



## Precision 28118 Octal-Channel Bridge Conditioner with Constant Voltage Excitation

**28118 Octal-Channel Bridge Conditioner with Constant Voltage Excitation** offers eight channels of conditioning to support a wide variety of transducers, including those that require constant voltage excitation. Balanced constant voltage excitation in a bridge configuration supports applications such as strain gages and pressure transducers. The 28118 is easily configured to operate as a precise voltage filter/amplifier for low-level voltage inputs.



### 28118

#### Applications

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

### Precision 28118 Features

- Eight channels per card, 128 channels per 28016 chassis
- Balanced programmable constant voltage excitation with remote sense
- Up to 20 V delivered to the bridge
- $\pm 10$  Vcm operation
- Up to 30 kHz “filtered” bandwidth or 190 kHz “wide-band” bandwidth
- 2- to 6-wire plus shield transducer input interface
- Automatic bridge balance/transducer suppress
- Programmable amplifier: x1/16 to x1024 with 0.05% vernier
- Distributed gain to provide reserve against out-of-band signal such as transducer resonances
- 4-pole low-pass filters with programmable pulse/flat characteristics
- 2° phase matching between any channels
- Overload detection
- Auxiliary front panel output connection to support the use of custom output modules (for unit without option 4)

### Overview

## 28000 Analog Signal Conditioning System

*The new standard for the world's most discriminating test labs.*



*The Precision 28000 signal conditioning system provides all the flexibility you need to manage your test measurements.*

The Precision 28000 makes it easy to manage a test, with hundreds of channels and a mix of transducers. Choose charge, IEPE w/TEDS, voltage (filter amplifier), strain, thermocouple, RTD, potentiometer, current, frequency, or other transducers.

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 28000 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 Precision 28000 offers ways to help you save time and money over the life of the system.

### 28000 System Features

- Graphical user interface (GUI) and Ethernet network interface 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
- Field-swappable AC power supplies
- Built-in temperature and power supply monitoring with alarms

# Precision 28118 Description

## Precision 28118 Description

The 28118 is a member of the Precision 28000 family of signal conditioners. The 28118 provides eight channels of conditioning to support a wide variety of transducers including those that require constant voltage excitation in a bridge configuration such as strain gages and pressure transducers. The 28118 may be easily configured to operate as a precise voltage filter/amplifier on low-level voltage inputs. Up to sixteen 28118 cards may reside in the 28000 system to provide up to 128 channels per chassis. In addition, the 28118 may be mixed with other conditioners in the 28000 family to meet unique signal conditioning requirements.

## Balanced Constant Voltage Excitation

The 28118 features a programmable constant voltage excitation supply that can source up to 20 volts to the bridge. Dedicated remote sense lines allow the excitation supply regulator to deliver an accurate voltage 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.

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.

## Input Stage

The 28118 differential input stage may be either AC or DC coupled. AC coupling is useful for dynamic applications where the DC bias on the transducer, that can limit dynamic range, can be coupled out of the signal. The input stage may be shorted under program control to verify signal conditioner channel noise and DC offsets.

A switch at the input stage is provided to connect the amplifier to the 28000 system test bus. The test bus is used to inject signals for performance verification. In addition, the excitation supply sense leads may be connected to the amplifier input so that the excitation voltage appears at the amplifier output. This feature allows the user to measure the excitation voltage with the data acquisition system.

## Amplifier

Programmable pre- and post-filter amplifiers provide an overall gain of 1024. 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. Examples of out-of-band signals that could cause clipping include shock (impulse) events that excite the transducer resonance or gear mesh noise on rotating machinery.

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-of-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 the 28118 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 5 mA of drive capability may be used to drive long output cable runs.

The 28118 features automatic calibration of gain and offset for the entire channel, including the amplifier and filter.

## Filter

The 28118 is specified with a 4-pole low-pass filter with five programmable cutoffs. In addition, the filter may be programmed to "flat" or "pulse" mode. The "flat" mode provides pass-band characteristics nearly identical to a Butterworth filter while providing a much sharper roll-off. This mode is a good choice for applications such as spectral analysis.

The "pulse" mode has time domain response similar to the Bessel filter yet provides superior amplitude response characteristics. The "pulse" mode is ideal for time domain applications including transient (shock) measurements and time domain waveform analysis.

