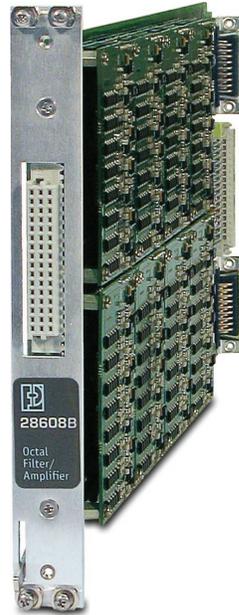




Precision 28608B Octal Programmable Filter/ Amplifier

The 28608B Octal Programmable Filter/Amplifier card is ideal for conditioning low-level voltage inputs in front of high-resolution digital data acquisition systems. It features a choice of 4 or 8-pole low-pass filters, 4 or 8-pole high-pass filters and 8-pole band-pass filters with programmable characteristics for either time or frequency domain applications. The 28608B octal programmable filter/amplifier cards allow for up to 128 channels of programmable precision filtering in one 28016 sixteen-card chassis. The balanced differential input of the 28608B allows for connection to grounded loads without introducing ground loops or for measuring bridge type sensors.



28608B Applications

- Anti-Aliasing Filters with Programmable Amplifiers
- General Purpose Voltage Amplifier for Dynamic Measurements
- Low Drift DC Amplifier for Low-Level DC Signals
- Noise Filter
- AC or DC Bridge Filter/Amplifier
- Underwater Acoustics
- Pyroshock Measurements
- Wind Tunnels
- Automatic Test Equipment
- Industrial Process Control
- Reconstruction Filters
- Data Acquisition
- Signal Conditioning

Precision 28608B Features

- Eight channels per card, 128 channels per 28016 chassis
- Balanced differential inputs with programmable AC/DC coupling
- Zero Suppress via a programmable DC voltage inserted at the channel input
- Distributed programmable gain of x1/16 to x8192 with 0.05% resolution
- Input MUTE mode to terminate unused channels in safe, quiet state
- Pre-filter overload detection
- Filter Choices:
 - 4 or 8-pole low-pass filters with programmable pulse/flat characteristics for optimized time domain or frequency domain performance
 - 4 or 8-pole high-pass filters
 - 8-pole band-pass filters
- Programmable low-pass filter cutoff frequencies:
 - Pulse Mode: Programmable from 1 Hz to 102.3 kHz
 - Flat Mode: Programmable from 2 Hz to 204.6 kHz
- Wide-band (500 kHz) or filtered operation
- Precise digital calibration
- Single-ended outputs with ground sense
- Programmable test modes for cal signal injection and input short, allowing for automated measurement system validation
- Output monitor bus
- Auxiliary front panel output connection supports the use of Precision Filters' output buffer modules for adding up to two buffered outputs per channel

Precision 28608B for the 28000 Analog Signal Conditioner

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, set-up, 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 28608B Description

Precision 28608B Description

The 28608B is a member of the Precision 28000 family of signal conditioners. The 28608B provides eight channels of programmable amplifiers having an overall gain of x1/16 to x1024 with fine resolution. Up to sixteen 28608B cards may reside in the 28000 system to provide up to 128 channels per chassis. In addition, the 28608B may be mixed with other conditioner cards in the 28000 family to meet unique signal conditioning requirements.

Input Stage

The 28608B input stage is a high impedance balanced differential input topology that may be used to receive differential signals from a bridge type transducer or to condition grounded (single-ended) voltage sources without introducing ground loops. The input is versatile in that it has low DC drift for DC measurement applications, low noise for wideband AC measurements and is equipped with programmable AC/DC coupling. AC coupling is useful for eliminating large DC bias on the signal so that more channel gain can be applied in order to emphasize small AC fluctuations in the signal.

