PRECISION FILTERS, INC.

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

Precision 28304
for the 28000 Analog Signal Conditioner

Precision 28304

Quad Charge/IEPE Conditioner with Long Distance TEDS™ and REZCOMP™ Technology

The 28304 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 versatile 4- or 8-pole filtering with programmable characteristics for either time or frequency domain applications and a filtered bandwidth up to 204.6 kHz or an unfiltered wide-band width of 450 kHz. The T-Insertion feature 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.

The 28304 features patent pending REZCOMP™ transducer compensation technology that extends the useable frequency response of resonant sensors. REZCOMP is effective at compensating the seismic mass resonant response of an accelerometer, the organ pipe resonant response of a recessed mounted pressure sensor and the resonant response associated with the protective screen of a microphone sensor. Based on a characterization of the sensor Q and resonance frequency, the compensation technique extends the usable sensor bandwidth by a factor of 3 or more.

The Precision Filters' LDTEDS™ (Long-Distance Transducer Electronic Data Sheet) can communicate with TEDS capable sensors out to a distance of 1500 feet.

28304 Measurements

- **Measurement of vibration, shock, pressure, acoustics**
- **High temperature PE sensor measurements**
- **Load, torque, force**
- **Extended frequency accelerometer, microphone and pressure measurements**
- **IEPE sensor measurements**
- **Low-level AC or DC voltage measurements**
- **Anti-aliasing filter/ amplifier**

28304 Applications

- **Wind tunnels**
- **Gas turbines**
- **Acoustic test**
- **Transmission driveline test**
- **Steam turbines**
- **Ballistic shock**
- **Cylinder pressure**

Precision 28304 Features

- Four channels per card, 64 channels per 28016 chassis system
- Dual mode: piezoelectric or IEPE
- REZCOMP™ technology to extend frequency response of accelerometer, microphone and pressure sensor measurements
- Ground Sense Input Mode allows grounded sensors
- Up to 204.6 kHz "filtered" bandwidth or 450 kHz "wide-band" 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 x8192 with 0.05/vernier
- 4 or 8-pole low-pass filters with programmable flat/pulse characteristics with filter bypass (wide-band)
- Optional 8-pole band-pass filter (4-pole high-pass and 4-pole low-pass filter)
- 2° phase matching between any channels, 10 Hz to Fc
- Overload detection
- Precise automatic calibration
- Auxiliary front panel output connection to support the use of custom output modules

Overview

28000 Analog Signal Conditioning System

The Precision 28000 Signal Conditioning System provides all the flexibility you need to manage your test measurements.

- Choose charge, IEPE w/TEDS, voltage (filter amplifier), strain, thermocouple, RTD, potentiometer, current, frequency, or other transducers.
- 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

REZCOMP™ Overview

Precision Filters developed the patent pending REZCOMP technology to extend the frequency response of accelerometers, pressure sensors and microphones in real-time with no need for data post-processing.

Accelerometers have the well-known under-damped seismic resonant response of the sensing mass. This response typically limits the use of the sensor to 20% of the resonance frequency. With REZCOMP, useable sensor bandwidth may be extended to as much as 80% of the resonance, resulting in a 4X improvement in overall measurement bandwidth.

rezcomp™

Precision 28304 Description

Precision 28304 Description

The 28304 is a member of the Precision 28000 family of signal conditioners. The 28304 provides four channels of dual mode Charge/IEPE conditioning. Up to sixteen 28304 cards may reside in the 28000 System to provide 64 channels in a single 6U chassis.

In charge mode the 28304 provides two charge conversion ranges with full-scale inputs of 10,000 or 100,000 pC. Channel gains of up to 8192 provide charge sensitivity as high as 8.192 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 28304 accommodates long cable runs with programmable IEPE current up to 12 mA. As with charge mode, accurate measurements of wide band, low-level signals are guaranteed by channel gains to 8192 filtered, frequency response to 204.6 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 28304 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 but 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 pre-test gage health documentation.

Amplifier and Filter

Programmable pre- and post-filter amplifiers provide an overall gain of 8192. Gain is distributed both before and after the filter to provide protection from large out-of-band energy or transients that could cause clipping before the filter, distorting the data. Gain is apportioned between the input and output based on the reserve setting in the GUI. Gain is distributed for best noise performance while conforming to the user's worst case estimate of out-band or transient signals. Overload detectors alert the user to over-voltage conditions.