## 28118 Programmable Features

- Excitation level (0 to 20.475 V in 5 mV steps)
- Excitation sense (local or remote)
- Automatic balance (zero)
- Input Coupling (AC or DC)
- Test Modes: Amp Short, Excitation Off, Voltage Substitution, Excitation Monitor
- Output monitor
- Gain: x1/16 to x1024 with 0.05% resolution
- Filter type: pulse or flat
- Cutoff frequency:  
FX02: 300 Hz, 1 kHz, 3 kHz, 10 kHz, 30 kHz
- Wide-band (190 kHz) or filtered operation

## 28118 Graphical User Interface Display

All programmable features in addition to:

- Balance (zero) status
- Input wiring
- Gage sensitivity
- System scaling in engineering units
- Overload status
- Gain Wizard
- Filter Wizard
- Group Control

# 28118 Details and Specifications

## 28118 Conditioner Cards

The detailed description and specifications for the 28118 are organized in the following sections:

- Bridge Wiring
- Excitation Supply
- Input Characteristics and Options
- Amplifier Characteristics
- Test Modes
- Filter Type Characteristics
- Output Characteristics
- General Card Characteristics
- Accessories
- Ordering Information

## Bridge Wiring

### Input Connector:

26-pin D-shell (2 ea.)

### Input Wires:

±EXCITATION (2)

±SENSE (2)

±SIGNAL (2)

SHIELD (1) two common shield pins shared across four channels in each input connector

## 28118 Excitation Supply

### Programmable Constant Voltage Excitation

#### Maximum Output:

20.475 V, 30 mA (balanced)

#### Steps:

Programmable from 0 to 20.475 V in 5 mV steps

#### Excitation Sense:

Programmable (local or remote sense)

#### Accuracy:

±0.1% or ±5 mV, whichever is greater

#### Current Limit:

40 mA, typical

#### Noise:

100  $\mu$ Vrms, 3 Hz to 50 kHz

#### Temperature Drift:

±0.0025%/°C of setting or ±50  $\mu$ V/°C, whichever is greater

#### Sense Leakage Current:

Less than 10  $\mu$ A

#### 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.

## 28118 Input Characteristics

### Type:

Balanced differential w/ Programmable AC/DC input coupling

### Input Impedance:

10 M $\Omega$  //100pF per side

### Max Level:

(AC + DC + Common Mode)

±10 Vpk for  $f < \text{or} = 200$  kHz

±10 Vpk x (200 kHz/f) for  $f > 200$  kHz

### Input Protection:

25 V continuous (power on)

60 Vpk transient

(1 ms pulse, 50% duty cycle)

### Offset Drift:

3.5  $\mu$ V/°C, typical

### AC Coupling Frequency:

0.25 Hz (-3.01 dB)

### CMRR (DC Coupled):

86 dB, DC to 440 Hz and input gain >x8

### CMRR (AC Coupled):

80 dB, 10 Hz to 440 Hz and input gain >x8

## 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.

### 64 mV/V Mode Auto-Balance Range:

0 mV/V to ±64 mV/V in ±1.95  $\mu$ V/V steps

### 512 mV/V Mode Auto-Balance Range

(Gain limited to x128):

0 mV/V to ±512 mV/V in ±15.625  $\mu$ V/V steps

### Accuracy:

±0.1% of setting ±0.1% of F.S. range

### Stability:

±0.0025% / °C of setting

### Drift (RTI):

±1  $\mu$ V / °C for 64 mV/V range;

±8  $\mu$ V / °C for 512 mV/V range

### Auto Balance Time:

Less than 15 seconds per system of 128 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.

### 1.28 V Suppress Ranges:

0 mV to ±1.28 V in ±39  $\mu$ V steps

### 10.24 V Suppress Ranges

(Gain limited to x128):

0 V to ±10.24 V in ±312.5  $\mu$ V steps

### Accuracy:

±0.1% of setting ±0.1% of F.S. range

### Stability:

±0.0025% / °C of setting

### Drift(RTI):

±1  $\mu$ V / °C for 1.28 V range;

±8  $\mu$ V / °C for 10.24 V range

### Auto Suppress Time:

Less than 15 seconds per system of 128 channels

# 28118 Details and Specifications

## 28118 Amplifier Specifications

### Pre-Filter Gain:

x1 to x64 in x2 steps with overload detection (10.2 Vpk threshold)

