



Precision 28114 Quad-Channel Transducer Conditioner with Voltage and Current Excitation

28114 Quad-Channel Transducer Conditioner with Voltage and Current Excitation offers four channels of conditioning to support a wide variety of transducers including those that require constant voltage excitation or constant current excitation. Balanced constant voltage excitation in a bridge configuration supports applications such as strain gages and pressure transducers. Balanced current excitation accommodates single arm static or dynamic strain gages, RTDs or other resistive transducers that require constant current to excite them. Gain is programmable to x1024.



28114 Applications

- Static, Dynamic or Transient Testing
- Turbine and Rocket Engine Test Stands
- Wind Tunnels
- Energetic Shock, Explosive, Ordnance Testing
- Structural Shock and Vibration Testing

Sensor Applications

- Static or dynamic strain gage conditioner
- Full bridge conditioner
- Pressure transducer conditioner
- Piezoresistive accelerometer conditioner
- RTD conditioner
- Thermocouple amplifier
- Load cell conditioner
- MEMS transducer conditioner
- Hot wire anemometry
- AC or DC filter/amplifier (<1 mV to 10 V inputs)

Precision 28114 Features

- Four channels per card, 64 channels per 28016 chassis
- Balanced programmable constant voltage excitation with remote sense – up to 20 V delivered to the bridge
- Balanced differential constant current excitation (20 mA/20 V compliance) with AC current test mode for verifying transducer, cabling and frequency response
- Option HC10 – RTD/Bridge/Thermocouple Configuration. 4-wire 0-1 mA RTD excitation. RTD substitution, thermocouple substitution (1 mV – 100 mV) and resistive shunt cal.
- Option HC14 – Bridge/Strain/IEPE Configuration. Prog. bridge configuration (1, 2, 4-Arm) or 2-wire/4-wire constant current. Prog. completion (120, 350 and 1 kOhm). Programmable precision 255 step bipolar resistive shunt calibration of R1 or R2. IEPE input mode (8 mA constant current source).
- On-the-fly report of measured transducer excitation and resistance
- Transducer open/short indication
- Transducer leakage to ground detection
- Automatic bridge balance/transducer suppress
- Up to 30 kHz “filtered” bandwidth or 190 kHz “wide-band” bandwidth
- 2 to 10-wire plus shield bridge input interface
- 2 or 4-wire input plus shield transducer interface with constant current excitation
- Programmable AC/DC input coupling
- Programmable gain: x1/16 to x1024 with 0.05% vernier
- 4-pole low-pass filters with programmable pulse/flat characteristics
- Overload detection
- Precise digital calibration
- Front panel connectors that accept output adapter modules for multiple buffered outputs per channel

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 28114 Description

Precision 28114 Description

The 28114 is a member of the Precision 28000 family of signal conditioners. The 28114 provides four channels of conditioning for transducers requiring constant current or constant voltage excitation. Up to sixteen 28114 cards may reside in the 28000 system to provide 64 channels per chassis. In addition, the 28114 may be mixed with other conditioners in the 28000 family to meet your unique signal conditioning requirements.

Large changes in sensor impedance or sensor excitation can indicate that data from this sensor is no longer meaningful. The unique transducer health monitor circuits of the 28114 provide an “on-the-fly” report of measured sensor excitation and resistance. Measured gage resistance is compared to user specified limits and flagged if out of tolerance. Also, the 28114 alerts the user to a transducer open or short condition. The input overload detector reports overloads by out-of-band signals which could cause in-band distortion.

The 28114 incorporates precise, automatic calibration of gain and offset for the entire channel, including the amplifier, filter, and excitation supply. Option HC14 supports programmable bridge configuration for 120 Ω , 350 Ω or 1 k Ω bridges along with 255 steps of precision bipolar shunt calibration and a current source for IEPE transducers. Option HC10 provides support for RTD's and thermocouples in addition to full bridge sensors.

Balanced Constant Voltage Excitation

The 28114 provides balanced constant voltage excitation of up to 20 volts and conditioning for 1-, 2-, and 4-arm resistive bridges. The 28114 features automatic calibration of gain and offset for the entire channel, including the amplifier, filter, and excitation supply. The 2- to 10-wire input connection provides 6 wires for the bridge, 3 wires for shunt calibration, 1 wire for the shield, and 1 wire for single-arm bridges. Automatic balance of the bridge is accomplished by inserting a voltage ratiometric with the excitation supply to the amplifier input stage. This balance method provides outstanding stability without loading the bridge. A wide range of unbalanced conditions may be accommodated.

Balanced constant voltage excitation offers a number of advantages over single-ended excitation. It enables a true balanced instrumentation amplifier input for outstanding rejection of high frequency common mode signals. Single-ended voltage excitation to balanced bridges produces a relatively large common mode voltage at half the excitation supply. The instrumentation amplifier must reject this signal. Balanced voltage excitation applied to balanced bridges results in lower common mode input voltages to the amplifier input stage.

The excitation supply has automatic amplitude and offset correction that may be run on the unit in place at any time. Dedicated remote sense lines allow the excitation supply regulator to deliver an accurate voltage to the bridge.