The 28304 with either the 4-pole or 8-pole low-pass filter with cutoffs settings programmable from 1 Hz to 204.6 kHz and a selectable "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 pass-band response similar to the Bessel filter yet provides superior reject-band characteristics. The "pulse" mode is ideal for time domain applications including transient (shock) measurements and time domain waveform analysis.

REZCOMP™ Technology

Precision Filters developed the patent pending REZCOMP™ technology to extend the frequency response of accelerometers, pressure sensors and microphones in real-time with no need for data post-processing.

For recessed mounted pressure sensors, classic organ pipe resonances occur in the middle of the useable frequency response range of the sensor. REZCOMP flattens this resonant response and compensates for phase as well.

The introduction of a protective screen of a microphone produces a well-known Helmholtz resonant response that occurs in the useable bandwidth of the sensor. REZCOMP flattens the response to make use of the full available frequency response of the microphone[1].

REZCOMP compensation is based on user entry of sensor quality factor Q and resonance Fr. The complementary transfer function is programmed to flatten the sensor frequency response and linearize the sensor phase response. Vendors such as Kulite™ provide Q and Fr data specific to each sensor. For even more accurate results, the sensitivity of Q and Fr to temperature may be accounted for simply by entering the operating temperature of the sensor.

As the block diagram on page 5 illustrates, programmable pre-filter gain is first applied to the input signal in order to preserve signal-to-noise ratio of the in-band sensor signal while allowing for headroom for out-of-band signals. Next the sensor frequency response correction is applied to compensate for the resonant response of the sensor. The programmable filter is then applied to the signal to eliminate out band energy and to prevent aliasing. The signal is then further amplified using post-filter gain to ensure the full use of the A/D dynamic range after compensation of the resonance characteristics.

It is possible to correct for undesired resonant frequencies by post-processing test data however post-processing data after digitization can result in poor signal-to-noise ratios since the A/D input must accommodate both the in-band signal of interest and the sensor resonance. Allocating amplifier headroom for the sensor resonance results in reduced amplification of the small in-band signal above the self-noise of the signal conditioner and A/D. This results in sub-optimal signal-to-noise ratios regardless of the resolution of the A/D. The REZCOMP correction approach provides superior real-time performance by maximizing signal-to-noise ratios.

Long Distance TEDS

The 28304 provides a mixed mode transducer interface in conformance with IEEE 1451.4 Smart Transducer Interface. The mixed mode interface supports IEPE (Integrated Electronic Piezo-Electric) sensors powered by current source and TEDS (Transducer Electronic Data Sheet) capable sensors. TEDS information such as manufacturer name, serial number, calibration data, etc. are 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 until now precluded the use of TEDS-equipped sensors.

To overcome the communications distance limitations of conventional TEDS, the 28304 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 utilizes a digital signal processor to process the TEDS data. LDTEDS can communicate with sensors at distances out to 1500 feet.

Precision 28304 Description

Accelerometer Conditioning

As the temperature of the test environment continues to increase, the vibration measurement task becomes more difficult. Accelerometer manufacturers have responded with high temperature accelerometers that perform at temperatures as high as 750°C; however, care must be taken 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 will cause excessive low frequency noise, gain errors, and in severe cases total saturation of the charge amplifier. The Precision 28304 is compatible with high temperature accelerometers and exhibits less than 1 dB of peaking even with accelerometer shunt resistance as low as 100 kOhm.

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 hand held shaker. A second operator in the control room monitors the output display, verifies receipt of the signal and attempts to make some inference on 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 28304 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 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.

Since 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-Insert measurements can also be presented as a report that can greatly enhance QA documentation and add a new level of test validity documentation.

Muting Faulty Sensors

While most attention is paid to properly functioning sensors, a "real world" perspective forces us to consider sensors that are NOT functioning properly. Often a malfunctioning sensor can cause noise or fault currents that 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 will create 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.

