



### Precision 28618 Octal Programmable Filter/ Amplifier

The 28618 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 versatile 4-pole low-pass with programmable characteristics for either time or frequency domain applications. The 28618 octal programmable filter/amplifier cards allow for up to 128 channels of programmable precision filtering in one 28016 sixteen-card chassis. The differential input of the 28618 allows for connection to grounded loads without introducing ground loops or for measuring bridge type sensors.



#### 28618 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
- Production Test Equipment
- Industrial Process Control
- Reconstruction Filters

#### Precision 28618 Features

- Eight channels per card, 128 channels per 28016 chassis
- Balanced differential inputs with programmable AC/DC coupling
- Distributed programmable gain of x1/16 to x1024 with 0.05% resolution
- Input MUTE mode to terminate unused channels in safe, quiet state
- Pre-filter overload detection
- 4-pole low-pass filters with programmable pulse/flat characteristics for optimized time domain or frequency domain performance
- Wide-band (190 kHz) or filtered operation
- Programmable low-pass filter cutoff frequencies: FX02: 300 Hz, 1 kHz, 3 kHz, 10 kHz, 30 kHz
- Precise digital calibration
- DC coupled outputs, single-ended 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 to support the use of custom output modules

#### 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 28618 Description

## Precision 28618 Description

The 28618 is a member of the Precision 28000 family of signal conditioners. The 28618 provides eight channels of programmable amplifiers having an overall gain of x1/16 to x1024 with fine resolution. Up to sixteen 28618 cards may reside in the 28000 system to provide up to 128 channels per chassis. In addition, the 28618 may be mixed with other conditioner cards in the 28000 family to meet unique signal conditioning requirements.

## Input Stage

The 28618 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. The 28618 input may be shorted under program control to verify channel noise and DC offsets. Also, a switch at the channel input allows the user to disconnect the input from the channel input and connect the input to the 28000 system test bus. The test bus is used to inject signals for performance verification. The "MUTE" function of the 28618 allows the user to program an unused or defective channel in the quietest quiescent state so that the channel's input and output do not couple signals into other channels.

## Amplifier

The amplifier on the 28618 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 x1024. The post-filter gain has resolution of better than 0.05% to enable precise system scaling of the 28618 outputs to match the full-scale input of the external recording device, given the transducer sensitivity and fullscale input in measurement units.

By distributing the gain around the filter, the 28618 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 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, DC offset and calibration coefficients and are stored in non-volatile memory on the card.

## Filter

A versatile 4-pole low-pass filter with five programmable cutoffs is provided for each 28618 channel. In addition to the cutoff frequency, the 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 28618 to function as a wideband amplifier with 190 kHz of bandwidth.

## Multiple Buffered Outputs

By adding the optional BUFF-8CH/(2)26HD output adapter, the 28618 can accommodate two additional independently buffered outputs for a total of three outputs. This allows each channel 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 28618 to drive either floating or grounded loads that are correctly ground referenced and free from ground loop noise.

