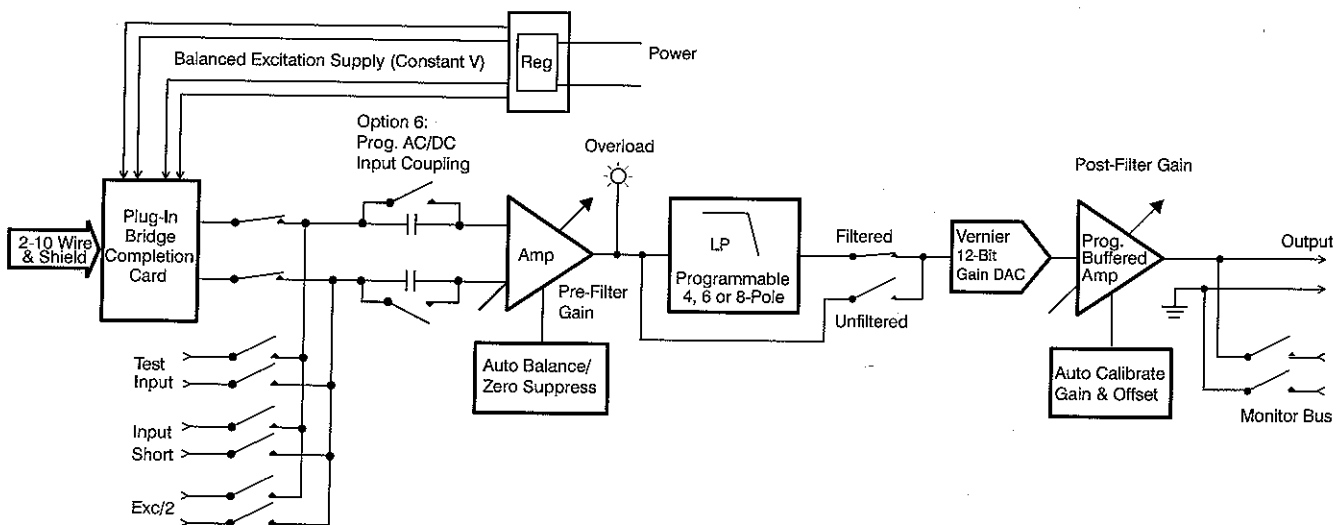
Impedance:  $(0.1 \mu\text{F} \& 1.58 \text{ M}\Omega)//100 \text{ pF}$  per side (1 Hz)  
 Common Mode Z:  $0.2 \mu\text{F} \& 30 \text{ M}\Omega$   
 CMRR: 120 dB, 60 Hz and input gain of x8 or greater  
 Noise:  $14 \text{ nV}/\sqrt{\text{Hz}}$  RTI at 1 kHz and gain  $> \text{x}64$

### Input Short (Standard)

Input Short: A switch at the amplifier input is used to ground the input stage to measure amplifier noise and DC offset.

### Test Input (Standard)

Test Input: Test input allows for injection of a test signal. An external test signal or the 27000B-?-TEST Test Subsystem may be connected at the rear panel. Refer to the 27000B-?-TEST Test Subsystem specification for more information.



## 27104A INPUT CHARACTERISTICS (Cont.)

### Auto Bridge Balance/Zero Suppress (Standard)

#### Auto Bridge

**Balance Mode:** The bridge is automatically balanced utilizing voltage insertion at the input amplifier when bridge balance mode is selected. The inserted voltage is derived from and thus tracks the excitation supply. A successive approximation A/D converter mechanization is used for rapid bridge balance.

**Range:** Bridge balance algorithm selects the most appropriate range to achieve balance with finest resolution. Ranges are:  
512 mV/V of excitation  
64 mV/V and 8 mV/V

**Resolution:**  $\pm 0.05\%$  of span

**Temp Coeff.:**  $\pm 50$  ppm/ $^{\circ}$ C

**Auto Balance Time:** Less than 15 seconds per system of 64 channels.

**Auto Suppress Mode:** A programmable DC offset derived from a precision 10 V reference is injected at the channel input stage to suppress the gage DC operating voltage. Manual or automatic suppression modes are supported.