For applications where DC or very low frequency signals are to be measured, the 28608B Zero Suppress feature allows the user to automatically zero the input DC voltage while the channel is DC coupled. By zeroing the initial DC operating point of the input signal, more gain may be applied to emphasize small DC and low frequency AC fluctuations. Zero suppress also provides the user with an effective means to balance a bridge type sensor or other DC coupled sensors.

Automated System Verification

Test-modes are defined by Precision Filters as special hardware states that are used for verification of the 28000 signal conditioning cards. The 28608B has test-modes called "short" and "test bus", which are used by the 28000 Test Subsystem to verify that the 28608B is performing to factory specifications. Test-modes simplify verification and trouble-shooting of the 28000 system.

For test-mode "test bus", the normal input signal is disconnected and a test signal is inserted at the channel input to verify the 28608B channel and any systems connected to the 28608B output. With test-mode "short", the 28608B input may be shorted under program control to verify channel noise and DC offsets.

For properly terminating unused or channels with faulty sensors, the "MUTE" feature of the 28608B sets the channel to the quietest quiescent state, preventing that channel's input and output from coupling signals to other channels.

Amplifier

The amplifier on the 28608B is distributed before and after the programmable filter as pre-filter and post-filter gain. Together, the pre- and post-filter amplifiers provide an overall programmable gain range of x1/16 to x8192. The post-filter gain has resolution of better than 0.05% to enable precise system scaling of the 28608B outputs to match the full-scale input of the external recording device.

By distributing the gain around the filter, the 28608B is able to provide protection against large out-of-band energy or transients that could cause clipping before the filter, distorting the data. The Gain Wizard in the 28000 GUI allows the user to set the out-band protection required and then apportions the gain between the input and output to provide optimal dynamic range while protecting against out-of-band signals. Pre-filter overload detectors alert the user to over-voltage conditions at the filter input that could distort the data and would otherwise be masked by the filter.

Automated calibration of the amplifier is performed via precise digital adjustments of gain and DC offset. Calibration coefficients and are stored in non-volatile memory on the card.

28608B Programmable Features

- Input Coupling (AC or DC)
- Test Modes: Amp Short, Test Bus (voltage substitution)
- MUTE mode
- Output monitor
- Gain: x1/16 to x8192 with fine resolution
- Filter type: pulse or flat
- Cutoff frequency:
 - Pulse Mode: Programmable from 1 Hz to 102.3 kHz
 - Flat Mode: Programmable from 2 Hz to 204.6 kHz
- Wide-Band (500 kHz) or filtered operation
- Zero suppress DC voltage

28608B Graphical User Interface Display

All programmable features in addition to:

- System scaling in engineering units
- Overload status
- Gain Wizard
- Filter Wizard
- Group Control

Filters

The 28608B offer a variety of filter characteristics for Low-Pass, High-Pass and Band-Pass filtering with independently programmable cutoffs frequencies for each of the eight channels. In addition to the cutoff frequency, the low-pass filter characteristic may be programmed to provide a frequency response appropriate to the type of measurement being performed.

The “flat” mode characteristic provides pass-band 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.