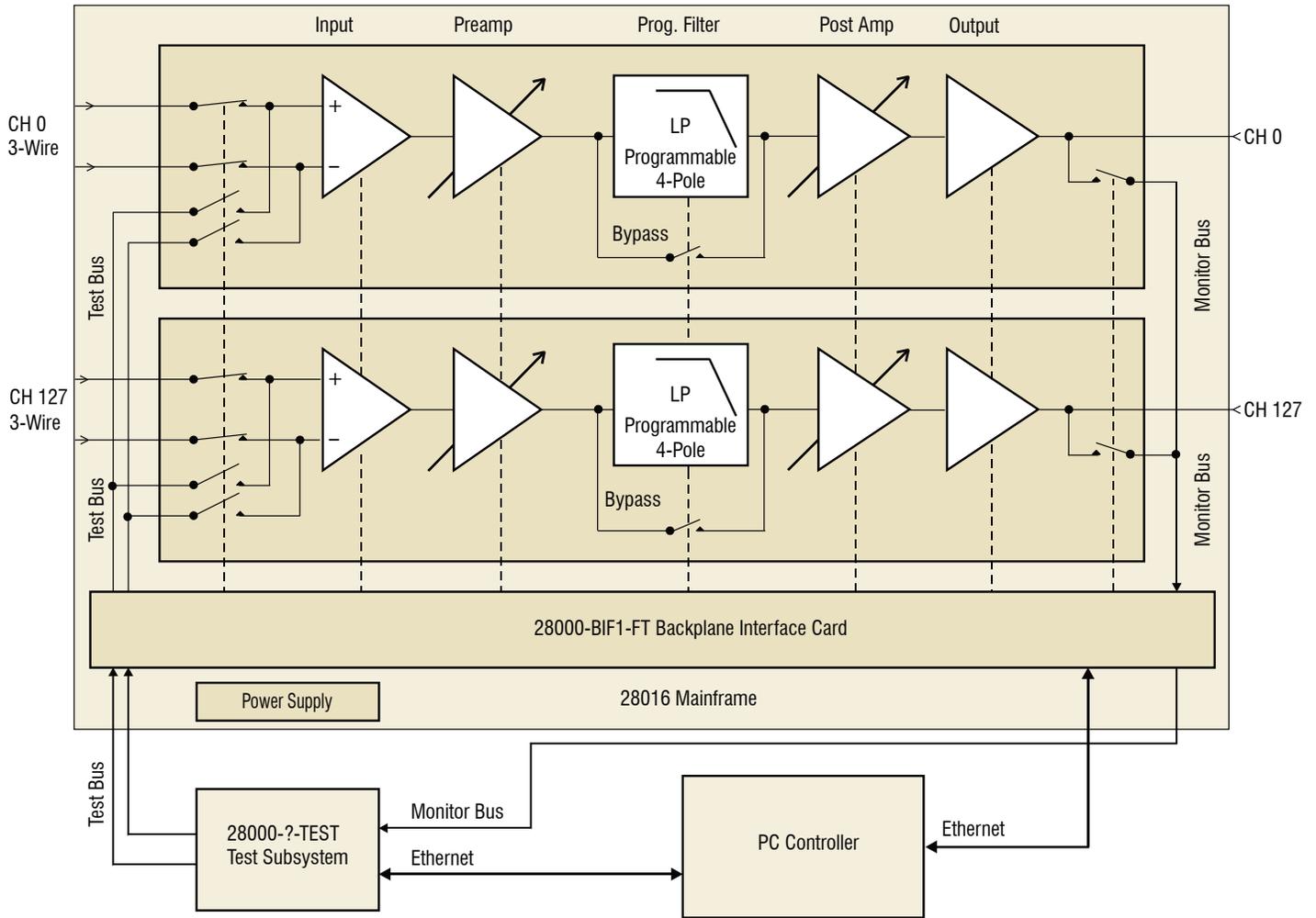
## 28618 Programmable Features

- Input Coupling (AC or DC)
- Test Modes: Amp Short, test bus (voltage substitution)
- Mute mode
- Output monitor
- Gain: x1/16 to x1024 with fine 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

## 28618 Graphical User Interface Display

All programmable features in addition to:

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



28000 System with 128 Channels of 28618 Filter/Amplifiers Block Diagram

# 28618 Details and Specifications

## 28618 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  $< 1X$

### Amplifier Frequency Response:

-3 dB typical at 190 kHz

### Temperature Coefficient:

$\pm 0.005\%$  /°C max

### DC Linearity:

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

## 28618 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 $\Omega$  //100pF per side

### Max Level:

(AC + DC + Common Mode)  
 $\pm 10$  Vpk for  $f \leq 200$  kHz  
 $\pm 10$  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

### Noise:

14 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):

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

### CMRR (AC Coupled):

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

## 28618 Test Modes

### Input Short:

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

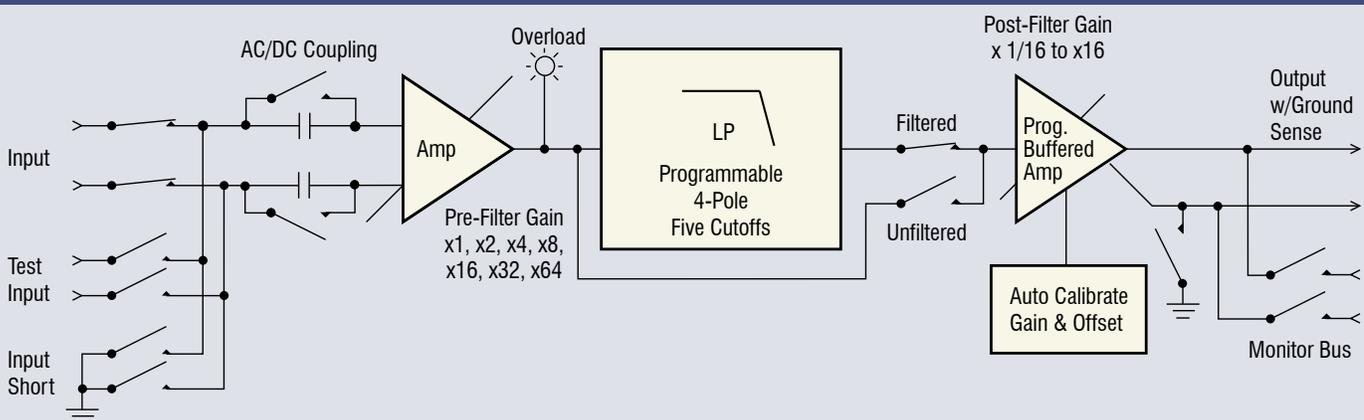
### Test Input:

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

## 28618 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 28618 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.