**Ranges:** -160 mV to +160 mV in 78  $\mu$ V steps  
-1.28 V to +1.28 V in 625  $\mu$ V steps  
-10.24 V to +10.24 V in 5 mV steps

**Accuracy:** 0.25% of setting +5 mV

**DC Drift:** Input drift +13.5  $\mu$ V/ $^{\circ}$ C

**Auto Suppress Time:** Less than 15 seconds per system of 64 channels

## 27104A AMPLIFIER CHARACTERISTICS

**Pre-filter Gain:** x1 to x512 in binary steps with overload detection (10.5 Vpk threshold)

**Post-filter Gain:** x1/16 to x16 in binary steps with vernier adjustment of 0.05% of setting

**DC Accuracy:** 0.1% after auto cal at any gain setting

**Stability:**  $\pm 0.02\%$  for 6 months

**Temp Coeff.:**  $\pm 0.004\%/^{\circ}$ C

**DC Linearity:**  $\pm 0.005\%$  re Fullscale, relative to the best straight line

**Freq. Response:** DC to 51 kHz, 0 dB  $\pm 0.1$  dB

## 27104A TEST MODES

**Shunt Cal:** Applies shunt to bridge.

**Excitation Monitor:** The amplifier input is switched from the bridge to the excitation supply to monitor the excitation voltage. Excitation monitor gain is x0.5.

**Excitation Off:** The excitation supply is programmed to zero volts.

**Amplifier Short:** A switch at the amplifier input is utilized to ground the input stage for measurement of noise and DC offset.

**Test Bus:** Test input allows for injection of a test signal. An external test signal or the 27000B-?-TEST Test Subsystem may be connected at the rear panel. Refer to the 27000B-?-TEST Test Subsystem specification for more information.

8-Pole Filter Selection Guide

	EL8	TD8A	TD8B	BU8	BE8
Filter Type	LP	LP	LP	LP	LP
Function	Cauer	Bessel w/Z	Bessel w/Z	Butterworth	Bessel
Number of Poles, Zeroes	8p, 8z	8p, 6z	8p, 8z	8p	8p
Pass-band Ripple (dB p-p)	0.1	n/a	0.2	n/a	n/a
-0.1 dB Frequency	$F_c$	0.104 $F_c$	0.569 $F_c$	0.791 $F_c$	0.185 $F_c$
-3.01 dB Frequency	1.099 $F_c$	0.565 $F_c$	$F_c$	$F_c$	$F_c$
-20 dB Frequency	1.266 $F_c$	1.345 $F_c$	1.694 $F_c$	1.333 $F_c$	2.347 $F_c$
-40 dB Frequency	1.441 $F_c$	1.867 $F_c$	2.340 $F_c$	1.778 $F_c$	3.337 $F_c$
-60 dB Frequency	1.618 $F_c$	2.396 $F_c$	2.951 $F_c$	2.371 $F_c$	4.522 $F_c$
-80 dB Frequency	1.750 $F_c$	2.915 $F_c$	3.332 $F_c$	3.162 $F_c$	6.069 $F_c$
Stop-band Frequency	1.788 $F_c$	n/a	3.332 $F_c$	n/a	n/a
Stop-band Atten. (dB)	90.75	n/a	80.28	n/a	n/a
Phase at $F_c$ ( $^{\circ}$ )	-359.20	-301.88	-301.88	-360.00	-182.16
Phase Distortion at $F_c$ ( $^{\circ}$ )	84.9	0.23	0.23	66.2	0.00
Overshoot (%)	19.8	0.19	5.56	16.7	0.34
1% Settling Time (sec)	5.15/ $F_c$	1.34/ $F_c$	1.54/ $F_c$	3.45/ $F_c$	0.79/ $F_c$
0.1% Settling Time (sec)	7.97/ $F_c$	1.86/ $F_c$	2.23/ $F_c$	5.08/ $F_c$	1.14/ $F_c$

## 27104A FILTER TYPE CHARACTERISTICS

A wide selection of 8-pole, 6-pole, and 4-pole low-pass anti-alias filter types are offered on the 27104A card. Refer to the detailed filter selection guides on the following pages for detailed specifications on the filter types listed below.