28304 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

REZCOMP Features

- Quality Factor, Q, 1 to 50
- Resonance Compensation Frequency, Fr, 10 Hz to 255 kHz
- Sensor Operating Temperature

IEPE/Charge Common Features

- Gain (x1/16 to x8192)
- Programmable filter cutoffs setting from 1 Hz to 204.6 kHz
- Programmable Filter Characteristics:
  "Flat" mode for flat pass-band Butterworth type response.
  "Pulse" mode for linear phase Bessel type response.
- Test modes:
  Run (operate), Input short, Cal voltage substitution (Test Bus)

28304 Graphical User Interface Display

All programmable features in addition to:

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

1 Hurst, A. M., Carter S., Firth D., Szary A., and VanDeWeert, J., 2015, "Real-Time, Advanced Electrical Filtering for Pressure Transducer Frequency Response Correction," ASME 2015 Gas Turbo Expo, ASME, Montreal, Canada, pp. 1-13

28304 Details and Specifications

28304 Conditioner Cards

The detailed description and specifications for the 28304 are organized as follows in the sections below:

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

28304 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:
±0.1 mA ±5% of setting

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

IEPE Current Noise:
130 pA/√Hz

Frequency Response:
0.25 Hz to 500 kHz

Noise:
10 nV/√Hz RTI at 1 kHz and pre-gain >64

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, 0.25 mV/pC to 8.192 V/pC
High range, 0.025 mV/pC to 0.8192 V/pC

Frequency Response:
0.5 Hz to 450 kHz, (–3 dB)
Note: High frequency response is affected by accelerometer capacitance, see chart 2.

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 PRG >64):
Low Range: 0.007 pC + 0.002 pC/nF
High Range: 0.07 pC + 0.002 pC/nF

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

Source Capacitance:
High frequency response is affected by accelerometer capacitance, see chart 2.

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

Filter/Amplifier Mode

Note: Specs at 25°C unless otherwise noted.

Common Mode V: ±10 V operating

Input Protection: ±25 V continuous (power on)

CMRR: –80 dB DC to 440 Hz (PGR >x8)

Input Impedance:

AC Coupled:
0.1 µF & 9 MΩ per side

DC Coupled:
9 MΩ//100pF per side

AC Coupling:

Frequency: 0.25 Hz (–3 dB)

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

Noise:
10 nV/√Hz RTI at 1 kHz and pre-gain >x8 typical

Prefilter Gain (PRG):
x1 to x 512 in binary steps

Postfilter Gain (POG): x1/16 to 16

Overall Gain: x1/16 to x8192

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 @ 500 kHz
–0.1 dB @ 200 kHz

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

Low Frequency Charge Mode Sensitivity to R (in)

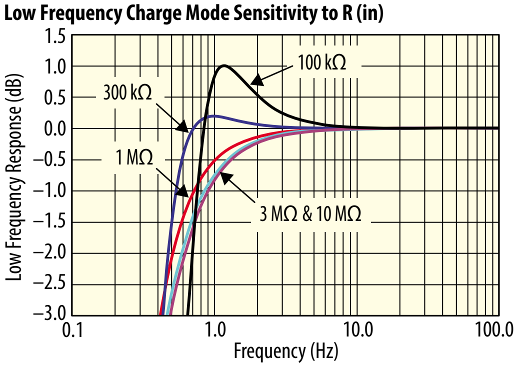


Chart 1

High Frequency Charge Mode Sensitivity to Accelerometer + Cable Capacitance

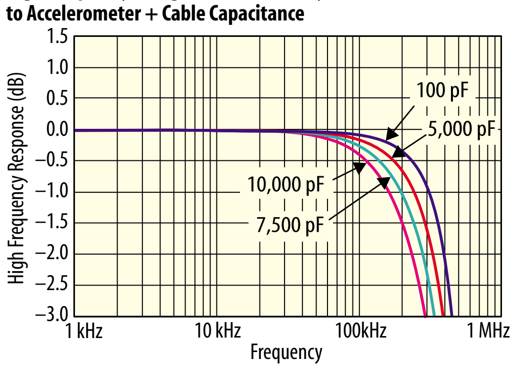


Chart 2

28304 Details and Specifications

28304 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
T-insertion BW: (accel +cable <1000 pF
±0.5% to 10 kHz
±5% to 100 kHz

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

28304 Output Characteristics

Type:

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

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

Front panel outputs must be used if dual outputs are desired in a 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)

