SYSTEM 28000 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
- Rigorous factory acceptance test for maintenance
- Field swappable AC power supplies
- Built-in temperature and power supply monitoring with alarms

28000 SIGNAL CONDITIONING SYSTEM

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 performance checks 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.

28314 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

28314 FEATURES

- 4 channels per card, 64 channels per chassis
- Dual mode: piezoelectric or IEPE
- Floating or grounded input
- Up to 200 kHz “filtered” bandwidth or 500 kHz “wide-band” bandwidth
- Two charge conversion ranges for 50,000 or 500,000 pC FS inputs
- Extremely large time constant for quasi-static charge measurements
- Programmable IEPE current to 25 mA
- TEDS compatible
- Programmable amplifier: x1 to x8192 with 0.05/vernier
- 4- or 8-pole low-pass filters with filter bypass (wide-band)
- 2° phase matching between any channels, DC to Fc
- Overload detection
- Precise automatic calibration
- Auxiliary front panel output connector to support use of custom output modules
The 28314 is a member of the Precision 28000 family of signal conditioners. The 28314 provides four channels of dual mode Charge/IEPE conditioning. Up to sixteen 28314 cards may reside in the 28000 System to provide 64 channels in a single 6U chassis.

In charge mode the 28314 provides two charge conversion ranges with full-scale inputs of 50,000 or 500,000 pC. Channel gains of up to 8192 provide charge sensitivity as high as 1.6 V/pC. A programmable input stage allows operation with either grounded or isolated accelerometers. Extremely large time constants allow measurement of quasi-static charge phenomena. Low noise, low-distortion and high accuracy circuits guarantee accurate high frequency measurements of even low-level signals.

A choice of 4- or 8-pole low-pass filters are available. Cutoff settings from 1 Hz to 204.6 kHz are supported. The low-pass filters may operate in either a “flat” mode for maximally flat pass-band amplitude response with sharp roll-off or in a “pulse” mode for low phase distortion and optimized transient response.

Overall measurement accuracy is assured with built-in charge gain adjustment circuits, which can be used in situ to adjust gain under run time conditions. 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 28314 accommodates long cable runs with programmable IEPE current up to 25 mA. As with charge mode, accurate measurements of wide band, low-level signals guaranteed by channel gains to 8192, 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 28314 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.

Long Distance TEDS

The 28314 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 28314 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.

Input Stage

The 28314 input stage connects to either the charge or the IEPE front end. The input stage has low distortion, low DC drift and ultra-low noise.

A programmable switch at the input stage is provided to connect the amplifier to the 28000 System test bus. The test bus is used to inject signals for performance verification.

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. The Gain Wizard in the GUI allows the user to set a gain reserve and then apportions the gain between the input and output. This provides input gain for best noise performance yet conforms to the limitations of the user’s worst case estimate of out-band or transient signals. Overload detectors alert the user to over-voltage conditions. A fully buffered output having over 20 mA of drive capability may be used to drive long output cable runs.

The 28314 contains a 4- or 8-pole low-pass filter with cutoffs programmable from 1 Hz to 204.6 kHz and programmable “flat” or “pulse” mode. The “flat” mode provides pass-band characteristics nearly identical to a Butterworth filter while providing a much sharper roll-off. This mode is a good choice for applications such as spectral analysis. The “pulse” mode has time domain response similar to the Bessel filter yet provides superior amplitude response characteristics. The “pulse” mode is ideal for time domain applications including transient (shock) measurements and time domain waveform analysis.
28314 PROGRAMMABLE FEATURES

Charge Mode Features

- FS range (50,000 pC or 500,000 pC)
- Input type (isolated or grounded)
- Time constant (long or short)
- Charge converter reset (reset or enable)
- Shunt calibration (on or off)

IEPE Mode Features

- IEPE current (0 to 25 mA, 1 mA steps)
- Bias monitor with programmable fault limits (upper limit and lower limit)
- Input mode (IEPE conditioner or differential input filter/amp)
- AC current dither

