PRECISION FILTERS, INC.

*On the **New Frontiers** of **Precision***

Precision 28324

Quad Charge/IEPE Conditioner with Long Distance TEDS™

The 28324 Quad Charge/IEPE Conditioner with Long Distance TEDS is a dual-mode card providing four channels of conditioning for either piezoelectric or IEPE sensors.

It features a versatile 4-pole low-pass filter with programmable characteristics for time- or frequency-domain applications, with a filtered bandwidth of up to 30 kHz or an unfiltered wideband width of 170 kHz. Use the T-Insertion feature as an electronic tap test to gather information on all accelerometer channels quickly and easily from the convenience of the control room. Precision Filters' LDTEDS™ (Long-Distance Transducer Electronic Data Sheet) can communicate with TED-capable sensors to a distance of 1500 feet.

28324 Applications

- Load, torque, dynamic force, dynamic pressure, shock, vibration, and acoustic measurements
- Piezoelectric crash tests
- Ballistics shock testing
- Machine health monitoring
- Structural response tests
- Flight tests
- Wind tunnels
- Ultrasonic transducers

Precision 28324 Features

- Four channels per card, 64 channels per 28016 chassis system
- Dual mode: piezoelectric or IEPE
- Ground sense input mode allows grounded sensors
- Up to 30 kHz "filtered" bandwidth or 170 kHz "wideband" bandwidth
- Two charge conversion ranges for 10,000 or 100,000 pC FS inputs
- T-insertion for health test of inaccessible accelerometers
- Programmable IEPE current to 0, 4, 8, 12 mA
- TEDS compatible
- Programmable amplifier: x1/16 to x1024 with 0.05/vernier
- 4-pole low-pass filters with filter bypass (wideband)
- 2° phase matching between any channels, 10 Hz to Fc
- 0.2° typical phase match 10 Hz to 30 kHz (unfiltered)
- Overload detection
- Precise automatic calibration
- Auxiliary front-panel output connection to support the use of custom output modules

Precision 28324 *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 28324 Description

Precision 28324 Description

The 28324 is a member of the Precision 28000 family of signal conditioners. The 28324 provides four channels of dual-mode charge/IEPE conditioning. Up to sixteen 28324 cards may reside in the 28000 system to provide 64 channels in a single 6U chassis.

In charge mode, the 28324 provides two charge conversion ranges with full-scale inputs of 10,000 or 100,000 pC. Channel gains of up to 1024 provide charge sensitivity as high as 1.024 V/pC. A programmable input stage allows operation with either grounded or isolated accelerometers. Low-noise, low-distortion, and high-accuracy circuits guarantee accurate high-frequency measurements of even low-level signals.

Verification and documentation of actual charge gain can be performed using built-in shunt calibration with secondary standard shunt calibration capacitors. The calibrated value of shunt cal capacitors is stored on card EEPROM and can be recalled by host software for exact span verification or data post processing.

In IEPE mode, the 28324 accommodates long cable runs with programmable IEPE current up to 12 mA. As with charge mode, accurate measurements of wideband, low-level signals are guaranteed by channel gains to 1024, frequency response to 170 kHz, low noise, and high-accuracy circuits.

Input signal visibility is a crucial aspect of IEPE sensors as the sensors' bias voltage is a useful indicator of sensor, cable, and connector health. The 28324 card IEPE input stage continually monitors the DC bias voltage present on the channel input prior to the AC coupling stage. Not only is this voltage level displayed for each channel, it is also compared to user programmable upper and lower threshold limits to alert the user to a sudden shift of the bias level. A system bias level report can be requested at any time, creating a file useful for pretest gage health documentation.

Long Distance TEDS

The 28324 provides a mixed-mode transducer interface in conformance with the IEEE 1451.4 Smart Transducer Interface. The mixed-mode interface supports IEPE (Integrated Electronic Piezoelectric) sensors powered by current source and TEDS (Transducer Electronic Data Sheet) capable sensors. TEDS information, such as manufacturer name, serial number, calibration data, etc., is readable by the system for use in system scaling, identification, bookkeeping, troubleshooting, and other functions.