### 8-Pole Filters

- EL8: 8-pole, 8-zero Elliptic low-pass filter.
- TD8: 8-pole, 6/8-zero constant time delay (linear phase) low-pass filter. Both the TD8A and TD8B characteristics are provided. Selecting between the TD8A and TD8B is accomplished via front panel or computer control.
- BU8: 8-pole Butterworth low-pass characteristic.
- BE8: 8-pole Bessel low-pass characteristic.

### 6-Pole Filters

- LP1: 6-pole, 6-zero Elliptic low-pass filter.
- TD6: 6-pole, 4/6-zero constant time delay (linear phase) low-pass filter. Both the TD6A and TD6B characteristics are provided. Selecting between TD6A and TD6B is accomplished via front panel or computer control.
- BU6: 6-pole Butterworth low-pass characteristic.
- BE6: 6-pole Bessel low-pass characteristic.

### 4-Pole Filters

- EL4: 4-pole, 4-zero Elliptic low-pass filter.
- TD4: 4-pole, 4-zero constant time delay (linear phase) low-pass filter.
- BU4: 4-pole Butterworth low-pass characteristic.
- BE4: 4-pole Bessel low-pass characteristic.

## CUTOFF FREQUENCY SETTINGS

A selection of cutoff frequency choices are supported, including fixed frequency and programmable cutoff frequency cards.

### Fixed Frequency Filters

27104A-XXXX-YYY Single fixed frequency  
 YYY = Filter Type Characteristic  
 XXXX = Single fixed frequency, from 1 Hz to 51 kHz

Examples:

- XXXX=0100 is  $F_c = 100$  Hz
- XXXX=25K5 is  $F_c = 25.5$  kHz
- XXXX=1K25 is  $F_c = 1.25$  kHz

### Programmable Filters

27104A-F8???-YYY Single programmable frequency range.  
 YYY = Filter Type Characteristic  
 ??? Hz to 255\*??? Hz in ??? steps  
 where ??? = 1, 10, 100 or 200  
 F8001 = 1 Hz to 255 Hz, 1 Hz steps  
 F8010 = 10 Hz to 2.55 kHz, 10 Hz steps  
 F8100 = 100 Hz to 25.5 kHz, 1 kHz steps  
 F8200 = 200 Hz to 51 kHz, 200 Hz steps

27104A-X-YYY

Dual programmable frequency range.  
 YYY = Filter Type Characteristic  
 X = C or E  
 C = 1 Hz to 255 Hz in 1 Hz steps  
 and 300 Hz to 25.5 kHz in 100 Hz steps  
 E = 1 Hz to 255 Hz in 1 Hz steps  
 and 260 Hz to 2.55 kHz in 10 Hz steps

### Custom Frequency Ranges

Custom frequency ranges are available. Contact the factory.

6-Pole Filter Selection Guide

	LP1	TD6A	TD6B	BU6	BE6
Filter Type	LP	LP	LP	LP	LP
Function	Cauer	Bessel w/Z	Bessel w/Z	Butterworth	Bessel
Number of Poles, Zeroes	6p, 6z	6p, 4z	6p, 6z	6p	6p
Pass-band Ripple (dB p-p)	0.1	n/a	0.2	n/a	n/a
-0.1 dB Frequency	0.925 $F_c$	0.109 $F_c$	0.582 $F_c$	0.731 $F_c$	0.186 $F_c$
-3.01 dB Frequency	$F_c$	0.589 $F_c$	$F_c$	$F_c$	$F_c$
-20 dB Frequency	1.190 $F_c$	1.388 $F_c$	1.882 $F_c$	1.467 $F_c$	2.350 $F_c$
-40 dB Frequency	1.474 $F_c$	2.113 $F_c$	3.093 $F_c$	2.154 $F_c$	3.640 $F_c$
-60 dB Frequency	1.776 $F_c$	3.017 $F_c$	4.428 $F_c$	3.162 $F_c$	5.416 $F_c$
-80 dB Frequency	1.970 $F_c$	4.064 $F_c$	n/a	4.642 $F_c$	7.990 $F_c$
Stop-band Frequency	1.970 $F_c$	n/a	4.893 $F_c$	n/a	n/a
Stop-band Attenuation (dB)	80	n/a	70	n/a	n/a
Phase at $F_c$ ( $^\circ$ )	-358.50	-255.32	-255.32	-270.00	-154.37
Phase Distortion at $F_c$ ( $^\circ$ )	111.3	2.11	2.11	48.6	0.00
Overshoot (%)	19.2	0.60	5.04	14.4	0.64
1% Settling Time (sec)	4.64/ $F_c$	1.21/ $F_c$	1.46/ $F_c$	2.36/ $F_c$	0.74/ $F_c$
0.1% Settling Time (sec)	8.45/ $F_c$	1.94/ $F_c$	2.21/ $F_c$	3.89/ $F_c$	1.16/ $F_c$



