



Precision 28316C Isolated IEPE Accelerometer Conditioner with Long Distance TEDS™

The **28316C** provides 16 channels of precision signal conditioning for IEPE (Integrated Electronic Piezoelectric) accelerometers or remote charge converters (RCC's). Programmable channel gain and 4-pole low-pass filters provide clean, amplified "data acquisition ready" output signals. Each channel input can be isolated to allow connection to grounded accelerometers without introducing ground loops. In addition, the 28316C may be used as a 16-channel Precision AC Filter/Amplifier with balanced differential input.

For facilitating gain setup on large channel count systems, the automatic gain setup mode can simultaneously range 256 channels on stationary signals to provide desired output signal level.



28316C Features

- 16 channels per card; 256 channels per chassis
- IEPE conditioner or AC Filter/Amplifier with balanced differential input
- Isolated channel input allows conditioning of grounded IEPE accelerometers without introducing ground loops
- Precision Filters' LDTEDS™ (Long-Distance Transducer Electronic Datasheet) compliant
- Gain x1/16 to x512 with 0.1% resolution
- Auto-gain setup for best ADC dynamic range
- Programmable 4-pole low-pass filters
- Current settings of 0, 2, 4, or 8 mA (programmable per channel)
- Sensor bias detector; in-range or out-of-range
- AC test current checks sensor, cable and signal conditioner health
- Overload detection
- Output monitor, selects any one of 512 outputs
- Test input for each channel

28316C Description

The 28316C provides a mixed mode transducer interface in conformance with IEEE 1451.4 Smart Transducer Interface. The mixed mode interface supports IEPE sensors powered by a 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.

Conventional TEDS readers in signal conditioners have been limited to a maximum cable run of 400 feet to the TEDS sensor. For applications such as weapons test, vibration test on large structures, safety and environmental testing, test article size and other factors often require cable runs in excess of 1000 feet that have precluded the use of TEDS equipped sensors.

The 28316C is equipped with Precision Filters' proprietary Long-Distance TEDS (LDTEDS)™. The proprietary LDTEDS circuitry digitizes the TEDS waveforms and utilizes digital signal processing to read the TEDS data. Precision Filters' LDTEDS can communicate with sensors at distances up to 1500 feet.

The test input and output monitor architecture of the 28316C makes the system ready to work with the 28000 test subsystem hardware to support automated Go/No-Go and Factory Acceptance tests.

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, setup, 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 28316C Description

Sensor and Cable Health

Traditional Go/No-Go tests for an IEPE amplifier allow insertion of a test signal to check the signal-conditioning channel. It is also standard to provide open and short detection on the sensor cables.

The 28316C provides these tests and two additional tests to verify sensor health. The operating bias point of an IEPE sensor may change before failing, so measuring the bias point is a means of monitoring the sensor health. The 28316C provides a readout of the bias voltage, as well as an 'out of range' indicator with user specified limits.

The second check is a measure of the output impedance of the sensor buffer, which may shift with a damaged sensor. A small AC calibration current is superimposed on the DC IEPE supply. This AC current reacts with the output impedance of the sensor to stimulate a sensor based AC test signal. This signal can be used as a measure of the device's output impedance as well as to provide a stimulus for an end-to-end check of the sensor, cable, signal conditioning and data acquisition system.

28316C Input Characteristics

Transducer Types:

IEPE transducer with or without TEDS and remote charge converter (RCC)

Transducer Connection:

Floating or grounded (programmable)

IEPE Current:

0, 2, 4, 8 mA

IEPE Accuracy:

0.1 mA, $\pm 5\%$ setting

Input Impedance:

IEPE Mode:

(Current source connected)

100 k Ω //100 pF per side

Filter/Amp Mode:

(Current source disconnected)

1.37 M Ω //100 pF per side

IEPE AC Current Injection:

Level:

0.1 mA pk/1 V pk (test bus)

Accuracy:

$\pm 3\%$

Bandwidth:

<0.1 dB to 10 kHz

-3 dB @ 96 kHz

28316C Input Characteristics continued

CMRR:

-80 dB (gain $\geq 16X$)
(10 Hz to 1 kHz)

Programmable LFRO

0.25 Hz Setting

-3 dB at 0.25 Hz
-5% at 0.7 Hz
-2% at 1.1 Hz

3.4 Hz Setting

-3 dB ± 0.2 dB at 3.4 Hz
-5% at 10 Hz
-2% at 15.9 Hz

IEPE Compliance Voltage

-5 VDC + (IEPE x 400) to
26 VDC - (IEPE x 400) where "IEPE" is the
programmed IEPE current in mA

Max Input Voltage (Linear operation)

Filter/Amp Mode:

± 10 Vpk for $f < 140$ kHz

IEPE Mode:

± 10 Vpk for $f \leq 30$ kHz;
 ± 10 Vpk x (30 kHz/f) for $f > 30$ kHz

Input protection:

± 30 V continuous

Maximum Distance to Sensor

(for TEDS Read):

1500 feet (30 pf/ft cable)

Sensor Bias Detector:

The sensor bias detector measures the bias level and determines if it is within user defined limits. The bias level and status is indicated on GUI and front panel LEDs.