TEDS sensors may be effectively applied to test models; however, there is a restriction that the cable run between the signal conditioner and the sensor be limited to 400 feet in order to be able to properly read the TEDS. For applications such as weapons test or vibration test on large structures, safety, environment, test article size, and other factors often require cable runs in excess of 1000 feet that have precluded the use of TEDS-equipped sensors—until now.

To overcome the communications distance limitations of conventional TEDS, the 28324 is equipped with Precision Filters' proprietary Long-Distance TEDS (LDTEDS) hardware. The proprietary LDTEDS circuitry uses an analog-to-digital converter to digitize the TEDS waveforms and a digital signal processor to process the TEDS data. LDTEDS can communicate with sensors at distances out to 1500 feet.

Amplifier and Filter

Programmable pre- and postfilter 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, which could cause clipping before the filter and distort the data. The GUI's Gain Wizard 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 overvoltage conditions.

The 28324 contains a 4-pole low-pass filter has two optional cutoff settings of 300 Hz, 1 kHz, 3 kHz, 10 kHz, and 30 kHz or 10 kHz, 20 kHz, 40 kHz, 80 kHz, 100 kHz and programmable "flat" or "pulse" mode. "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. "Pulse" mode has pass-band response similar to the Bessel filter yet provides superior reject-band characteristics. "Pulse" mode is ideal for time-domain applications, including transient (shock) measurements and time-domain waveform analysis.

Accelerometer Conditioning

As the temperature of the test environment increases, measuring vibration becomes more difficult. Accelerometer manufacturers have responded with high-temperature accelerometers that perform at temperatures as high as 750°C.

Care must be taken, however, when using these sensors. One common characteristic of accelerometers is a decreasing insulation resistance across the piezoelectric sensing element at high temperature. If a general-purpose charge amplifier is used, low frequency gain peaking could be as high as 20 to 30 dB. This causes excessive low frequency noise, gain errors, and in severe cases total saturation of the charge amplifier.

The Precision 28324 is compatible with high-temperature accelerometers and exhibits less than 1 dB of peaking—even with accelerometer shunt resistance as low as 100 kOhm.

28324 Details and Specifications

Verification of Cables and Sensor Health

T-Insertion

Acceleration measurements at high temperature (above 250°C) require the use of piezoelectric (charge mode) accelerometers. A very crude check of accelerometer functionality is known as the "tap test". One by one, each accelerometer case is physically tapped or stimulated with a handheld shaker. A second operator in the control room monitors the output display, verifies receipt of the signal, and attempts to make some inference about functionality of the installed accelerometer. While this is a crude and time-consuming technique, it is important in harsh environments to confirm basic sensor and cable health.

The Precision Filters 28324 accelerometer conditioner has built-in "T-insertion" capability to electronically stimulate the attached piezoelectric accelerometer to output a charge signal. Charge output of a stimulated accelerometer is dependent on the exact properties of the accelerometer and the connecting cable. This output is extremely repeatable and can therefore be used to detect any change resulting from a faulty or damaged accelerometer. Additionally, the stimulation frequency can be increased to interrogate the accelerometer in the vicinity of its mounted resonance frequency. Because resonance characteristics are affected by accelerometer mounting, high-frequency performance can identify mechanical damage that occurred during a test run.

In summary, T-insertion can be used as an "electronic tap-test" to gather information on all accelerometer channels quickly and easily from the convenience of the control room. Pre- and post-T-insertion measurements can also be presented as a report to enhance QA documentation and add a new level of test validity documentation.