## 28618 Channel Block Diagram



28618-FX??-LP4FP Channel Block Diagram

## 28618 Output Characteristics

### Type:

DC-coupled, single-ended output.  
Programmable wideband (190 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.

### 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.

## 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.

## 28618 General Characteristics

### 28618 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 28618 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 inputs. 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.

28618 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.

# 28618 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

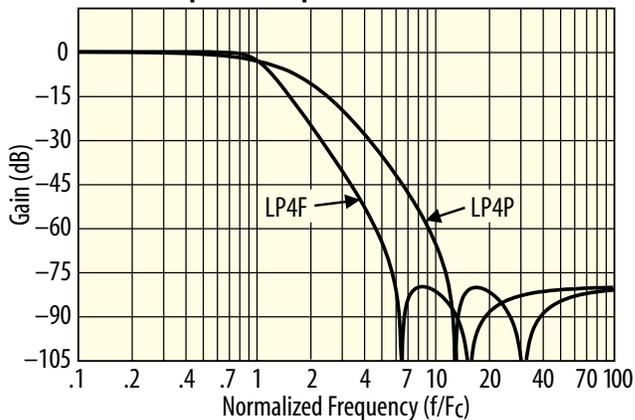
Precision LP4F "flat" mode characteristics are specified to have outstanding passband flatness equivalent to the Butterworth yet deliver very sharp roll-off characteristics.

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.

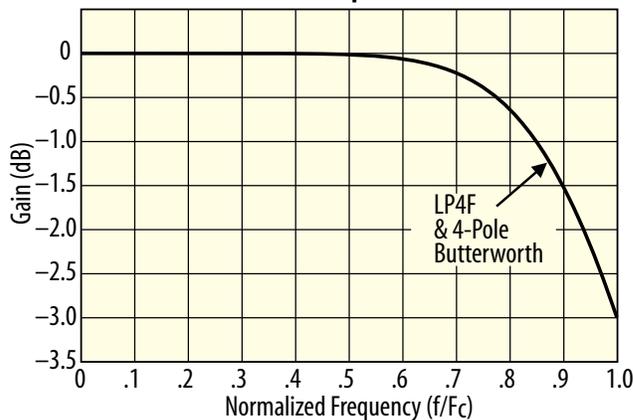
## Pulse Mode Low-Pass Filters

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.