### Post-Filter Gain:

x1/16 to x16 in binary steps with vernier adjustment

### Overall Gain:

x1/16 to x1024

### Gain Setability:

0.05% steps for POG  $\geq 1X$   
0.05%/POG for POG  $< 1X$

### DC Gain Accuracy:

0.02% typical, 0.2% maximum for POG  $\geq 1X$   
0.2%/POG maximum for POG  $< 1X$

### Frequency Response:

DC to 100 kHz; 0 dB  $\pm 0.1$  dB; -3 dB typical at 190 kHz

### Temperature Coefficient

$\pm 0.005\%$  / $^{\circ}C$  max

### DC Linearity:

$\pm 0.01\%$  re: Fullscale, relative to best straight line

## 28118 Mute Mode

In harsh test environments, a sensor or input cable can become faulty or intermittent during a critical test. With high-gain signal conditioning, this can be troublesome if large signal swings on input or output cabling cross-couple to other channels. The 28118 Mute control places the channel in the quietest operational state to minimize system noise in the event of a failed sensor. Mute mode is also useful to terminate unused channels in a safe and quiet state.

## 28118 Test Modes

### 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:

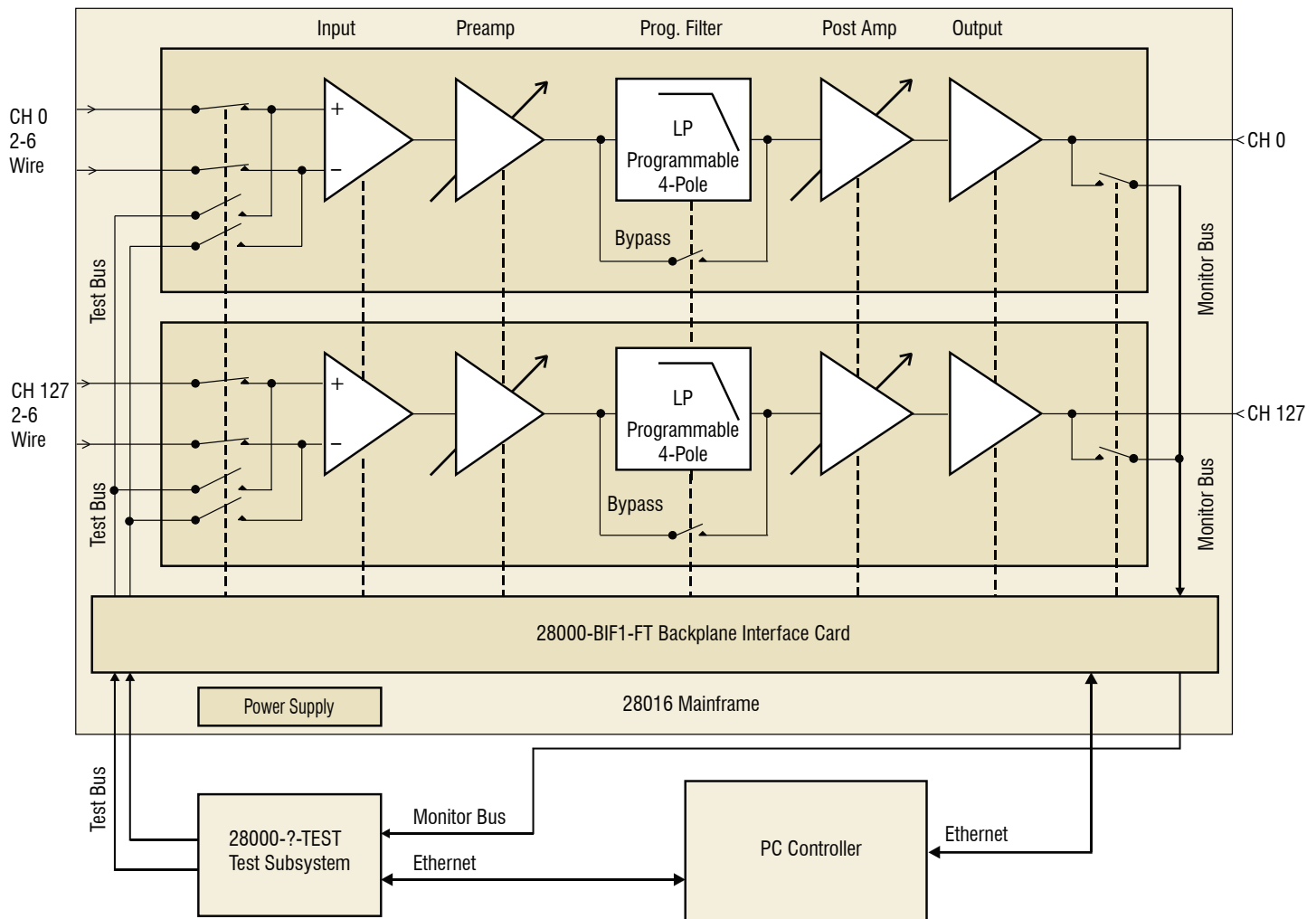
The excitation supply is programmed to zero volts.