Muting Faulty Sensors

While most attention is paid to sensors that are functioning properly, a real-world perspective forces us to consider sensors that are *not* functioning properly. Often a malfunctioning sensor can cause noise or fault currents, which can corrupt other properly functioning channels. One common example of this is cable chatter caused by IEPE sensors with intermittent connections.

Due to cable, connector, or sensor faults, it is not uncommon to develop an open circuit condition. When an open circuit occurs, the positive IEPE signal wire suddenly shifts to the compliance voltage level of the attached signal conditioner. A gross fault resulting in a permanent open condition does not cause a noise problem; however, an intermittent fault creates a chatter condition whereby the long connecting wires continually switch between the high voltage compliance level and the functional bias level of the IEPE sensor. This chatter condition creates a hostile noise source to any other gage extension wires near the hostile cable. Often a user may notice the noisy output signal and disable or ignore the faulty channel. However, if the input is not properly muted by removing the IEPE current source, the unsuspecting user will still have difficulty understanding why other channels are showing increased noise.

Depending on the sensor type, various techniques must be used to quiet the channel's input and output circuits and ensure that no noise coupling occurs. Precision 28000 signal conditioning channels have a "Mute" feature, which places the faulty channel in its quietest quiescent state and minimizes the possibility of coupling noise to properly functioning channels.

28324 Programmable Features

Charge Mode Features

- FS range (10,000 pC or 100,000 pC)
- Ground Sense Input mode (breaks ground loops with grounded accelerometers)
- Shunt calibration (on or off)
- T-insertion (on or off)

IEPE Mode Features

- IEPE current (0, 4, 8, 12 mA)
- Bias monitor with programmable fault limits (upper limit and lower limit)
- Input mode (grounded or isolated)
- AC current dither
- Current source disconnect for input filter/amplifier

IEPE/Charge Common Features

- Gain (1/16X to 1024X)
- Cutoff frequency:
  FX02: 300 Hz, 1 kHz, 3 kHz, 10 kHz, 30 kHz
  FX03: 10 kHz, 20 kHz, 40 kHz, 80 kHz, 100 kHz
- Wideband 170 kHz (filter bypassed)
- Test modes:
  Run (operate), Input Short, Cal Voltage Substitution (Test Bus)

28324 Graphical User Interface Display

All programmable features in addition to:

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

28324 Details and Specifications

28324 Conditioner Cards

The detailed description and specifications for the 28324 are organized as follows in the sections below:

- Input Characteristics
- Filter/Amplifier Characteristics
- Test Modes
- Output Characteristics
- Filter Characteristics
- General Card Characteristics
- Accessories
- Ordering Information

28324 Input Characteristics

IEPE Inputs (IEPE Mode)

Type:
Programmable, grounded (sensor floating) or isolated (sensor grounded)

Connector:
Two combo-D pins (two channels per connector)

IEPE Current:
0, 4, 8, 12 mA with disconnect

Current Accuracy:
±1%

IEPE Compliance Voltage:
26 VDC – (IEPE x 400)

IEPE Current Noise:
130 pA/$\sqrt{Hz}$

Frequency Response:
0.25 Hz to 173 kHz

Noise:
15 nV/$\sqrt{Hz}$ RTI at 1 kHz and pregain >x8

Maximum Distance to Sensor (with LDTEDS, Option T):
1500 feet (30 pf/ft cable)

Piezoelectric Inputs (Charge Mode)

Type:
Programmable, grounded (sensor floating) or isolated (sensor grounded)

Connector:
Two isolated coaxial insert combo-D (BNC or microdot using plug-on adapters)

Maximum Input:
Low range: 10,000 pC (F ≤200 kHz)
10,000 pC * 200 kHz/F (F ≥200 kHz)
High range: 100,000 pC (F ≤50 kHz)
100,000 pC * 50 kHz/F (F ≥50 kHz)

Charge Sensitivity:
Low range: 1 mV/pC to 1.024 V/pC
High range: 0.1 mV/pC to 0.1024 V/pC

Frequency Response:
–0.5 Hz to 170 kHz, (–3 dB), typical

Charge Conversion Accuracy:
0.4% (V_{out}/Q_{in} after auto gain adjustment at 55 Hz, Gain = 1X (low range), Gain =10X (high range))

Shunt Calibration Capacitor:
1,000 pF ±0.3%
Actual value of shunt cal cap is measured in FAT and stored in non-volatile memory and is displayed on the GUI. Display value has an uncertainty of 0.12%.