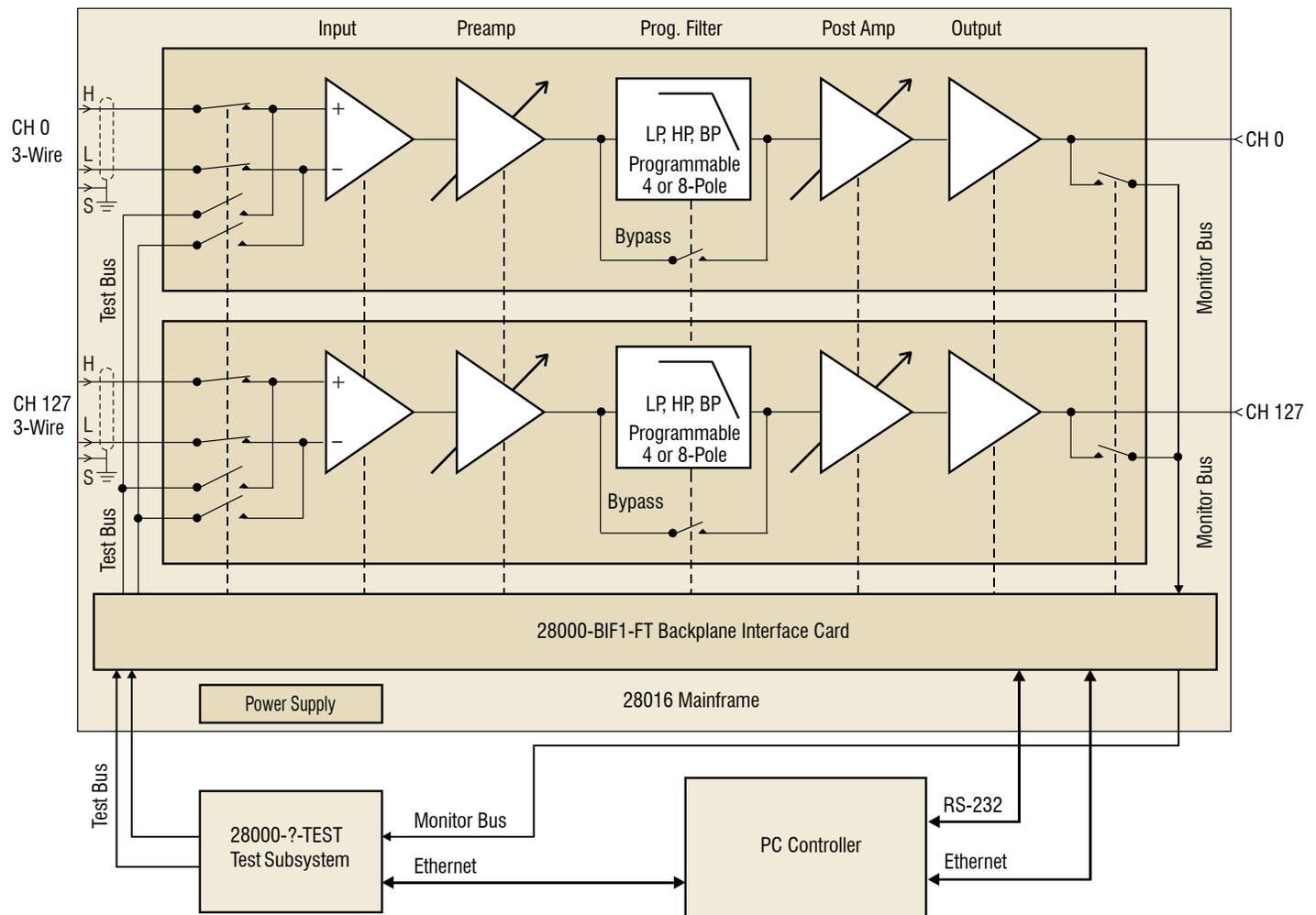
The “pulse” mode characteristic has time domain response similar to the Bessel filter yet provides superior amplitude response characteristics. The “pulse” mode is ideal for time domain applications including transient (shock) measurements and time domain waveform analysis.

The filter may be bypassed under program control, allowing the 28608B to function as a wideband amplifier with 500 kHz of bandwidth.

Multiple Buffered Outputs

By attaching the optional BUFF-8CH/(2)26HD output adapter to the front panel of the 28608B card, the 28608B can accommodate two additional independently buffered outputs for a total of three outputs per channel. Now each channel is able to drive the primary data acquisition hardware plus two additional devices, such as a control system or back-up system, without introducing ground loops that plague T output connections. Each output can be configured as single-ended or ground sensing, allowing the 28608B to drive either floating or grounded loads that are correctly ground referenced and free from ground loop noise.