## 27104A FILTER SPECIFICATIONS

Cutoff Amplitude: -0.1 dB for EL8  
 -3.01 dB for TD8B, BU8, BE8, LP1  
 TD6B, BU6, BE6, EL4, TD4, BU4, BE4  
 -10.06 dB for TD8A  
 - 9.61 dB for TD6A

### BU4, BE4, EL4, TD4, BU6, BE6, TD6, BU8, BE8, TD8:

Ampl. Accuracy: (DC to F-3.01 dB)  $\pm 0.1$  dB max  
 Ampl. Match: (DC to F-3.01 dB)  $\pm 0.05$  dB max,  $F_c \leq 20$  kHz  
 $\pm 0.1$  dB max,  $F_c > 20$  kHz

Phase Match: (DC to F-3.01 dB)  $\pm 0.5^\circ$  max,  $F_c \leq 20$  kHz  
 $\pm 1^\circ$  max,  $F_c > 20$  kHz

### For LP1, EL8:

Ampl. Accuracy: (DC to F-0.1 dB)  $\pm 0.1$  dB max,  $F_c \leq 20$  kHz  
 (DC to F-0.1 dB)  $\pm 0.15$  dB max,  $F_c > 20$  kHz

Ampl. Match: (DC to F-0.1 dB)  $\pm 0.05$  dB max,  $F_c \leq 20$  kHz  
 $\pm 0.1$  dB max,  $F_c > 20$  kHz

Phase Match: (DC to F-0.1 dB)  $\pm 0.5^\circ$  max,  $F_c \leq 20$  kHz  
 $\pm 1^\circ$  max,  $F_c > 20$  kHz

## 27104A FILTER SPECIFICATIONS (Cont.)

**Filter Bypass (Std):** Bypasses the filter but not the amplifier stages. Specifications when the filter is bypassed:  
 -3.01 dB Bandwidth: 100 kHz, typ  
 High Freq. Rolloff: 12 dB/octave  
 Freq. Response:  $\pm 0.1$  dB, DC to 51 kHz

### Other Specifications

#### Stop-Band Amplitude Response

Conformance:  $f$  = frequency in the stop-band or where there is greater than 80 dB attenuation for monotonic filters.  
 $A_{min}$  = Minimum stop-band attenuation of filter or -80 dB for monotonic filters.

for  $f \leq 100$  kHz, attenuation =  $A_{min} \pm 3$  dB  
 for  $100 \text{ kHz} < f < 1 \text{ MHz}$ ,  $A_{min} \pm 5$  dB