Noise (100 kHz BW, RTI):
Low range: 0.008 pC +0.002 pC/nF
High range: 0.08 pC +0.002 pC/nF

Ground Signal Rejection:
–50 dB DC to 1 kHz (Isolated Mode)

Source Resistance:
Low frequency response exhibits less than 1 dB of peaking with R(in) as low as 100 kΩ. See Chart 1.

Low Frequency Charge Mode Sensitivity to R (in)

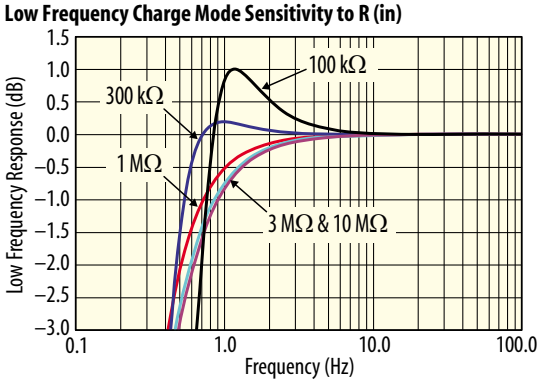


Chart 1

Filter/Amplifier Characteristics

Note: Specs at 25°C unless otherwise noted.

Common Mode V: ±10 V operating

CMRR: –80 dB DC to 1 kHz

Input Protection: ±30 V

Input Impedance:

AC Coupled:
0.1 µF & 9 MΩ per side

DC Coupled:
9 MΩ//100 pF per side

AC Coupling:

Frequency:
0.25 Hz (–3 dB)

Max Level:
±10 Vpk for F ≤200 kHz;
±10 Vpk (100 kHz/F) for F >100 kHz

Noise:
15 nV/$\sqrt{Hz}$ RTI at 1 kHz and pregain >x8, typical

Prefilter Gain (PRG):
x1 to x 64 in binary steps

Postfilter Gain (POG):
x1/16 to 16

Overall Gain:
x1/16 to x1024

Gain Setability:
0.05% steps for gain >1X
0.05%/POG for gain <1X

Gain Accuracy:
0.02% typical, 0.2% maximum for gain >1X
0.2%/ Gain maximum for gain <1X

Distortion:
0.1% re Fullscale

Frequency Response (Bypass Mode):
–3.01 dB @ 173 kHz
–0.1 dB @ 40 kHz

Bypass (Unfiltered) High Frequency Rolloff:
18 dB/octave

28324 Details and Specifications

28324 Test Modes

Shunt Cal:
(Charge Mode only) Test bus signal is applied to charge amp input through a 1000 pF shunt cal capacitor.

T-insertion:
(Charge Mode only) Attached accelerometer low connection is driven with test signal to produce charge signal equal to Q=V (T-insert) * C (sensor+cable). Charge Q is measured by charge amp as indication of sensor and cable health. T-Insert voltage is derived from the system test bus according to:
V (T-insert) = V (Test Bus)/10

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

Test Bus:
Test input allows for injection of voltage substitution test signal. An external test signal or the 28000 Test Subsystem may be connected at the BIF card front panel.

AC Current:
(IEPE Mode only) An AC dither current is summed with the IEPE current to create an AC voltage signal based on the transducer's output impedance. AC current is derived from test bus voltage according to:
AC Current = V (Test Bus)/10000

28324 Output Characteristics

Type:
Two independently buffered single-ended outputs (per channel) are available via rear panel high-density 26-pin connector when using an M5-equipped chassis.