28000 System Block Diagram



28000 System with 128 Channels of 28608B Filter/Amplifiers Block Diagram

28608B Details and Specifications

28608B Conditioner Cards

The detailed description and specifications for the 28608B are organized as follows in the sections below:

- Amplifier Characteristics
- Input Characteristics
- Test Modes
- Mute Mode
- Output Characteristics
- General Characteristics
- Filter Characteristics
- Accessories
- Ordering Information

28608B Amplifier Specifications

Pre-Filter Gain:

x1 to x512 in x2 steps with overload detection (10.2 Vpk threshold)

Post-Filter Gain:

x1/16 to x16

Post-Gain Resolution:

Let G = Post-Gain Setting
 Resolution (min) = 0.05% for $G \geq x0.5$
 0.1% for $x0.5 > G \geq x0.25$
 0.2% for $x0.25 > G \geq x0.125$
 0.4% for $x0.125 > G \geq x0.0625$

Amplifier Frequency Response:

-3 dB typical at 500 kHz

DC Accuracy:

0.02% typical, 0.2% max, gain $>x0.5$

Temperature Coefficient

$\pm 0.008\%$ /°C max

DC Linearity:

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

28608B Input Characteristics

Type:

Balanced Differential w/ programmable AC/DC input coupling

Input Connector:

High-density 26-pin D-shell at rear panel

Input Impedance:

10 M Ω //100pF per side

Max Level:

(AC + DC + Common Mode)
 ± 10 Vpk for $f \leq 200$ kHz
 ± 10 Vpk x (200 kHz/f) for $f > 200$ kHz

Input Protection:

35 V continuous (power on)
 60 Vpk transient
 (1 ms pulse, 50% duty cycle)

Offset Drift:

1 μ V/°C, typical

Noise:

9 nV/ $\sqrt{\text{Hz}}$ at 1 kHz and pre-filter gain >64 , typical

AC Coupling Frequency:

0.25 Hz (-3.01 dB)

CMRR (DC Coupled):

100 dB, DC to 440 Hz and input gain $>x16$

CMRR (AC Coupled):

80 dB, 10 Hz to 440 Hz and input gain $>x16$

28608B Test Modes

Input Short:

All amplifier inputs may be programmed to ground to measure amplifier noise and DC offset.

Test Input:

A switch at the channel input allows for injection of external test signal via an external 28000 chassis front panel BNC connector.

Zero Suppress:

Precision programmable DC offset is injected at the channel input stage to suppress the DC operating voltage. Manual or automatic suppression modes are supported.

Range:

-160 mV to +160 mV in 78 μ V steps
 -1.28 V to +1.28 V in 625 μ V steps
 -10.24 V to +10.24 V in 5 mV steps

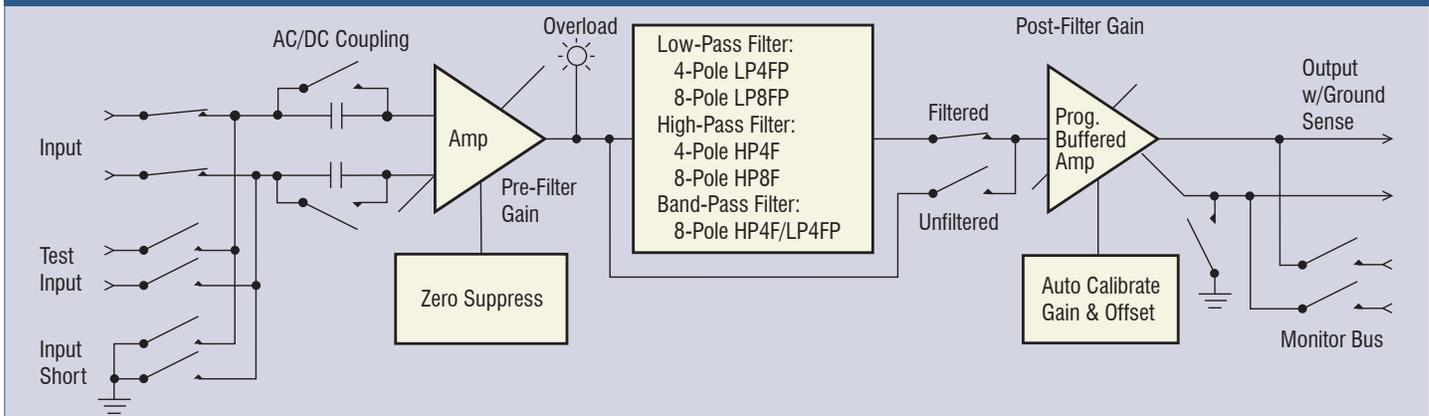
Accuracy:

$\pm 0.25\%$ of setting ± 5 mV

28608B 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 28608B Mute control places the channel in the quietest operational state to minimize system noise in the event of a failed sensor. The Mute Mode is also useful to terminate unused channels in a safe and quiet state.

28608B Channel Block Diagram



28608B Channel Block Diagram

28608B Output Characteristics

Type:

DC-coupled, single-ended output.
Programmable wideband (500 kHz)
or filtered.

Output Ground Sense:

Used for driving grounded single-ended loads. Output is referred to ground at the load. Output sense also reduces ground loop interference by providing a high impedance connection between the ground at the load and the output stage ground.

Impedance:

High Output: 10 Ω // 100 pF

Low Output (Sense Input):

Sense (100 Ω // 100 pF) or ground via manual card switch

Output Shield:

Selectable ground or open via manual card switch

Max Output:

± 10 Vpk, ± 5 mA pk

Offset:

<5 mV after auto-adjust at any gain setting

Offset Drift:

1 μ V/°C, RTI + 150 μ V/°C, RTO, typical

Noise:

2.8 μ V rms RTI + 60 μ V rms RTO, typical
3 Hz to 100 kHz

Crosstalk:

-90 dB, DC to 100 kHz between adjacent channels with the same configuration and programmed settings.

Auto-Offset Adjust (Standard)

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)

A programmable 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 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.

28608B General Characteristics

28608B 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 and Output Connectors:

The input and output connectors are integral to the 28608B card. Cutouts on the 28000 frames allow the connectors to pass through the backplane and to directly mate with the input cables.

One 26-pin high-density D connectors is utilized for the eight inputs and one 26-pin high-density D connectors is utilized for the eight outputs. Three wires per input or output are provided in order to accommodate twisted/shielded cables. Connectors have high quality machined gold plated pins/sockets.

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 output connector with machined crimp pins and metal backshell with strain relief.

CONN-IN-26D-SC: High-Density 26-pin D-shell mating output 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.

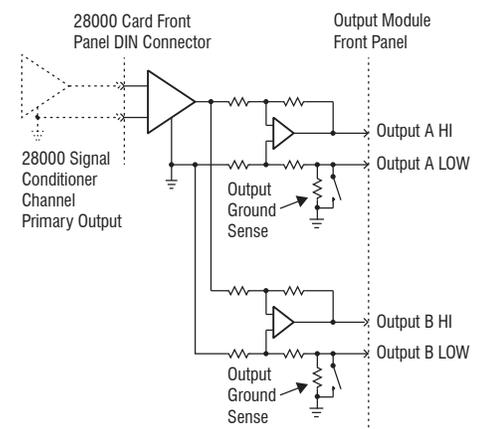
CONN-OUT-26D-SC: High-Density 26-pin D-shell mating output connector with machined solder cup pins and metal backshell with strain relief.

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 and other destinations.

28608B cards are fitted with front panel connectors which 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: Dual output buffer for 8-channel cards provides two buffered outputs per channel on 26-pin high density D-type connectors.