### 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 28000-?-TEST Test System may be connected at the rear panel. Refer to the 28000-?-TEST Test System specification for more information.



System Block Diagram

# 28118 Filter Characteristics

You want your analog data to come clean before digital conversion.

## Flat/Pulse Low-Pass Filters

Our LP4FP 4-pole flat/pulse low-pass filters provide the user with the versatility to address applications in either the time or frequency domain and are available on many 28000 card models.

## Flat Mode Low-Pass Filters

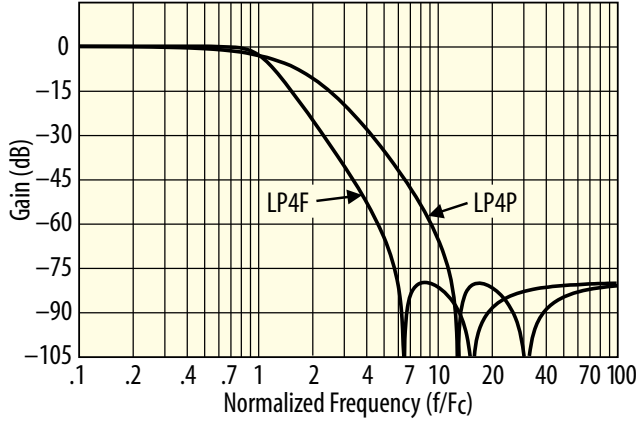
Precision LP4F "flat" mode characteristics are specified to have outstanding passband flatness equivalent to the Butterworth yet deliver very sharp roll-off characteristics.

The LP4F is a good choice as an anti-aliasing filter and for applications such as spectral analysis. The LP4F has zero passband ripple and roll-off superior to the Butterworth.

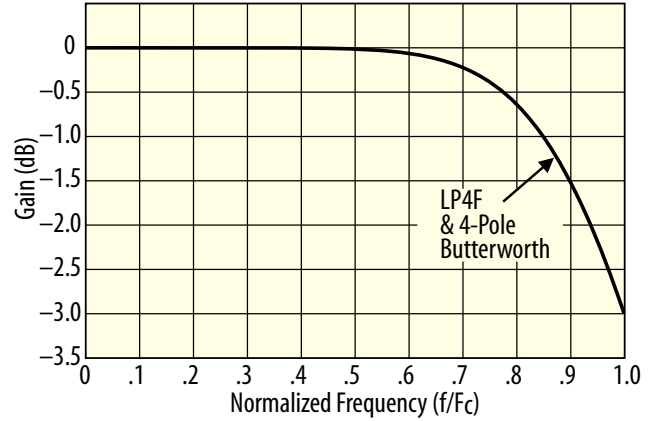
## Pulse Mode Low-Pass Filters

For the time domain, program the 28618 low-pass filter to "pulse" mode. These filters have excellent transient response and phase linearity making them ideal filters for time domain applications including transient (shock) measurements and time domain waveform analysis ... all with roll-off characteristics superior to their Bessel filter counterparts.