The four primary outputs (Out A) are available via rear panel DB50 connector when using an M3-equipped chassis.

Front panel outputs must be used if dual outputs are desired in an M3-equipped chassis.

Z:
10 Ω shunted by 100 pF

Max Output:
±10 Vpk, ±5 mA pk

Noise:
5 µVrms RTI + 60 µVrms RTO, typical 3 Hz to 100 kHz

Crosstalk:
–80 dB, DC to 30 kHz between channels with the same configuration and programmed settings

Output Monitor (Standard)

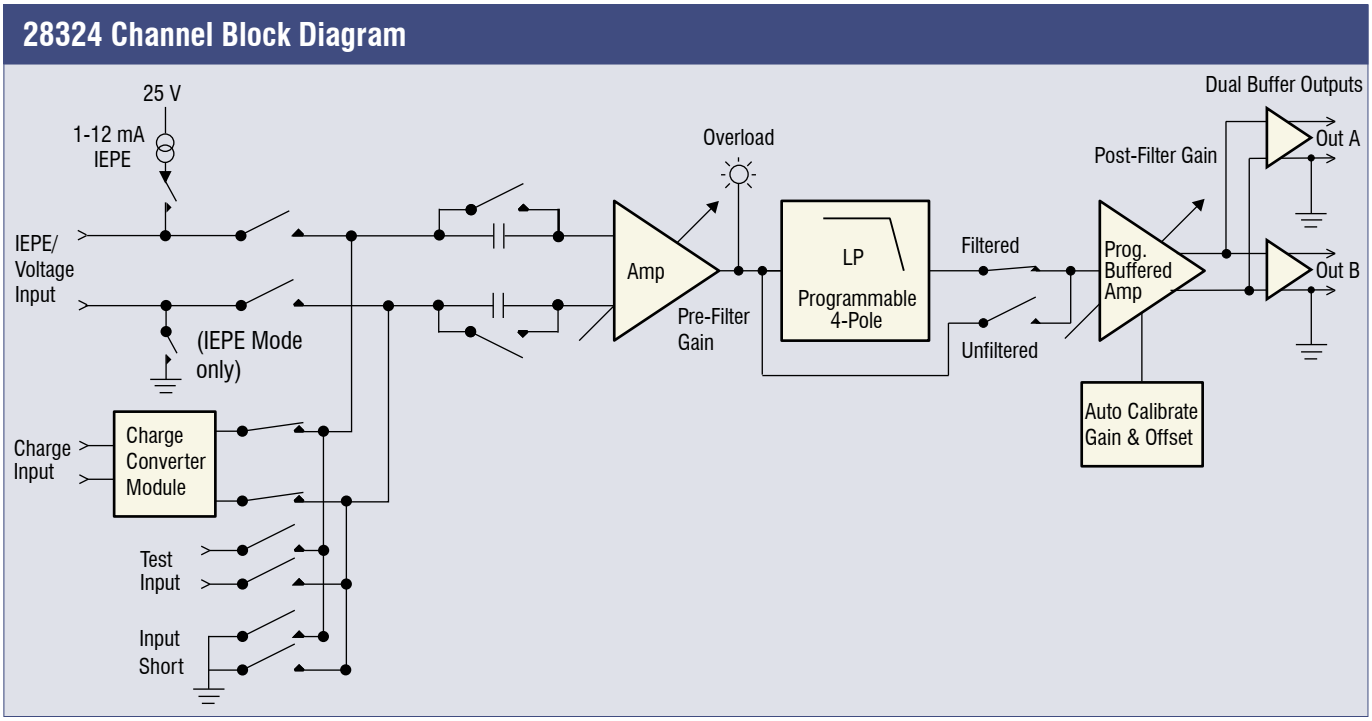
A switch located at the output of each channel allows for multiplexed connection to the mainframe output monitor bus. The output monitor bus is available at a connector located at the rear of the mainframe. The monitor function is used by the test subsystem or is available to the user for viewing channel output.