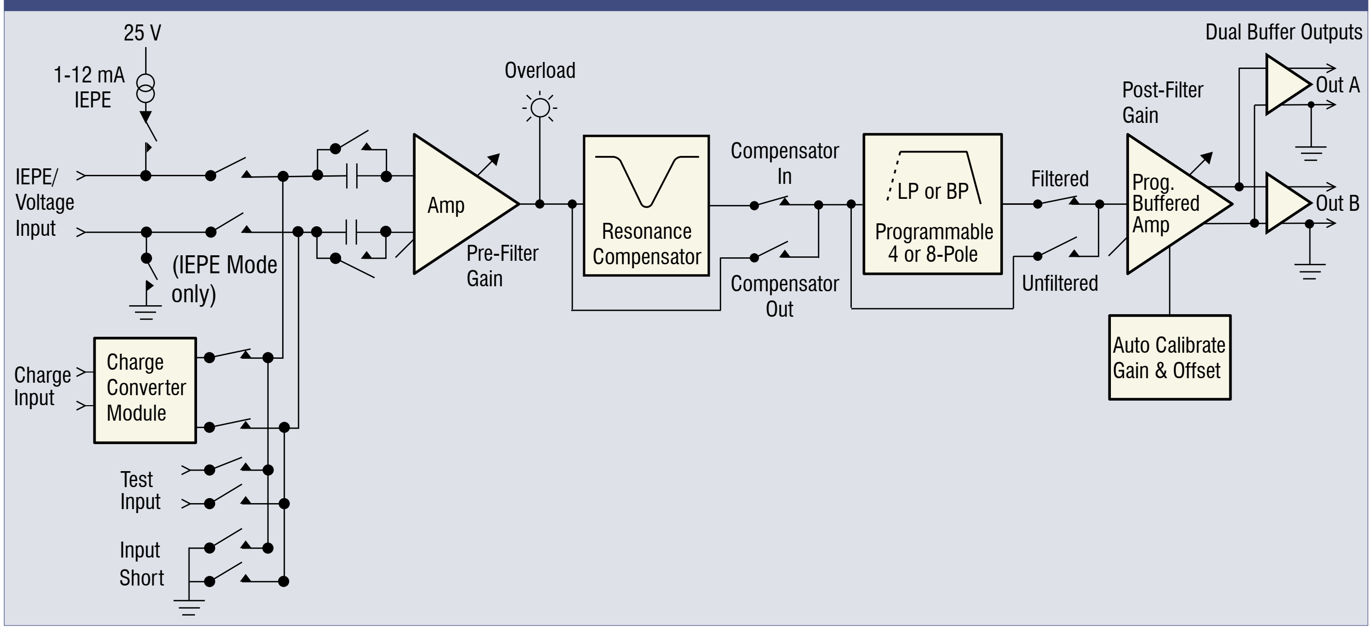
A switch located at the output of each channel allows for multiplexed connection to the mainframe output monitor bus. The output monitor bus is available at a connector located at the rear of the mainframe. The monitor function is used by the Test Subsystem or is available to the user for viewing channel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

28304 with Auxiliary Output Connector, left, and the 28304 with Option 4, right

28304 Channel Block Diagram



28304 Channel Simplified Block Diagram

28304 Filter Characteristics

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

The 28304 Card has a variety of high performance filter characteristics available for HP, LP or BP Precision filtering.

Flat/Pulse Low-Pass Filters

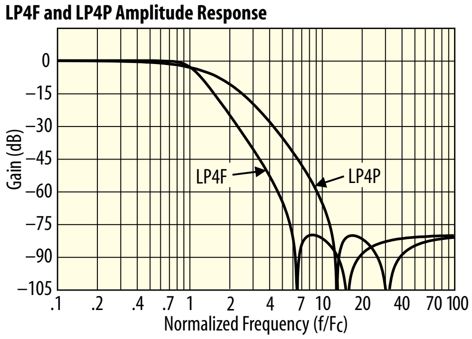
Our new choice of LP4FP 4-pole or LP8FP 8-pole flat/pulse low-pass filters provide the user with the versatility to address applications in either the time or frequency domain and are available on many 28000 card models. Frequencies can range as high as 204.6 kHz with fixed frequency choices for economy.

Flat Mode Low-Pass Filters

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

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.