IEPE/Charge Common Features

- Gain (1X to 8192X)
- Cutoff frequency: (1 Hz to 102.3 kHz, pulse mode) (2 Hz to 204.6 kHz, flat mode)
- Wide band (500 kHz) or filtered operation
- Test modes: run (operate), input short, cal voltage substitution (Test Bus)

INPUT CHARACTERISTICS

IEPE Inputs (IEPE Mode)

- Type: Single-ended (Low connected to conditioner ground)
- Connector: Two Combo-D pins (two channels per connector)
- IEPE Current: 0 to 25 mA in 1 mA steps with disconnect
- Current Accuracy: ±1%
- Maximum Input: 22 V (DC bias + AC signal)
- IEPE sensitivity: 1 mV/mV to 12,000 mV/mV
- IEPE Current Noise: 130 pA/√Hz
- Freq. Response: 1 Hz to 200 kHz
- Noise: 7 nV/√Hz RTI at 1 kHz and pre-gain >x100

Piezoelectric Inputs (Charge Mode)

- Type: Programmable single-ended (sensor floating) or isolated (sensor grounded)
- Connector: Two isolated coaxial insert Combo-D (two channels per connector)
- Maximum Input: Low range, 50,000 pC (F<200 kHz)
  50,000 * 200 kHz/F (F<200 kHz)
  High Range, 500,000 pC (F<20 kHz)
  500,000 pC * 20 kHz/F (F>20 kHz)
- Charge Sensitivity: Low range, 0.2 mV/pC to 1.64 V/pC
  High range, 0.02 mV/pC to 0.164 V/pC
- Charge Conversion Accuracy: 0.2% (Vout/Qin after auto gain adjustment at 55 Hz, Gain = 1X)
- Shunt Calibration Capacitor: 5,000 pF ±0.1% (Calibrated value stored in card EEPROM)
- Shunt Cal Frequency Response: –0.05 dB at 100 kHz, –0.2 dB at 200 kHz
- Time Constant: Low Range: 10 or 5,000 seconds
  High Range: 100 or 50,000 seconds
- Noise (100 kHz BW): Low Range: 0.08 pC + 0.0033 pC/nF
  High Range: 0.8 pC + 0.0033 pC/nF
- Drift: 2pC/Sec
- Ground Signal Rejection: –60 dB DC to 1 kHz (Isolated Mode)
- Source Capacitance: <0.03 μF meets all specifications
- Source Resistance: >10 MΩ meets all specifications
- Reset: 1 KΩ shunt resets conversion capacitor

Front Panel Charge/IEPE Mode Switch

28314 Card Input Connectors
FILTER/AMPLIFIER MODE CHARACTERISTICS

Note: Specs at 25°C unless otherwise noted.

Common Mode V: ±10 V operating
CMRR: –80 dB DC to 10 kHz
Input Protection: ±35 V

Input Impedance:
(DC Coupled) 10 MΩ/100 pF per side
20 MΩ/50 pF differential
100 MΩ/24 pF common mode

Input Impedance:
(AC Coupled) (0.1 μF & 10 MΩ)/100 pF per side
(0.159 Hz)
0.2 μF & 20 MΩ common mode

Max Level: ±10 Vpks for f≤200 kHz;
±10 Vpks (200 kHz/f) for f>200 kHz
Offset Drift: 2.5 μV/°C, max
Noise: 7 nV/√Hz RTI at 1 kHz
and pre-gain >x100

28314 AMPLIFIER CHARACTERISTICS

Pre-filter Gain: x1 to x512 in binary steps,
with overload detection
(10.5 Vpks threshold)
Post-filter Gain: x1/16 to x16 in binary steps with
vernier adjustment of 0.05% of setting
DC Accuracy: 0.12% after auto cal at any gain setting
Stability: ±0.02% for 6 months
Temp Coef.: ±0.004%/°C
DC Linearity: ±0.01% re Fullscale, relative to the
best straight line
Freq. Response: DC to 200 kHz, –0.15 dB ±0.15 dB
–3.01 dB BW: 500 kHz, typical

28314 TEST MODES

Shunt Cal: (Charge Mode only) Test Bus signal is applied to
charge amp input through a 5000 pF shunt cal capacitor.