Output Adapter BUFF-8H/(2)26HD
Channel Block Diagram

28608B Filter Characteristics

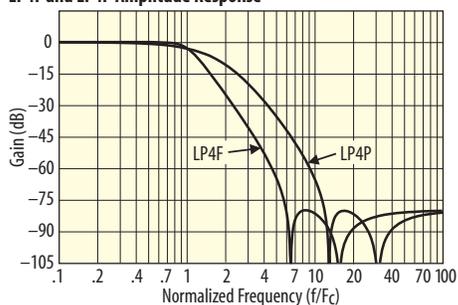
You want your analog data to come clean before digital conversion.

The 28608B card has a variety of high performance filter characteristics available for HP, LP or BP Precision filtering.

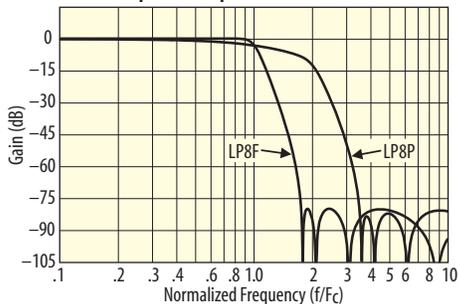
Flat/Pulse Low-Pass Filters

Our new choice of LP4FP 4-pole or LP8FP 8-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. Frequencies can range as high as 204.6 kHz with fixed frequency choices for economy.

LP4F and LP4P Amplitude Response



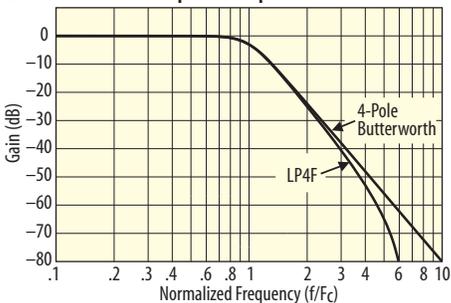
LP8F and LP8P Amplitude Response



Flat Mode Low-Pass Filters

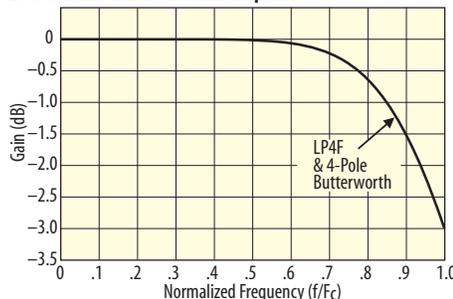
Precision LP4F and LP8F "flat" mode characteristics are specified to have outstanding pass-band flatness equivalent to the Butterworth yet deliver very sharp roll-off characteristics.

LP4F vs Butterworth Amplitude Response



The LP4F and LP8F are a good choice as an anti-aliasing filter and for applications such as spectral analysis. The LP8F has zero passband ripple and over 100 dB/octave attenuation slope.

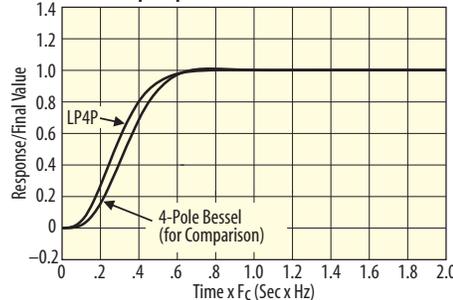
LP4F vs Butterworth Passband Response



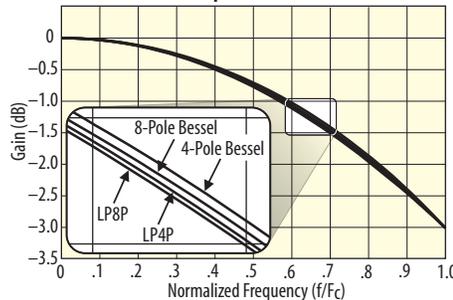
Pulse Mode Low-Pass Filters

For the time domain, there are the LP4P and LP8P "pulse" mode low-pass filters. 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.