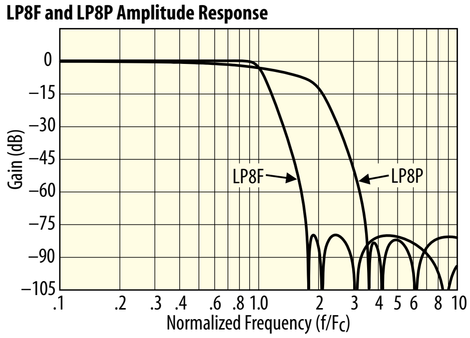
LP4F and LP4P Amplitude Response



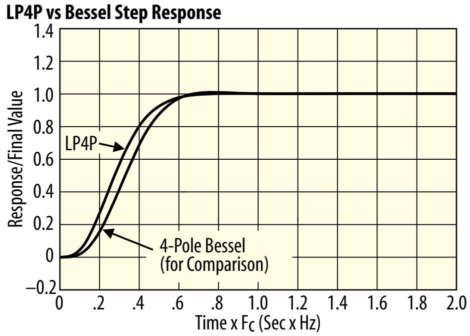
Pulse Mode Low-Pass Filters

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.

LP8F and LP8P Amplitude Response



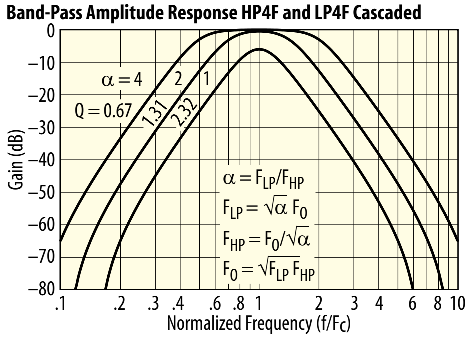
LP4P vs Bessel Step Response



High-Pass and Band-Pass Filters

For high-pass filtering, we offer the HP4F 4-pole characteristics. For band-pass filtering, choose the HP4F/LP4FP band-pass characteristic to provide programmable bandwidth and center frequency filters.

Band-Pass Amplitude Response HP4F and LP4F Cascaded

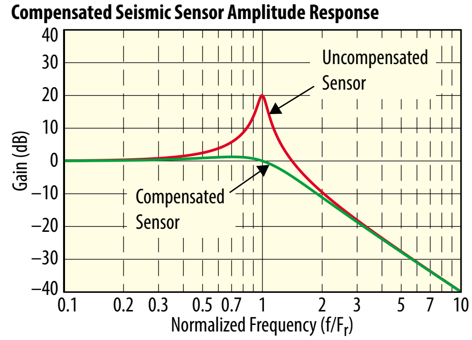


REZCOMP Sensor Compension

Patent pending REZCOMP™ technology extends the frequency response of accelerometers, pressure sensors and microphones in real-time with no need for data post-processing. Based on user entry of sensor Q and resonant frequency, REZCOMP extends usable sensor bandwidth by a factor of two or more.

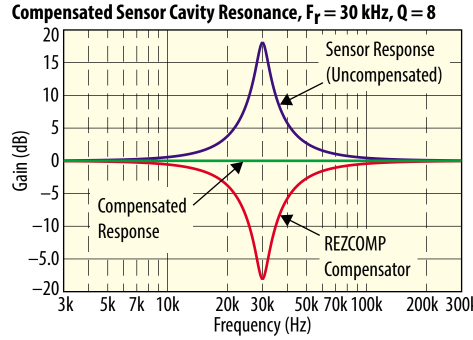
When applied to an accelerometer with Q of 10, REZCOMP extends useable 5% bandwidth by a factor of 5X as shown below.

Compensated Seismic Sensor Amplitude Response



The cavity resonant response caused by the protective screen of a microphone or a recess mount pressure sensor is reduced using REZCOMP technology.

Compensated Sensor Cavity Resonance, F_r = 30 kHz, Q = 8



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.

28304 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).

Option REZC/LP4FP:

REZCOMP® sensor compensation cascaded with LP4FP low-pass filter.

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

Note: Other filter types and cutoff ranges available upon request. Please consult factory.