4-Pole Filter Selection Guide

	EL4	TD4	BU4	BE4
Filter Type	LP	LP	LP	LP
Function	Cauer	Bessel w/Z	Butterworth	Bessel
Number of Poles, Zeroes	4p, 4z	4p, 4z	4p	4p
Pass-band Ripple (dB p-p)	0.1	n/a	n/a	n/a
-0.1 dB Frequency	$0.827 F_c$	$0.189 F_c$	$0.625 F_c$	$0.189 F_c$
-3.01 dB Frequency	$F_c$	$F_c$	$F_c$	$F_c$
-20 dB Frequency	$1.492 F_c$	$2.524 F_c$	$1.776 F_c$	$2.542 F_c$
-40 dB Frequency	$2.398 F_c$	$4.483 F_c$	$3.162 F_c$	$4.724 F_c$
-60 dB Frequency	$3.666 F_c$	$7.049 F_c$	$5.623 F_c$	$8.482 F_c$
-80 dB Frequency	$4.719 F_c$	$9.144 F_c$	$10.00 F_c$	$15.13 F_c$
Stop-band Frequency	$4.719 F_c$	$9.144 F_c$	n/a	n/a
Stop-band Attenuation (dB)	80	80	n/a	n/a
Phase at $F_c$ ( $^\circ$ )	-220.35	-107.16	-180.00	-120.82
Phase Distortion at $F_c$ ( $^\circ$ )	53.26	0.25	30.49	0.28
Overshoot (%)	13.8	0.80	11.4	1.03
1% Settling Time (sec)	$2.73/F_c$	$0.63/F_c$	$1.66/F_c$	$0.64/F_c$
0.1% Settling Time (sec)	$4.36/F_c$	$1.15/F_c$	$2.73/F_c$	$1.00/F_c$

## 27104A OUTPUT CHARACTERISTICS

Type: DC-coupled, single-ended output. Programmable wideband (100 kHz) or filtered.

Z: 50  $\Omega$  shunted by 100 pF

Max Output:  $\pm 10$  Vpk,  $\pm 20$  mApk

Offset Drift: 1  $\mu\text{V}/^\circ\text{C}$ , RTI + 150  $\mu\text{V}/^\circ\text{C}$ , RTU, typ

Noise: 2  $\mu\text{Vrms}$  RTI + 300  $\mu\text{Vrms}$  RTO, typ  
0.1 Hz to 51 kHz

Crosstalk: -80 dB, DC to 25 kHz between adjacent channels with the same configuration and programmed settings.

### Auto-Offset Adjust (Standard)

Auto-Offset Auto-offset automatically zeroes offset at the channel output to less than 5 mV at any gain setting. The auto-offset cycle is initiated in the GUI. The offset DAC settings are stored in non-volatile memory on the card for every gain setting. Changes in gain result in minimal disruption of the channel.

### Output Monitor (Standard)

Output Monitor: A switch located at the output of each channel allows for multiplexed connection to the mainframe output monitor bus. The output monitor bus is available at a connector located in the 17th slot at the rear of the mainframe. The monitor function is used by the Test Subsystem or is available to the user for viewing channel outputs.

## 27104A CARD GENERAL CHARACTERISTICS

27104A Card Size: 5.68 x 13.15 x 0.75 inches  
14.43 x 33.40 x 1.91 cm

Card Weight: 1.87 lb. net, 3.3 lb. shipping  
(0.85 kg net, 1.5 kg shipping)

Temperature: 0 $^\circ$  to 40 $^\circ$  C (operating)  
-20 $^\circ$  to 70 $^\circ$  C (storage)

## 27000 MAINFRAMES

27000D-M3-E03: 16-slot chassis with low-noise linear supply and four DB50 connectors for 27104A outputs. External excitation supply input (Option E). RS-232C remote interface. Compatible with all other 27000 signal conditioning cards. 120 VAC operation, 46-66 Hz.