Front Panel Output Option 4

If a direct connection to the four outputs is desired via the front panel, Option 4 should be specified. Option 4 is useful if dual outputs are required in a M3 equipped chassis. Option 4 replaces the auxiliary output adapter connector with a industry standard HD26 connector.

28324 with Auxiliary Output Connector (L), and 28324 with Option 4 (R)

28324 Channel Block Diagram



28324 Simplified Channel Block Diagram

28324 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

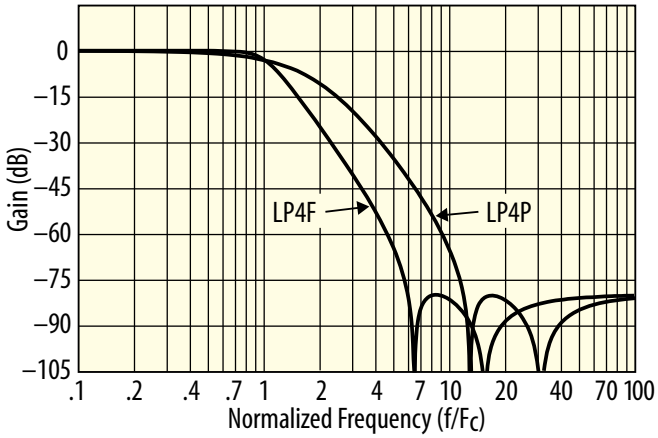
Precision LP4F "flat" mode characteristics are specified to have outstanding passband flatness equivalent to the Butterworth yet deliver very sharp roll-off characteristics.

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.

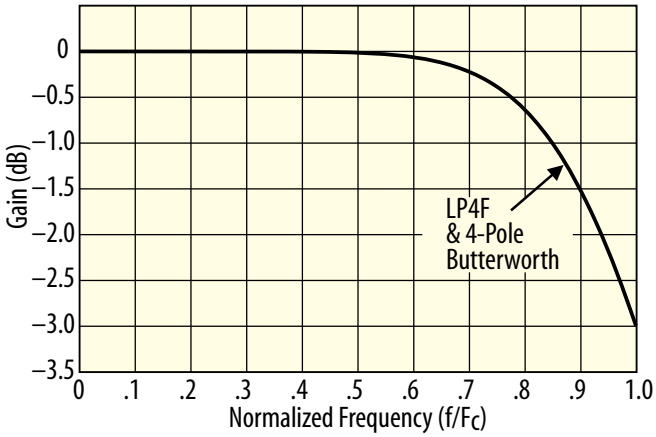
Pulse Mode Low-Pass Filters

For the time domain, program the 28324 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.