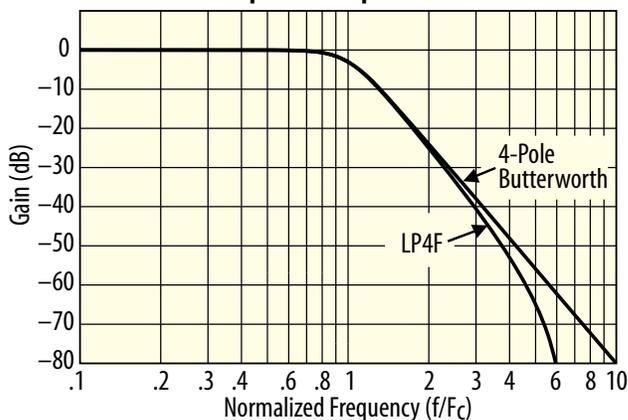
LP4F and LP4P Amplitude Response



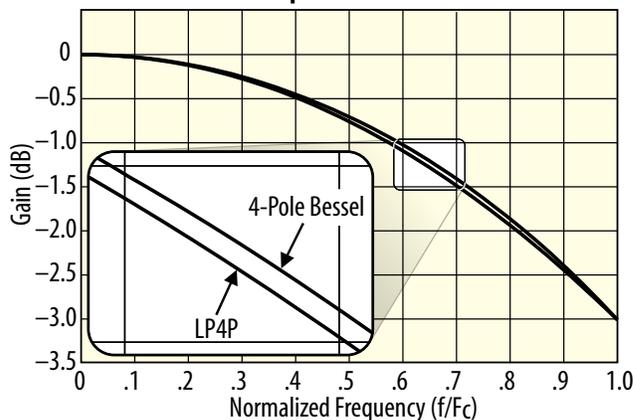
LP4F vs Butterworth Passband Response



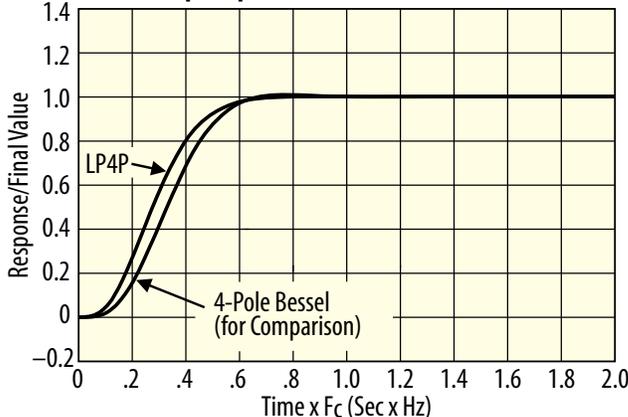
LP4F vs Butterworth Amplitude Response



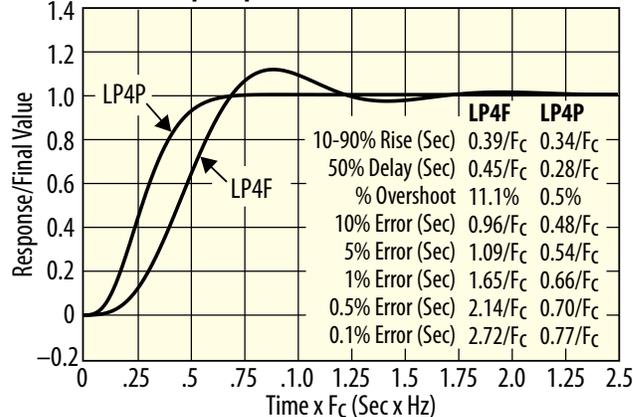
LP4P vs Bessel Passband Response



LP4P vs Bessel Step Response



LP4F and LP4P Step Response



# 28618 Details and Specifications

## 28618 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:

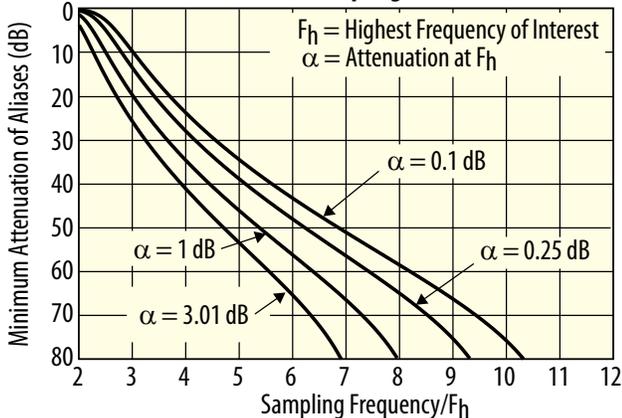
Bypasses filter but not amplifier stages.  
 Bypass Bandwidth: 190 kHz, typical

### Custom Filters:

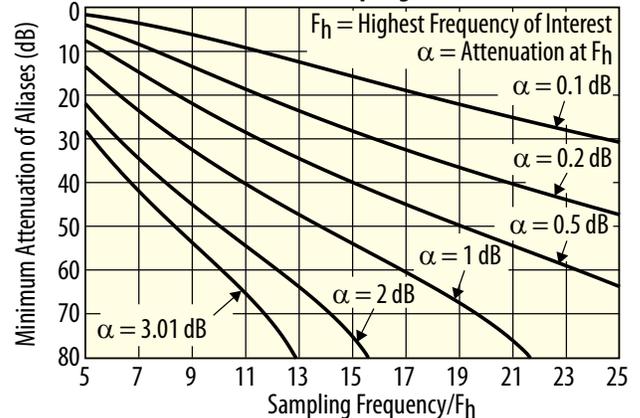
Other filter characteristics and cutoff frequencies are available. Please consult with factory for more information.

Specification	LP4F Maximally Flat Low-Pass Filter	LP4P Constant Time Delay 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



## Accessories

### Mating Connectors

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### 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.

28618 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.

### 28618 Card Model Number

The 28618 card model number describes the filter range, filter characteristic and output options.

28618-<Filter Range>-LP4FP

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

### 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.