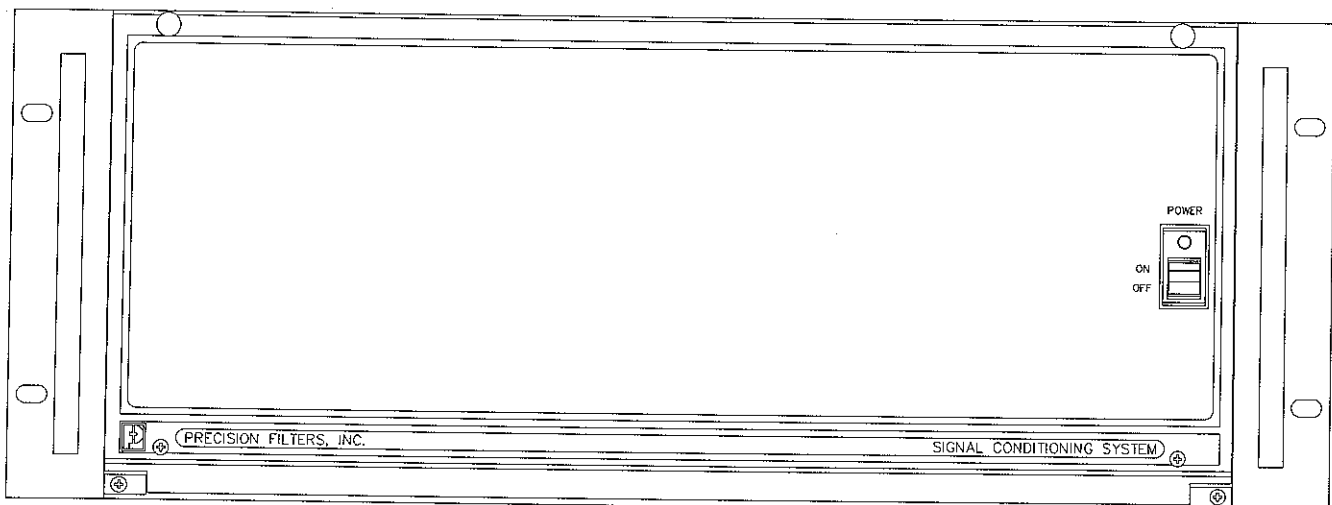
**Option 2:** 220 VAC Power Supply

**Option 3:** 240 VAC Power Supply

## BACKPLANE INTERFACE CARD

27000C-BIF1 Backplane interface module with Auto Offset capability. Installed in dedicated card slot 17 in 27000D-M3-E03 mainframe.

**Option T:** Test hardware to support 27000B-2-TEST



## ACCESSORIES

### Input Mating Connectors

The input connectors are integral to the 27104A. Cutouts on the 27000 Mainframe allow for the input connector to pass through the back-plane to directly mate with the input cable.

27000-IN-26D: High-Density 26-pin D-shell mating connector with crimp pins and back-shell with strain relief. Two connectors required per slot (4 channels).

### Output Mating Connectors

The 27000D-M3-E03 mainframe contains four 50-pin D shell connectors mounted on the rear panel. Sixteen twisted pairs are accommodated per connector.

27000-OUT-50D: 50-pin D-shell mating connector with crimp pins and back-shell with strain relief. One required per 16 channels or up to four per 27000 mainframe.

### Backplane Interface Mating Connectors

27000-CAL-9D: 9-pin D-shell mating connector, back-shell with strain relief.

27000-MON-9D: 9-pin D-shell mating connector, back-shell with strain relief.

## ACCESSORIES

### Cables

CB-DD50P/16BNCM-L: DD50P to 16 channel isolated BNC male output cable. L = length in feet.

CB-DD50P/16BNCF-BH-L: DD50P to 16 channel isolated BNC female output cable for bulkhead panel mount. L = length in feet.

PNL-32BNCBH-1U: Panel for 32 bulkhead mounted BNC's. Standard 19" rack mount, 1.75" high.

### Fan Trays

When greater than four cards are installed in the 27000 mainframe, fan trays are required for system cooling.

27000-FT1: Fan Tray Assembly 115 VAC

27000-FT2: Fan Tray Assembly 220 VAC

Note: Fan trays require 2U of rack space above and 1U of rack space below the 27000 chassis for a total of 5.25 inches of vertical rack space. The fan trays accommodate a rack mounting depth of 17.75 inches to 23.75 inches.

### Rack Mount Kits

SM18: Rack mount kit with slides. Accommodates a nominal rack mounting depth of 18 inches

SM20: Rack mount kit with slides. Accommodates a nominal rack mounting depth of 20 inches.