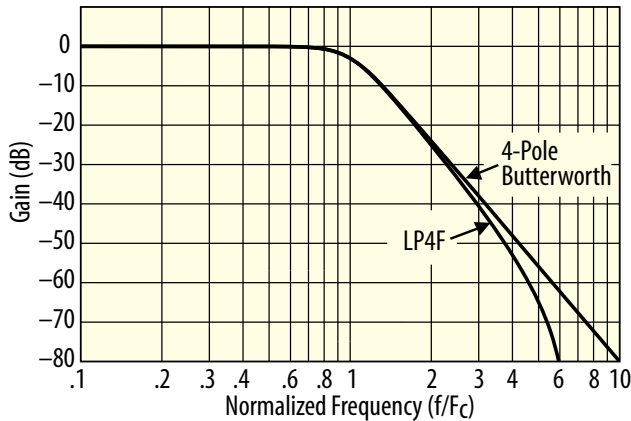
LP4F and LP4P Amplitude Response



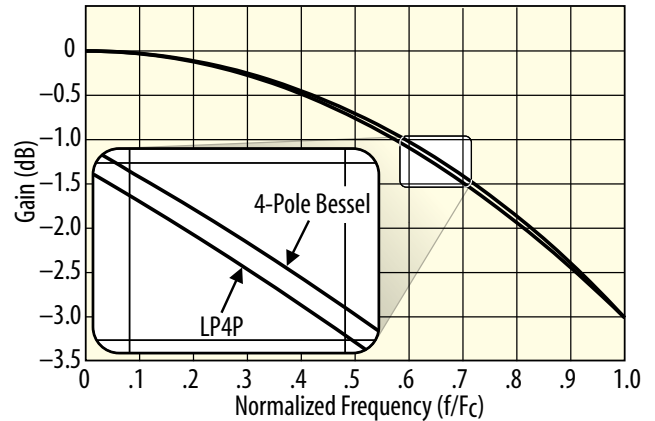
LP4F vs Butterworth Passband Response



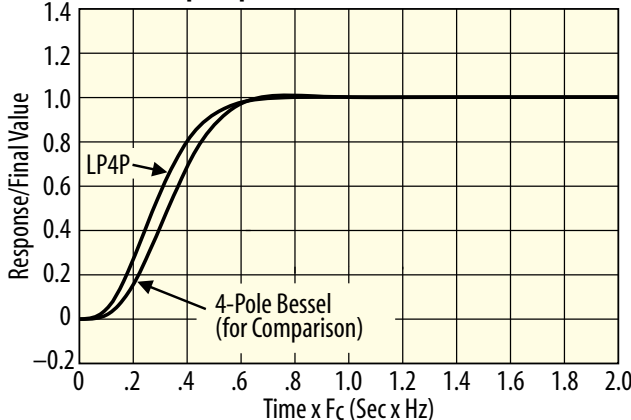
LP4F vs Butterworth Amplitude Response



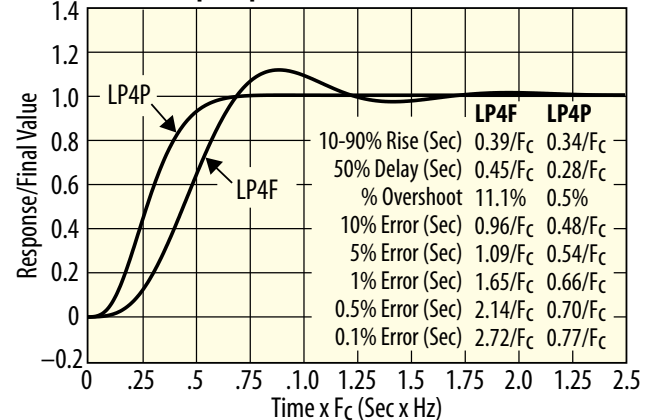
LP4P vs Bessel Passband Response



LP4P vs Bessel Step Response



LP4F and LP4P Step Response



# 28118 Filter Characteristics

## 28118 Filter Type Characteristics

### Filter Type:

LP4FP: 4-pole, 4-zero low-pass filter.  
 Programmable for maximally flat pass-band (LP4F) or linear phase with optimized pulse response (LP4P).