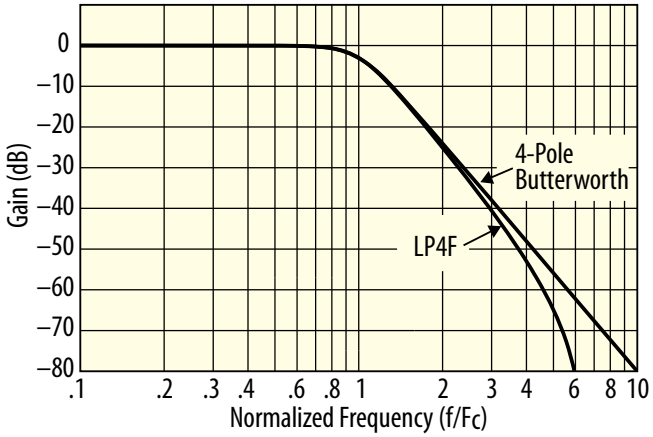
LP4F and LP4P Amplitude Response



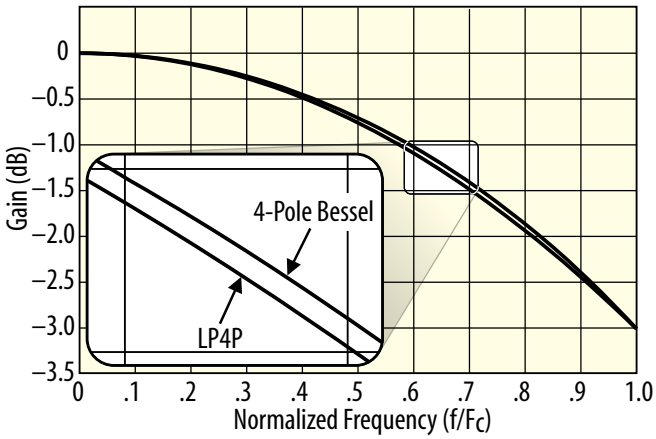
LP4F vs Butterworth Passband Response



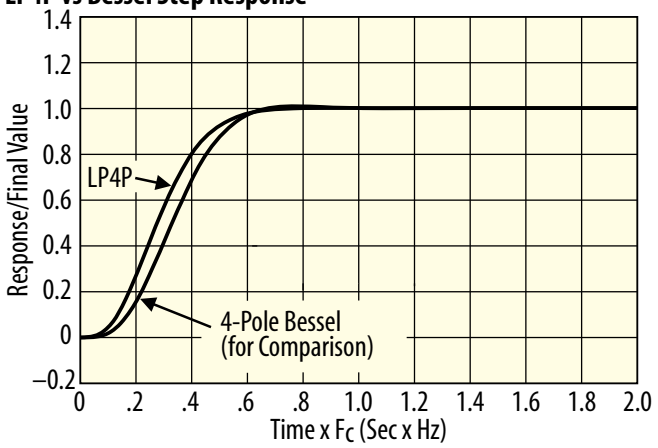
LP4F vs Butterworth Amplitude Response



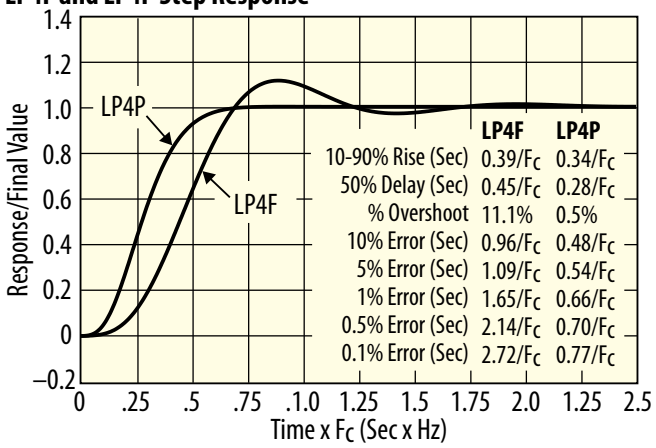
LP4P vs Bessel Passband Response



LP4P vs Bessel Step Response



LP4F and LP4P Step Response



28324 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
FX03: 10 kHz, 20 kHz, 40 kHz, 80 kHz, 100 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:

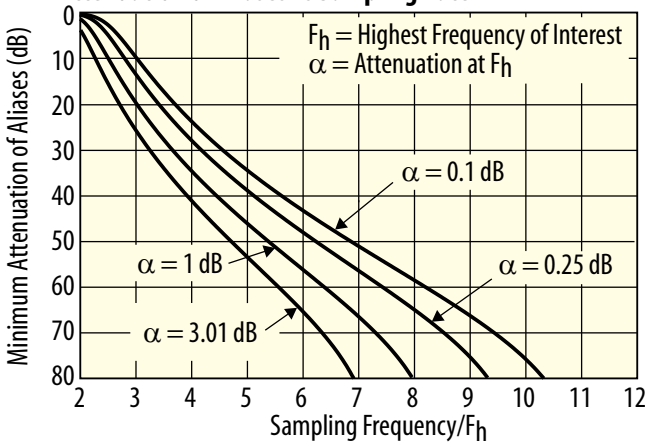
Bypasses filter but not amplifier stages.
Bypass Bandwidth: 170 kHz, typical