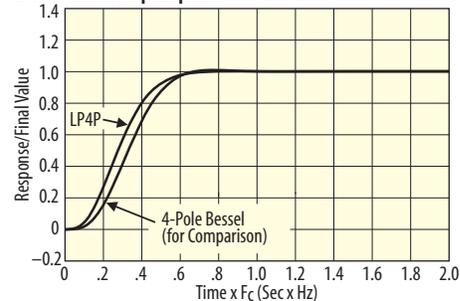
LP4P vs Bessel Step Response



LP8P and LP4P Passband Response



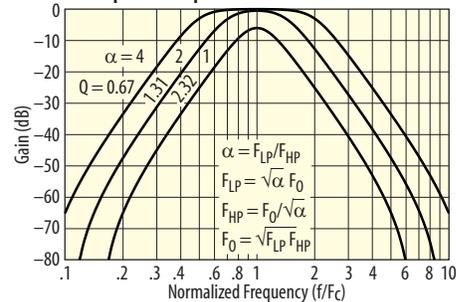
LP4P vs Bessel Step Response



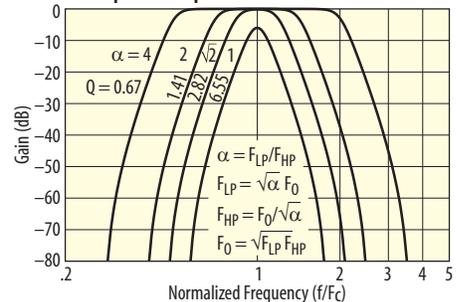
High-Pass and Band-Pass Filters

For high-pass filtering, we offer the HP4F 4-pole and HP8F 8-pole characteristics. For band-pass filtering, choose the HP4F/LP4FP band-pass characteristic to provide programmable bandwidth and center frequency filters. For more selective band-pass filtering, cascade an HP8F with an LP8F.

Band-Pass Amplitude Response HP4F and LP4F Cascaded



Band-Pass Amplitude Response HP8F and LP8F Cascaded



Traditional Filters

Of course, we offer the traditional filter types such as Butterworth and Bessel characteristics ... just ask!

In any case, we deliver to you a tightly controlled filter with phase match better than 1 degree and usually better than 0.5 degrees.

28608B Details and Specifications

28608B Filter Type Characteristics

Option LP4FP:

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

Option LP8FP:

8-pole, 8-zero low-pass filter.
Programmable for maximally flat pass-band (LP8F) or linear phase with optimized pulse response (LP8P).

Option HP4F/LP4FP:

8-pole, 8-zero band-pass filter.
Flat HP4F 4-pole, 4-zero high-pass filter cascaded with a 4-pole, 4-zero low-pass filter. Low-pass filter programmable for maximally flat pass-band (LP4F) or linear phase with optimized pulse response (LP4P).

Cutoff Frequencies:

Flat Mode:
2 Hz to 2.046 kHz in 2 Hz steps
2.2 kHz to 204.6 kHz in 200 Hz steps

Pulse Mode:
1 Hz to 1.023 kHz in 1 Hz steps
1.1 kHz to 102.3 kHz in 100 Hz steps

LP4F, LP4P, LP8F, LP8P:

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

HP4F/HP8F:

Amplitude Accuracy:
±0.2 dB max, 1.2 Fc to 204.6 kHz
±0.35 dB max, Fc to 1.2 Fc

Amplitude Match:
±0.1 dB max, 1.2 Fc to 204.6 kHz
±0.2 dB max, Fc to 1.2 Fc

Phase Match:
±1° max, 1.2 Fc to 204.6 kHz
±2° max, Fc to 1.2 Fc

Bypass:
Bypasses filter but not amplifier stages.
Each filter may be independently bypassed for the HP4F/LP4FP band-pass filter.