Connectors:

2 ea. 26-pin D shell (male) input connector.

Input Mating Connector:

26-pin D female mating connector
CONN-IN-26D-MTL (crimp sockets),
PF # A9405G2
CONN-IN-26D-SC-MTL
(solder cup sockets),
PF # A9405G3

28316C Output Characteristics

The 28316C has two separate AC outputs. If a 28000-M5 chassis is used, the 16-channel outputs are available on 26-pin D shell connectors (one per card) on the rear of the 28000 chassis. A second set of outputs are available at the 28316C front panel; the front panel signals are independently buffered from the rear panel signals.

Output Type:

Single-ended with low side connected to channel ground

Z out:

10 Ω //100pF

Output Voltage:

± 10 Vpk for $f \leq 40$ kHz;
 ± 10 Vpk x (40 kHz/f) for $f > 40$ kHz

Output Current:

± 10 mA maximum

DC Offset:

± 5 mV maximum

Protection:

Short circuit protected

Output Connector:

Front Panel:

1 ea. 37-pin D Shell (Female)

37-Pin D Male Mating Connector:

CONN-OUT-37D (crimp pin),
PF # A10095G1
CONN-OUT-37D-SC, (solder cup pin)
PF # A10095G2

Rear Panel: (requires M5 chassis)

1 ea. 26-pin D shell (Female) output connector

26-Pin D Male Mating Connector:

CONN-OUT-26D-MTL PF # A9405G1
CONN-OUT-26D-SC-MTL PF # A9405G4

Output Impedance:

10 Ω //100 pF



28316C Cards Installed in a 28016-Card Mainframe

Precision 28316C Description

28316C Amplifier Characteristics

Gain:

Programmable:

x1/16 to x512 with 0.1% resolution

Gain Accuracy:

0.25% at 1 kHz for gain $\geq 1x$

0.25% / gain for gain $< 1x$

Gain Tempco:

50 ppm/ $^{\circ}C$

HFRO:

-2% at 95.5 kHz

-5% at 105 kHz

-3 dB at 141 kHz

Channel Match (Bypass on, 5 Hz to 40 kHz):

Amplitude Match:

0.5% max, 0.1% typical

Phase Match:

3.0 $^{\circ}$ max, 1.0 $^{\circ}$ typical (any gain)

Distortion:

<0.1% of fullscale at 1 kHz

Crosstalk:

-80 dB, DC to 20 kHz

Amplifier Noise:

RTI (Gain $\geq 64x$):

15 nV/ \sqrt{Hz} RTI at 1 kHz,

5 μV RMS, 100 kHz meas BW

RTO (Gain = 1X, 100 kHz meas BW):

65 μV RMS, Filter Bypassed

90 μV RMS, $F_c = 10$ kHz (BU4)

120 μV RMS, $F_c = 10$ kHz (TD4)

IEPE Supply Noise:

100 pA/ \sqrt{Hz} at 1 kHz

3.3 μV RMS in 100 kHz BW

(100 Ω sensor resistance)

28316C Isolation Mode

Many signal conditioners for IEPE sensors utilize a grounded input whereby the sensor "low" is connected to channel ground at the signal conditioner input. This is usually the most appropriate connection since the low input is often the shield of the coaxial cable. Occasionally however, the IEPE low connection is grounded at the sensor. This can be a troublesome situation as it creates a ground loop if the low side is also connected to ground at the signal conditioner. Simply disconnecting the low connection at the signal conditioner is not an option since IEPE current must be returned directly to the IEPE current source.

To solve this difficult problem, the 28316C has a programmable input stage which can be grounded or isolated from the channel ground. In isolated mode, the low connection can be grounded at the distant sensor location and no ground loops will be created. Proprietary IEPE circuitry assures that all IEPE current will be returned through the floating low connection and not through the chassis

earth ground connection.

Channel Test Modes

Run:

Normal "Run Time" configuration of the channel.

Test Bus:

Sensor inputs are disconnected and the buffered internal test bus is connected to the channel input.