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

Test Bus: Test input allows for injection of a test signal. An ex-
ternal test signal or the 28000-?-TEST Test Subsystem may be
connected at the rear panel. Refer to the 28000-?-TEST Test
Subsystem specification for more information.

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:

\[ \text{AC Current} = \frac{V \times \text{Test Bus}}{10000} \]

28314 Channel Block Diagram

28314 Channel Simplified Block Diagram
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).

Other filter types available upon request. Consult factory for more information.

### FILTER CHARACTERISTICS (Continued)

<table>
<thead>
<tr>
<th>Specification</th>
<th>LP4F Maximally Flat Low-Pass Filter</th>
<th>LP4P Constant Time Delay Low-Pass Filter</th>
<th>LP8F Maximally Flat Low-Pass Filter</th>
<th>LP8P Constant Time Delay Low-Pass Filter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cutoff Frequency Amplitude</td>
<td>–3.01 dB</td>
<td>–3.01 dB</td>
<td>–3.01 dB</td>
<td>–3.01 dB</td>
</tr>
<tr>
<td>DC Gain</td>
<td>0.00 dB</td>
<td>0.00 dB</td>
<td>0.00 dB</td>
<td>0.00 dB</td>
</tr>
<tr>
<td>Pass-Band Ripple</td>
<td>0.00 dB</td>
<td>0.00 dB</td>
<td>0.00 dB</td>
<td>0.00 dB</td>
</tr>
<tr>
<td>Stop-Band Frequency</td>
<td>5.9465 Fc</td>
<td>11.863 Fc</td>
<td>1.7479 Fc</td>
<td>3.4688 Fc</td>
</tr>
<tr>
<td>Cutoff Frequency Phase</td>
<td>–180.0 deg</td>
<td>–101.5 deg</td>
<td>–360 deg</td>
<td>–161.9 deg</td>
</tr>
<tr>
<td>Phase Distortion (DC to Fc)</td>
<td>&lt;31.8 deg</td>
<td>&lt;3.7 deg</td>
<td>&lt;102 deg</td>
<td>&lt;0.05 deg</td>
</tr>
<tr>
<td>Zero Frequency Group Delay</td>
<td>0.4117/Fc</td>
<td>0.2920/Fc</td>
<td>0.7197/Fc</td>
<td>0.4496/Fc</td>
</tr>
<tr>
<td>Percent Overshoot</td>
<td>11.1%</td>
<td>0.5%</td>
<td>18.9%</td>
<td>1.1%</td>
</tr>
<tr>
<td>1% Settling Time</td>
<td>1.65/Fc</td>
<td>0.66/Fc</td>
<td>4.03/Fc</td>
<td>1.25/Fc</td>
</tr>
<tr>
<td>0.1% Settling Time</td>
<td>2.72/Fc</td>
<td>0.77/Fc</td>
<td>7.02/Fc</td>
<td>2.25/Fc</td>
</tr>
<tr>
<td>–0.1 dB Frequency</td>
<td>0.635 Fc</td>
<td>0.182 Fc</td>
<td>0.8538 Fc</td>
<td>0.180 Fc</td>
</tr>
<tr>
<td>–1 dB Frequency</td>
<td>0.8487 Fc</td>
<td>0.5741 Fc</td>
<td>0.9437 Fc</td>
<td>0.5685 Fc</td>
</tr>
<tr>
<td>–2 dB Frequency</td>
<td>0.9370 Fc</td>
<td>0.8129 Fc</td>
<td>0.9772 Fc</td>
<td>0.8087 Fc</td>
</tr>
<tr>
<td>–3.01 dB Frequency</td>
<td>1.0000 Fc</td>
<td>1.0000 Fc</td>
<td>1.0000 Fc</td>
<td>1.0000 Fc</td>
</tr>
<tr>
<td>–20 dB Frequency</td>
<td>1.7412 Fc</td>
<td>3.0248 Fc</td>
<td>1.2149 Fc</td>
<td>2.2342 Fc</td>
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<tr>
<td>–40 dB Frequency</td>
<td>2.9555 Fc</td>
<td>5.6932 Fc</td>
<td>1.4443 Fc</td>
<td>2.7556 Fc</td>
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<tr>
<td>–60 dB Frequency</td>
<td>4.5986 Fc</td>
<td>9.0980 Fc</td>
<td>1.6391 Fc</td>
<td>3.2016 Fc</td>
</tr>
</tbody>
</table>