Custom Filters:

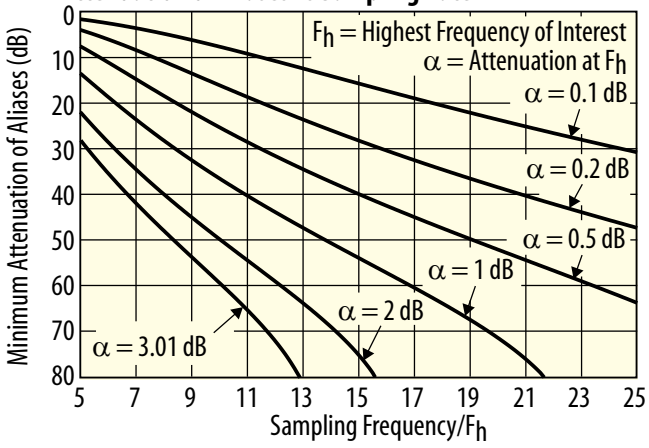
Other filter characteristics and cutoff frequencies are available. Please consult the factory for more information.

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



28324 Accessories and Ordering

General Characteristics

28324 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 connectors are integral to the 28324 card. Cutouts on the 28000 frames allow the connectors to pass through the backplane and to directly mate with the input cables.

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

CONN-OUT-26D-SC-MTL: 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.

28324 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-4BNC/15D Output Buffer

The BUFF-4BNC/15D quad output buffer module provides one buffered output per channel on 4 BNC connectors and one 15-pin multipin connector.

BUFF-4CH/(2)15D Dual Output Buffer

The BUFF-4CH/(2)15D dual output buffer provides two buffered outputs per channel on 15-position D-type female connectors.

28000-ACCEL/VEL4 Acceleration to Velocity Integrator

The 28000-ACCEL/VEL4 converts the front-panel acceleration outputs signals to analog signals representative of velocity. Velocity output for each channel is available via four BNC connectors and one 15-pin D-shell connection.

Factory Acceptance Test (FAT) Adapters

28000-TEDS-ADAPTER-A

Supports FAT tests of the LDTEDS function of the 28324 card. This dual channel adapter incorporates TEDS memory and a load capacitor that emulates the Long Distance TEDS (LDTEDS) capability.

28304/28324-FAT-ADAPTER

Supports FAT tests of the charge circuit on 28324 cards. Consists of Combo-D input adapter and NIST traceable calibration capacitor.

28234 Card Model Number

The 28324 card model number describes the filter range, filter characteristic, and output options.

28324-<Filter Range>-LP4FP-Option 4-Option T

- Option T: Long Distance TEDS
- Option 4: Front-panel output via HD26 connect
- Filter Range:
  - **FX02:** 300 Hz, 1 kHz, 3 kHz, 10 kHz, 30 kHz
  - **FX03:** 10 kHz, 20 kHz, 40 kHz, 80 kHz, 100 kHz

PRECISION FILTERS, INC.

Precision Product Solutions

For over 40 years, Precision Filters has been a global provider of instrumentation for test measurements. You can rely on a single source for signal conditioning and switching—*a complete range of instrumentation*—products optimized to work together to provide high performance at reasonable cost.

Precision Products

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

Exceptional desktop performance at low cost.

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.

464*k*B High-Density Programmable Switch Matrix

Computer-controlled analog signal switching replaces tedious manual patch panels.

The 464kB is a reliable solid-state switch matrix system that provides computer-controlled connection between 256 inputs and 256 outputs, all in a single mainframe. 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.

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P8465 Rev D