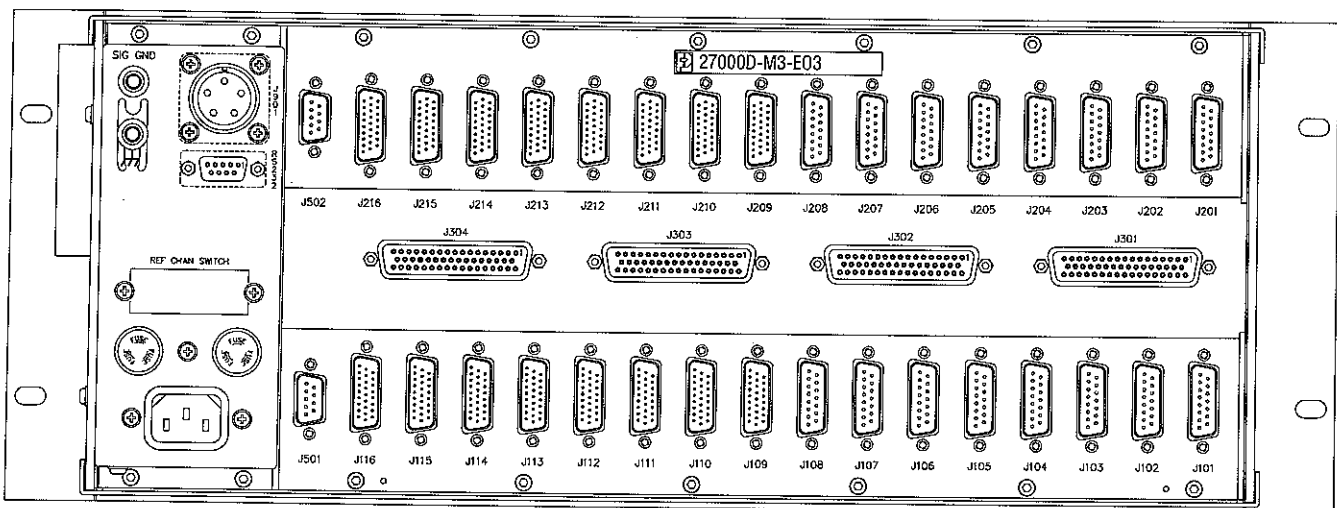
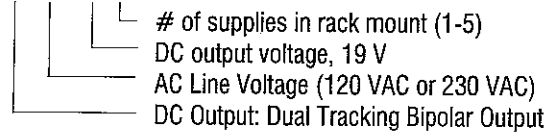
SM22: Rack mount kit with slides. Accommodates a nominal rack mounting depth of 22 inches.

SM24: Rack mount kit with slides. Accommodates a nominal rack mounting depth of 24 inches.

## EXTERNAL EXCITATION SUPPLIES

Note: One excitation supply is required per mainframe.

27000-EXC2-YYY-19-n



27000D-M3-E03 Mainframe Rear Panel

## GRAPHICAL USER INTERFACE

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27000-GUI-WIN: Graphical User Interface Software for 27000 system. Requires Pentium Computer, 266 MHz or higher with one serial port, 1024x768 graphics resolution and 64 MB of RAM.

27000-GUI-SL: Site license for 27000 GUI software.

## OPTIONAL BUILT-IN TEST

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27000-2-TEST: Test instruments required for Factory Acceptance Test (FAT) and Go/No-Go (GNG) tests.

27000-FAT-WIN: Factory Acceptance Test software. Requires Pentium computer as specified for 27000-GUI-WIN. In addition, the 27000-FAT-WIN requires two serial ports or one GPIB port for control of the test instruments.

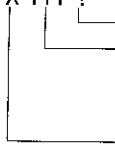
27000-GNG-WIN: Go/No-Go Test software. Requirements are the same as for the 27000-FAT-WIN

27000-FAT-SL: Site license for 27000 FAT software.

27000-GNG-SL: Site license for 27000 GNG software.

## ORDERING INFORMATION

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27104A-X-YYY-?\*  


Options: 6, N, P  
Filter Type: EL8, TD8, BU8, BE8,  
LP1, TD6, BU6, BE6,  
EL4, TD4, BU4, BE4  
Cutoff Frequency: C, E, ... etc. See  
Cutoff Frequency  
Settings section

\* Note: A 27104A-BR?/? Bridge Resistor Module and 27104A-BC?/? Bridge Completion Module must be ordered in addition to the base 27104A card.