TMODE_X1:

Test Bus is connected to the channel input and channel gain is set to 1x. (Channel gain is restored upon leaving TMODE_X1)

SHORT:

Channel inputs are disconnected from the sensor and connected to ground.

ACCURRENT:

An AC test current is superimposed on the DC IEPE current.

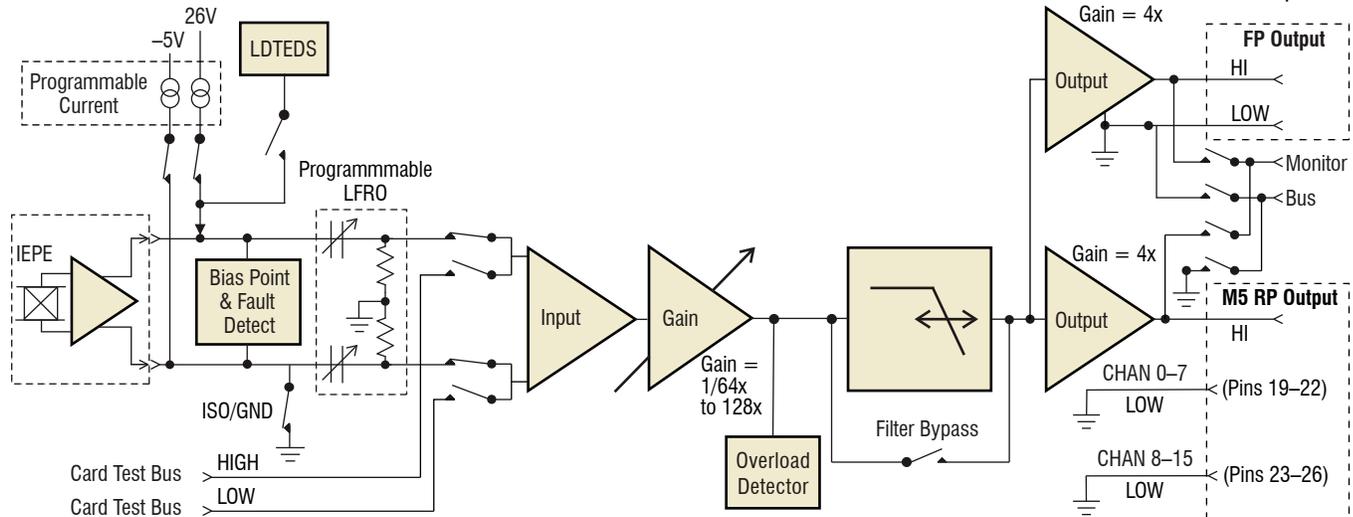
Sensor Bias Point and Overload Detector

Sensor Bias Point Detector:

Sensor bias detector determines if the sensor bias voltage is within limits and indicates the status on the GUI and the front panel LEDs. Bias detector upper and lower thresholds are user specified to work with any IEPE sensor type.

Overload Detector:

An overload detector is provided for each channel and can be set for continuous or latched operation. Located before the filter, the overload detector detects large out-of-band signals the filter might remove. The overloads are indicated on the 28316C GUI and the front panel LEDs.



28316C Channel Block Diagram

Precision 28316C Description

28316C Filter Characteristics

4-Pole Filters

TD4

4-pole, 4-zero constant time delay (linear phase) low-pass filter.

BU4

4-pole Butterworth low-pass filter.

28316C Corner Frequency Settings

Corner frequencies may be programmed to the settings indicated. The filter response is -5% (-0.445 dB) at the corner frequency ($F_{-5\%}$).

Programmable Models

FX01

Programmable corner frequency settings of 100 Hz, 300 Hz, 1 kHz, 3 kHz, 10 kHz, Bypass.

FX02

Programmable corner frequency settings of 300 Hz, 1 kHz, 3 kHz, 10 kHz, 30 kHz, Bypass.

Custom frequency ranges are available, consult factory.

Fixed Frequency Models

FFF

FFF denotes a fixed corner frequency in the range between 1 Hz and 50 kHz.

28316C Filter Specifications

Corner Frequency Amplitude:

-5%

Amplitude Accuracy (5 Hz to $F_{-5\%}$):

Filter char. ± 0.2 dB max

Amplitude Match (5 Hz to $F_{-5\%}$):

0.2 dB max, 0.02 dB typical

Phase Match (5 Hz to $F_{-5\%}$):

4° max, 0.5° typical

Filter Bypass:

Bypasses the filter but not the amplifier stages. Bypass bandwidth is 140 kHz (-3 dB).