### 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

### 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

### Bypass

- **Bypass**: Bypasses filter but not amplifier stages
- **Bypass BW**: 500 kHz, typical
The 28314 card output connections are made at the rear panel 50-pin D-shell connectors. The 28016-M3 mainframe provides four 50-pin connectors, which provide four outputs per card slot in the mainframe. The 28008-M3 frame provides two 50-pin connectors.

In addition, an auxiliary front panel output connector is provided to support the use of custom output modules.

**Type:** DC-coupled, single-ended output with ground reference.
- **Z:** $10 \, \Omega$ shunted by $100 \, \mu F$
- **Max Output:** $\pm 10 \, \text{Vpk, } \pm 20 \, \text{mApk}$
- **Offset Drift:** $2.5 \, \mu \text{V/}^\circ \text{C, RTI} + 150 \, \mu \text{V/}^\circ \text{C, RTO}$
- **Noise:** $5 \, \mu \text{Vrms RTI} + 300 \, \mu \text{Vrms RTO}$
- **Crosstalk:** $-80 \, \text{dB, DC to 100 kHz}$ between adjacent channels with the same configuration and programmed settings.

**Option T:** Balanced differential output
- **Z:** $10 \, \Omega$ shunted by $100 \, \mu F$ per side
- **Max Output:** $\pm 5 \, \text{Vpk per side (20 mApk)}$
  $\pm 10 \, \text{Vpk differential}$

**Auto-Offset Adjust (Standard)**
Auto-Offset: Auto-offset automatically zeroes offset at the channel output to less than 5 mV at any gain setting. The auto-offset cycle is initiated in the GUI. The offset DAC settings are stored in non-volatile memory on the card for every gain setting. Changes in gain result in minimal disruption of the channel.

**Output Monitor (Standard)**
Output Monitor: A 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 in the 17th slot at the rear of the mainframe. The monitor function is used by the Test Subsystem or is available to the user for viewing channel outputs.

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28314 CARD GENERAL CHARACTERISTICS

- **28314 Card Size:** 6.6 x 17.5 x 0.75 inches
- **Card Weight:** 1.4 lb. net
- **Temperature:** $0^\circ \text{ to } 40^\circ \text{C (operating)}$
  $-20^\circ \text{ to } 70^\circ \text{C (storage)}$

28314 CARD MODEL NUMBER and ORDERING INFORMATION

The 28314 card model number describes the configuration of the four channels on the card. The model number identifies the options included on the card.

<table>
<thead>
<tr>
<th>Filter Specification</th>
<th>Options</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LP4FP</strong> (4-pole low-pass)</td>
<td></td>
</tr>
<tr>
<td><strong>LP8FP</strong> (8-pole low-pass)</td>
<td></td>
</tr>
</tbody>
</table>

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28314 Filter Type

Filter Specification

- **LP4FP** (4-pole low-pass)
- **LP8FP** (8-pole low-pass)