### Cutoff Frequencies:

FX02: 300 Hz, 1 kHz, 3 kHz, 10 kHz, 30 kHz

### Amplitude Accuracy:

±0.1 dB max, DC to 0.8 Fc  
 ±0.2 dB max, 0.8 Fc to Fc

### Amplitude Match:

±0.1 dB max, DC to 0.8 Fc  
 ±0.2 dB max, 0.8 Fc to Fc

### Phase Match:

±1° max, DC to 0.8 Fc  
 ±2° max, 0.8 Fc to Fc

### Filter Bypass:

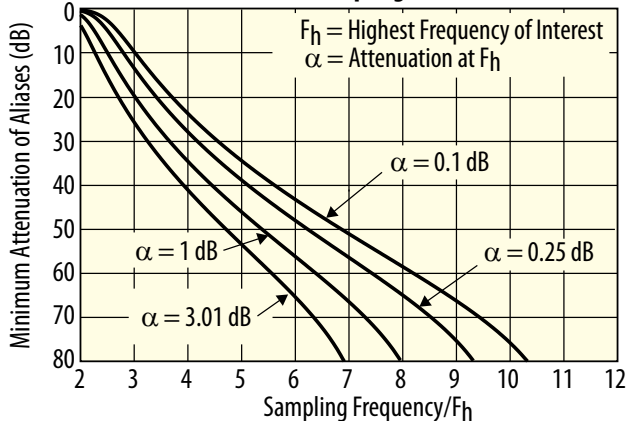
Bypasses filter but not amplifier stages.  
 Bypass Bandwidth: 190 kHz, typical

### Custom Filters:

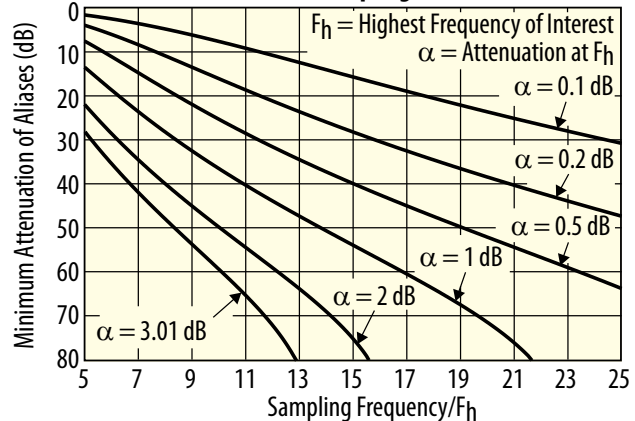
Other filter characteristics and cutoff frequencies are available. Please consult with factory for more information.

| Specification               | LP4F<br>Maximally Flat<br>Low-Pass Filter | LP4P<br>Constant Time Delay<br>Low-Pass Filter |
|-----------------------------|---|--|
| Cutoff Frequency Amplitude  | -3.01 dB                                  | -3.01 dB                                       |
| DC Gain                     | 0.00 dB                                   | 0.00 dB  |
| Pass-Band Ripple            | 0.00 dB                                   | 0.00 dB  |
| Stop-Band Frequency         | 5.9465 Fc                                 | 11.863 Fc                                      |
| Cutoff Frequency Phase      | -180.0 deg                                | -101.5 deg                                     |
| Phase Distortion (DC to Fc) | < 31.8 deg                                | < 3.7 deg                                      |
| Zero Frequency Group Delay  | 0.4117/Fc                                 | 0.2920/Fc                                      |
| Percent Overshoot           | 11.1%                                     | 0.5%   |
| 1% Settling Time            | 1.65/Fc                                   | 0.66/Fc  |
| 0.1% Settling Time          | 2.72/Fc                                   | 0.77/Fc  |
| -0.1 dB Frequency           | 0.6348 Fc                                 | 0.1816 Fc                                      |
| -1 dB Frequency             | 0.8487 Fc                                 | 0.5742 Fc                                      |
| -2 dB Frequency             | 0.9370 Fc                                 | 0.8129 Fc                                      |
| -3.01 dB Frequency          | 1.0000 Fc                                 | 1.0000 Fc                                      |
| -20 dB Frequency            | 1.7412 Fc                                 | 3.0248 Fc                                      |
| -40 dB Frequency            | 2.9555 Fc                                 | 5.6932 Fc                                      |
| -60 dB Frequency            | 4.5986 Fc                                 | 9.0980 Fc                                      |
| -80 dB Frequency            | 5.9465 Fc                                 | 11.8629 Fc                                     |