4-Pole Filter Selection Guide

	TD4	BU4
Filter Type	Low-pass	Low-pass
Function	Bessel w/Zeroes	Butterworth
Number of Poles, Zeroes	4p, 4z	4p
-0.1 dB Frequency	$0.475 F_{-5\%}$	$0.826 F_{-5\%}$
-5% (-0.445 dB) Frequency	$1.00 F_{-5\%}$	$1.00 F_{-5\%}$
-3.01 dB Frequency	$2.51 F_{-5\%}$	$1.32 F_{-5\%}$
-20 dB Frequency	$6.34 F_{-5\%}$	$2.35 F_{-5\%}$
-40 dB Frequency	$11.3 F_{-5\%}$	$4.18 F_{-5\%}$
-60 dB Frequency	$17.7 F_{-5\%}$	$7.43 F_{-5\%}$
-80 dB Frequency	$23.0 F_{-5\%}$	$13.2 F_{-5\%}$
Stop-band Frequency	$23.0 F_{-5\%}$	n/a
Stop-band Attenuation (dB)	80	n/a
Phase at $F_{-5\%}$ (Degrees)	-47.4	-127
Phase Distortion at $F_{-5\%}$ (Degrees)	0.00	-13.3
Overshoot (%)	0.80	11.4
1% Settling Time (sec)	$0.25/F_{-5\%}$	$1.3/F_{-5\%}$
0.1% Settling Time (sec)	$0.46/F_{-5\%}$	$2.1/F_{-5\%}$

Precision 28316C Description

Auto Gain Ranging Mode

The auto-gain ranging mode provides a means of setting up all 256 channels in four gain ranging periods, where the gain ranging period, T, is selected from 1/8 S to 128 S depending on the signal type (periodic or random) and the response of the structure (narrow-band or wide-band). When the auto-ranging is initiated, all channels are set to a gain of x16 and the output level detector determines if the channel output exceeded the target level at any time during the period T1.

If the target level was exceeded during period T1, the gain is set to x4. If the target level was not exceeded, the gain is set to x64. The level detectors are reset and the level detectors operate for another period (period T2).

If the target level was exceeded during period T2, the gain is decreased. If the target level was not exceeded, the gain is decreased. The level detectors are reset and the level detectors operate for another period (period T3).

At the end of four periods (4T) all 256 channels have been set to the operating gain. See the Auto-Ranging Gain Decision Tree diagram below. The output level detector is set to allow for crest factor and creep.

Gain Range Periods:

1/8 second to 128 second in binary steps

Output Overload Detector Limit:

1 V to 10 V, adjustable

28316C Go/No-Go and Sensor Test

(The 28316C Go/No-Go Test requires a 28000 Test Subsystem and Option F on the 28000-BIF1-T backplane interface card.)

A sinewave source is selected for the channels under test. An accurate AC current level is superimposed on the IEPE sensors' DC current. This precise AC current flows through the sensor cable and output impedance at the sensor buffer which develops a signal at the output of the 28316C channel equal to:

$$e_o = E \sin 2\pi f t (Z_s + R_c) A K$$

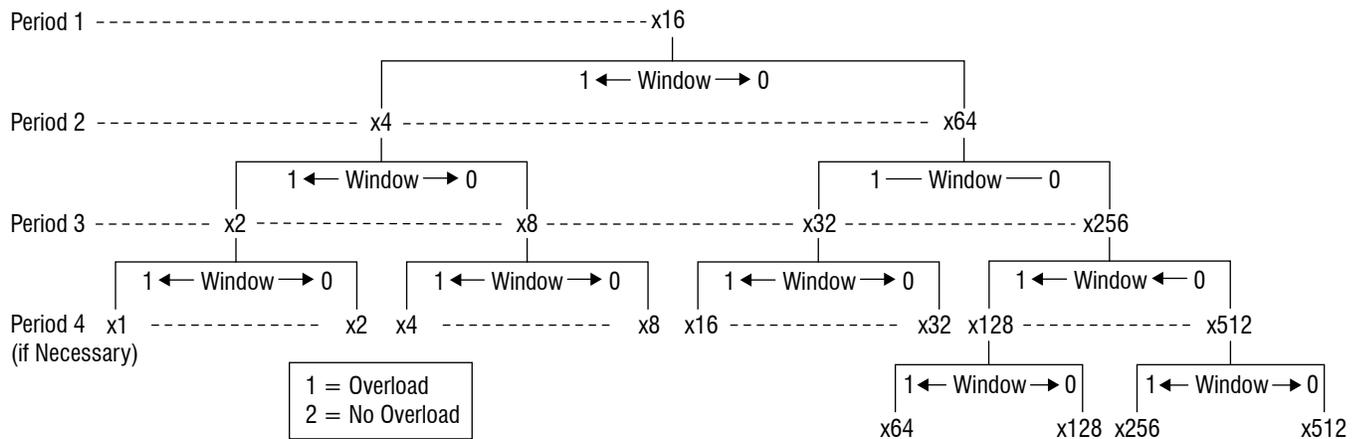
Where:

- E = Test source amplitude in volts
- f = Test source frequency in Hz
- Z_s = Sensor output impedance in Ohms
- R_c = Cable resistance in Ohms
- A = Channel gain of the 28316C
- K = Conversion factor of voltage to current

The 28316C test software selects the test source amplitude and test source frequency appropriate to the filter type and settings and it uses the current settings of channel gain.



28316C Card Installed in 28016-M3 Frame



Auto-Gain Ranging Decision Tree

Precision 28316C Description

TEDS Reader/Writer, Option T

TEDS (Transducer Electronic Data Sheet) reader/writer option is available as Option T on the 28316C card. Option T provides the ability to read stored data on TEDS-compliant devices.

The separate TEDS reader/writer program, 28000-TEDS- READER, is required to support Option T. The reader/writer program is compatible with IEEE 1451.4 V0.9 transducers.

TEDS data is displayed as a spreadsheet that can be displayed and saved as a configuration file. 28316C system information such as channel number and a time stamp of the time that TEDS information for each channel was last read are provided.

Manufacturer's information read from the sensor including manufacturer name, model number, version number and version letter of the sensor together with sensor serial number and cal date are displayed in the table. Accelerometer template information in accordance with the IEEE standard is displayed as well as application dependent information. Sensor sensitivity is used to set channel gains for EU scaling of 28316C outputs.

28316C General Characteristics

28316C Card Size:

6.63 x 17.5 x 0.75 inches

Card Weight:

1.4 lb. net

Temperature:

0° C to 40° C (operating)

28316C Accessories

CONN-IN-26D

Mating Connector, PF # A9405G2, with crimp machined sockets and metal backshell.

CONN-IN-26D-SC

Mating Connector, PF # A9405G3, with solder cup machined sockets and metal backshell.

CONN-OUT-26D

Mating Connector, PF # A9405G1, with crimp machined pins and metal backshell.

CONN-OUT-26D-SC

Mating Connector, PF # A9405G4, with solder cup machined pins and metal backshell.

CONN-OUT-37D

Mating Connector, PF # A10095G1, 37-pin mating output connector with crimp pins and metallized backshell.

CONN-OUT-37D-SC

Mating Connector, PF # A10095G2, 37-pin mating output connector with solder cup pins and metallized backshell.

CB-DC37P/16BNCL

Output cable: DC37P to 16-channel BNC male. L = length in feet.

CB-DC37P/16BNCF-BH-L

Output cable, DC37P to 16-channel BNC female output for bulkhead panel mount. L = length in feet.

PNL-32BNCF-BH-1U

Bulkhead panel mount. 1U height.

28316B-TEST-ADAPTER-A

Used to support FAT tests (with the 28000 Test Subsystem) to test the IEPE mode of the 28316C cards with the TEDS option.

Ordering Information

28316C-XXXX-YYY-?

Options: Option T - TEDS Reader/Writer
 Filter Type: BU4 or TD4
 Corner Frequency: FFF, FX01, or FX02. See Corner Frequency Settings Section

The screenshot shows the 'PF Teds Reader' application window. At the top, there is a menu bar with 'File', 'TEDS', and 'Tools'. Below the menu bar, there is a 'Read All TEDS' button and a 'Total TEDS Sensors Displayed' field showing the number '3'. The main area contains a table with the following data:

Ch Number	Time Last Read	Mfg	Model #	Ver #	Ver Let	S/N	Cal Date	Sen @ Fref	Fref	F hp Elec	Pol	Dir	Pos ID	User Data
0.02.08	10/30/03 17:15	Kistler	8772	50	A	194302	1/1/1998	1.046200E-2 V/(m/s ²)	9.908354E+1 Hz	1.000226E+0 Hz	Negative	y	70	
0.02.09	10/30/03 17:15	PCB	333	7	M	14400	9/4/2003	1.000369E-2 V/(m/s ²)	9.908354E+1 Hz	2.959190E-2 Hz	Positive		0	
0.02.10	10/30/03 17:15	Kistler	8632	10	C	191251	1/1/1998	4.981887E-2 V/(m/s ²)	9.908354E+1 Hz	1.000226E+0 Hz	Positive	z	101	

TEDS Data Display Panel