REZCOMP Q & Fr:

Compensation Q: 1 to 20 in 0.1 steps; 20 to 50 in 0.5 steps

Compensation Frequency (Fr):

Low-Range: 10 Hz to 2.55 kHz in 10 Hz steps
Mid-Range: 2.6 kHz to 51 kHz in 200 Hz steps
High-Range: 52 kHz to 255 kHz in 1 kHz 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:

Amplitude Accuracy:

±0.1 dB max, 1.2 Fc to 204.6 kHz
±0.2 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

REZCOMP (REZC)

Amplitude Accuracy:

Low-Range:

±0.1 dB DC to 0.8 Fr; 1.25 Fr ≤ f ≤ 10 kHz
Q ≤ 10: ±0.2 dB; 0.8 Fr < f < 1.25 Fr
Q > 10: ±0.02 dB * Q; 0.8 Fr < f < 1.25 Fr

Mid-Range:

±0.15 dB DC to 0.8 Fr; 1.25 Fr ≤ f ≤ 100 kHz
Q ≤ 10: ±0.25 dB; 0.8 Fr < f < 1.25 Fr
Q > 10: ±0.025 dB * Q; 0.8 Fr < f < 1.25 Fr

High-Range:

±0.2 dB; DC to 0.6 Fr;
±0.5 dB; 1.7 Fr ≤ f ≤ 255 kHz
Q ≤ 10: ±1.25 dB; 0.6 Fr < f < 1.7 Fr or 255 kHz whichever is less
Q > 10: ±0.125 dB * Q; 0.6 Fr < f < 1.7 Fr or 255 kHz whichever is less

Phase Match:

±2°, DC to 0.8 Fr Low and Mid-Ranges;
DC to 0.6 Fr High-Range

Amplitude Match:

±0.2 dB, DC to 0.8 Fr Low and Mid-Ranges;
DC to 0.6 Fr High-Range

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
Cutoff Frequency Amplitude	-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
Stop-Band Frequency	5.9465 Fc	11.863 Fc	1.7479 Fc	3.4688 Fc	0.1682 Fc
Phase Distortion (DC to Fc)	< 31.8 deg	<3.7 deg	<102 deg	<0.05 deg	–
Percent Overshoot	11.1%	0.5%	18.9%	1.1%	–
1% Settling Time	1.65/Fc	0.66/Fc	4.03/Fc	1.25/Fc	1.86/Fc
-0.1 dB Frequency	0.6348 Fc	0.1816 Fc	0.8538 Fc	0.180 Fc	1.5753 Fc
-1 dB Frequency	0.8487 Fc	0.5742 Fc	0.9437 Fc	0.5685 Fc	1.1783 Fc
-3.01 dB Frequency	1.0000 Fc	1.0000 Fc	1.0000 Fc	1.0000 Fc	1.0000 Fc
-40 dB Frequency	2.9555 Fc	5.6932 Fc	1.4443 Fc	2.7556 Fc	0.3384 Fc
-80 dB Frequency	5.9465 Fc	11.8629 Fc	1.7479 Fc	3.4688 Fc	0.1682 Fc

28304 Specifications and Accessories

PRECISION FILTERS, INC.

General Characteristics

28304 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 28304 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: 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.

28304 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 multi-pin 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

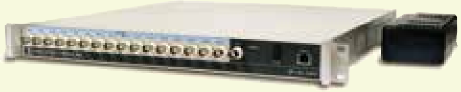
Supports FAT tests of the charge circuit on 28304 cards. Consists of Combo-D input adapter and NIST traceable calibration capacitor.

Ordering Information

28304-<LP4FP|REZC/LP4FP|LP8FP|HP4F/LP4FP>-Option 4-Option T

- T: Long Distance TEDS
- 4: Front panel output via HD26 connect
- Filter Specification:
  - 4-pole low-pass (LP4FP)
  - REZCOMP w/4-pole low-pass (REZC/LP4FP)
  - 8-pole low-pass (LP8FP)
  - 8-pole band-pass (HP4F/LP4FP)

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

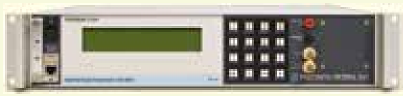


Exceptional desktop performance.

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 464kB Switch Matrix System

Precision switch systems are reliable solid-state switch matrix systems, providing computer-controlled connection between input and output signals. Configure the 464kB 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.

PRECISION FILTERS, INC.
ISO 9001 CERTIFIED QUALITY

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