Bypass Bandwidth:
500 kHz, typical

Custom Filters:
Other filter types and cutoff frequencies are available. Please consult with Precision Filters for more information.

Specification	LP4F Maximally Flat Low-Pass Filter	LP4P Constant Time Delay Low-Pass Filter	LP8F Maximally Flat Low-Pass Filter	LP8P Constant Time Delay Low-Pass Filter	HP4F Maximally Flat High-Pass Filter	HP8F Maximally Flat High-Pass Filter
Cutoff Frequency Amplitude	-3.01 dB	-3.01 dB	-3.01 dB	-3.01 dB	-3.01 dB	-3.01 dB
DC Gain	0.00 dB	0.00 dB	0.00 dB	0.00 dB	-80 dB	-80 dB
Pass-Band Ripple	0.00 dB	0.00 dB	0.00 dB	0.00 dB	0.00 dB	0.00 dB
Stop-Band Frequency	5.9465 Fc	11.863 Fc	1.7479 Fc	3.4688 Fc	0.1682 Fc	0.5721 Fc
Cutoff Frequency Phase	-180.0 deg	-101.5 deg	-360 deg	-161.9 deg	180 deg	360 deg
Phase Distortion (DC to Fc)	< 31.8 deg	<3.7 deg	<102.0 deg	<0.05 deg	-	-
Zero Frequency Group Delay (SEC)	0.4117/Fc	0.2920/Fc	0.7197/Fc	0.4496/Fc	-	-
Percent Overshoot	11.1%	0.5%	18.9%	1.1%	-	-
1% Settling Time (SEC)	1.65/Fc	0.66/Fc	4.03/Fc	1.25/Fc	1.86/Fc	4.2/Fc
0.1% Settling Time (SEC)	2.72/Fc	0.77/Fc	7.02/Fc	2.25/Fc	2.92/Fc	7.2/Fc
-0.1 dB Frequency	0.6348 Fc	0.1816 Fc	0.8527 Fc	0.1792 Fc	1.5753 Fc	1.1712 Fc
-1 dB Frequency	0.8487 Fc	0.5742 Fc	0.9438 Fc	0.5685 Fc	1.1783 Fc	1.0597 Fc
-2 dB Frequency	0.9370 Fc	0.8129 Fc	0.9774 Fc	0.8088 Fc	1.0672 Fc	1.0233 Fc
-3.01 dB Frequency	1.0000 Fc	1.0000 Fc	1.0000 Fc	1.0000 Fc	1.0000 Fc	1.0000 Fc
-20 dB Frequency	1.7412 Fc	3.0248 Fc	1.2152 Fc	2.2342 Fc	0.5743 Fc	0.8231 Fc
-40 dB Frequency	2.9555 Fc	5.6932 Fc	1.4443 Fc	2.7556 Fc	0.3384 Fc	0.6924 Fc
-60 dB Frequency	4.5986 Fc	9.0980 Fc	1.6391 Fc	3.2016 Fc	0.2175 Fc	0.6101 Fc
-80 dB Frequency	5.9465 Fc	11.8629 Fc	1.7479 Fc	3.4688 Fc	0.1682 Fc	0.5721 Fc

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.

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 and other destinations.

28608B cards are fitted with front panel connectors which 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: Dual output buffer for 8-channel cards provides two buffered outputs per channel on 26-pin high density D-type connectors.

28608B Card Model Number

The 28608B card model number describes the card model number and filter type options.

28608B-<LP4FP|LP8FP|HP4F|HP8F|HP4F/LP4FP>

LP4FP: Low-pass, 4-pole, Flat/Pulse Filters

LP8FP: Low-pass, 8-pole, Flat/Pulse Filters

HP4F: High-pass, 4-pole, Flat Filters

HP8F: High-pass, 8-pole, Flat Filters

HP4F/LP4FP: 8-pole, Band-pass Filters

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.