LP4F Attenuation of Aliases vs Sampling Rate



LP4P Attenuation of Aliases vs Sampling Rate





# 28118 Details and Specifications

## 28118 Output Characteristics

### Type:

DC-coupled, single-ended output.  
Programmable wideband (190 kHz)  
or filtered

### Z:

10  $\Omega$  shunted by 100 pF per side

### Max Output:

$\pm 10$  Vpk,  $\pm 5$  mApk

### Offset:

<5 mV after auto-adjust at any gain  
setting

### Offset Drift:

3.5  $\mu$ V/°C, RTI + 150  $\mu$ V/°C, RTO, typical

### Noise:

6  $\mu$ Vrms RTI + 100  $\mu$ Vrms RTO, typical  
3 Hz to 100 kHz

### Crosstalk:

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

### Differential Output (Option T):

Balanced differential output

### Max Output:

$\pm 5$ V pk per side (5 mA pk)  
 $\pm 10$ V pk differential

## 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 programmable switch located at the  
output of each channel allows for mul-  
tiplexed connection to the mainframe  
output monitor bus. The output monitor  
bus is available at a connector located  
on the controller card at the rear of the  
mainframe. The monitor function is used  
by the 28000-?-TEST Test System and is  
available for viewing channel outputs  
by the user.

## General Characteristics

### 28118 Card Size:

6.63 x 17.5 x 0.75 inches

### Card Weight:

1.4 lb. net

### Temperature:

0 °C to 40 °C (operating);  
-20 °C to 70 °C (storage)

## Input Connectors:

The input connectors are integral to the  
28118 card. Cutouts on the 28000 frames  
allow the input connector to pass through  
the backplane and to directly mate with the  
input cables.

Two 26-pin high-density D connectors are  
utilized for the eight inputs (4 inputs per  
connector). Connectors have high quality  
mached gold plated pins/sockets.

## Output Mating Connectors

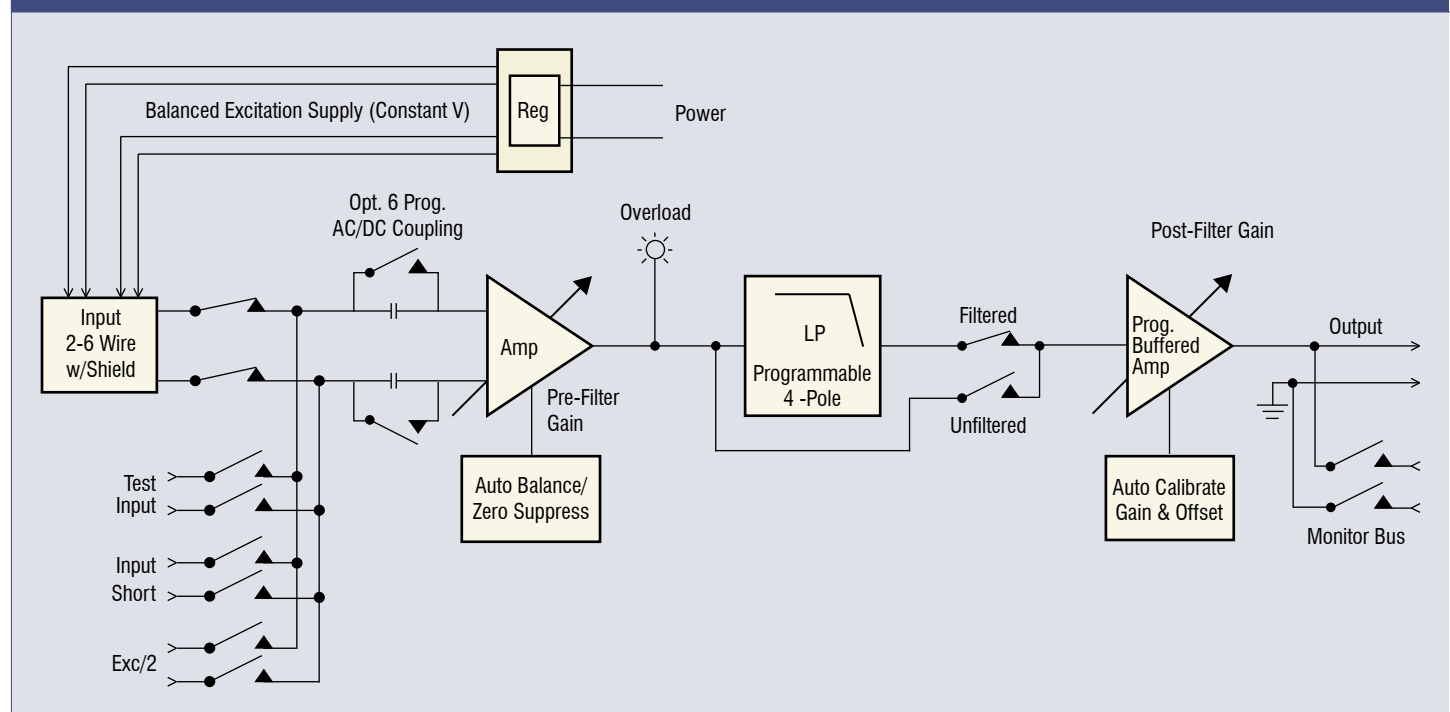
A summary of 28118 card compatibility with  
Precision Filters chassis model numbers is  
provided below:

**28016-M5, 28008-M3/M5, 28004-M3/M5  
or 28002-M5:** Output connectors are integral  
to the 28016-M5, 28008-M3/M5, 28004-M3/  
M5 and 28002-M5 chassis rear panels. One  
high-density 26-pin connector is provided  
per slot to accommodate the eight  
28118 outputs.

**28016-M3 or 28008-M3:** The 28118 card  
must be configured with Option 4 when used  
in the 28016-M3 or 28008-M3 chassis. The  
eight 28118 outputs are available on 26-pin D  
connectors that are integral to the 28118 card  
front panel (Option 4).

Note: Output buffer modules may not be  
used with a card that is equipped with  
Option 4.

## 28118 Channel Block Diagram



## Accessories

### Mating Connectors

Precision Filters mating connectors accommodate up to 22-AWG wire and are supplied with high-quality metal backshells and gold plated screw machined contacts for high reliability connections and long service life.

**CONN-IN-26D** High-density 26-pin D-shell mating input connector with machined crimp pins and metal backshell with strain relief.

**CONN-IN-26D-SC** High-density 26-pin D-shell mating input connector with machined solder cup pins and metal backshell with strain relief.

**CONN-OUT-26D** High-density 26-pin D-shell mating output connector with machined crimp pins and metal backshell with strain relief.

**CONN-OUT-26D-SC** High-density 26-pin D-shell mating output connector with machined solder cup pins and metal backshell with strain relief.

### Test Adapter

**28118-TEST-ADAPTER** supports FAT testing of the excitation supply and is used to test excitation accuracy under full load, linearity, sense, current limit, and offset.

### Output Adapters

Measurement systems often require multiple outputs per signal conditioning channel or special functions such as a DC output in proportion to the AC signal level. These outputs may be routed to control systems, tape backup systems, auxiliary data acquisition systems, scope bays, or other destinations.

28118 cards (without Option 4) are fitted with front-panel connectors that accept Precision output adapter modules. Adapters plug on to the front of the signal conditioner card and are secured to the card by two screws.

**BUFF-8CH/(2)26HD:** Octal output buffer for 8-channel cards provides two buffered outputs per channel on 26-pin high-density D-type connectors.

### Precision PF-1U-FA Multi-Channel Programmable Filter/Amplifier System



#### Exceptional desktop performance.

Ideal for conditioning low-level voltage inputs in front of high-resolution digital data acquisition systems. Fully programmable 8-channel and 16-channel configurations are available, both offering a choice of either 4 or 8-pole low-pass filters with programmable gain.

### High Density Programmable Switch Systems

Computer controlled analog signal switching replaces tedious manual patch panels.



#### Precision 4164 64x64 Switch Matrix System



#### Precision 464kC Switch Matrix System

Precision switch systems are reliable solid-state switch matrix systems, providing computer-controlled connection between input and output signals. Configure the 464kC with up to 256 inputs and 256 outputs, all in a single mainframe, or choose the compact 4164 system with 64 inputs and 64 outputs. Save time and reduce errors on test system setup. Download switch configurations from the host computer over the network. Built-in self-test with fault diagnostics.



28118 with Auxiliary Output Connector (L), and 28118 with Option 4 (R)

### 28118 Card Model Number

The 28118 card model number describes the configuration of the four channels on the card. The model number identifies the filter range, and output options.

28118-<Filter Range>-LP4FP-Options