Balanced Constant Current Excitation™

The 28114 is equipped with Precision Filters' proprietary balanced differential constant current excitation that is optimized for making dynamic strain measurements on single active strain gages. Balanced constant current excitation provides an accurate means of measuring dynamic strain with a single active strain gage using only a two-wire connection. Electrostatic pickup is reduced when compared to single-ended constant current excitation or a quarter bridge configuration with remote completion resistors or unbalanced current sources. The balanced current excitation circuit operates properly even under certain common gage fault conditions such as a direct short of the gage to the test model.

Balanced constant current excitation provides a true balanced input for rejection of common-mode signals. Programmable excitation provides 0 to ± 20 mA of constant current with an “excitation off” mode to detect input cable noise pickup. Gage open/short detection is also provided.

For dynamic strain conditioning applications, the 28114 can provide accurate measurements with only two wires by AC coupling the input. For best AC or DC measurements (required for RTD type transducers), the 28114 provides a 4-wire Kelvin connection for remote sense. Constant current excitation may be applied to full bridge applications with the advantage that excitation delivered to the bridge is unaffected by excitation supply lead wire resistance.

Suppression of the gage DC operating point is performed automatically using the zero suppress feature of the 28114. Zero suppress allows the use of more gain to emphasize small gage fluctuations. Zero suppress also provides the user with an accurate means to balance a full bridge.

The excitation current source output may be modulated to allow AC current injection in the loop. The frequency and amplitude of the AC current is user controlled. This allows the user to simulate changes in gage resistance in the loop and provides direct AC input stimulation to the signal conditioner for end-to-end system calibration.

Input Stage

The 28114 balanced differential input stage may be either AC or DC coupled. AC coupling is useful for dynamic applications where the DC bias on the transducer, that can limit dynamic range, can be coupled out of the signal. The input stage may be shorted under program control to verify signal conditioner channel noise and DC offsets.

A 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. In addition, both drive and sink current levels may be monitored separately making it possible to detect excitation current leakage conditions in the external current loop.

Amplifier and Filter

Programmable pre- and post-filter 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 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-of-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 28114 is specified with a 4-pole low-pass filter with five programmable cutoffs. In addition, the filter may be programmed to "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

Verification of Cables and Sensor Health

Strain Gage Loop Resistance Measurement: Dynamic strain measurements often require complicated wiring schemes. Long cable runs, multiple connection points, high-temperature high-impedance very small diameter wire and slip rings combine to cause uncertainty in the strain gage connection. Often a sudden increase in gage resistance is a predictor of gage failure. The Precision 28114 gives continual real time monitoring of the total "Loop Resistance" of the gage and cable circuit. This loop resistance reading can be compared to preset limits to alert the user of unexpected resistance shifts as well as gross gage short and gage open conditions.

Cable Roll-off: One often asked question of many measurements engineers is "How will my cable capacitance affect my high frequency strain measurement"? This question can be answered quickly and easily and all from the convenience of the control room. The AC dither current feature of the 28114 modulates a small AC current on top of the DC excitation current to stimulate an AC signal across the actual strain gage sensing element. Since the stimulus signal is based at the sensor, it will exhibit the same roll-off characteristics as a signal resulting from actual dynamic strain. The test frequency of the dither signal can be increased as necessary to chart the cable roll-off characteristics and validate the cable circuit for use at the desired measurement frequencies.

Gage Leakage Measurements: In extremely hot sections of a gas turbine engine, it is impossible to use standard insulating materials in gage wiring. Often a rigid section of a stainless steel or Inconel sheath encloses high temperature inner conductor wires. The inner core of the sheath is filled with magnesium oxide (MGO) as a high temperature insulating material. The insulating properties of the MGO are affected by moisture absorption at damage points or improperly sealed cable terminations. In extreme conditions, insulation breakdown can cause a leakage path to ground and corrupt a gage reading. Other causes of cable leakage are fatigue or failure at extension wire tie-down points, or in the strain gage itself. The leakage detection feature of the 28114 continually monitors leakage and compares readings to preset threshold limits. Sensors which show higher than normal leakage can be quickly identified prior to or during the test run.

Muting Faulty Sensors

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. For example, an intermittent gage will create a gage chatter condition whereby the connecting wires continually switch between the high voltage fault level and the proper low voltage operational level. This chatter condition creates a hostile noise source to any other gage extension wires in the vicinity of the hostile cable. Precision 28114 signal conditioning channels have a "MUTE" feature, which places the channel in its quietest quiescent state and minimizes the possibility of coupling noise to properly functioning channels.

28114 Programmable Features

- Constant voltage excitation level: 0 to 20.475 V in 5 mV steps
- Constant current excitation level: 0 to 20.475 mA in 5 μ A steps
- RTD Constant current excitation level (Option HC10): 0 to 1 mA in 0.25 μ A steps
- IEPE current source (Option HC14): 0 or 8 mA
- Expected transducer resistance and tolerance
- Transducer leakage resistance thresholds
- Voltage excitation sense: instrument or gage
- Current excitation input interface: 2-wire or 4-wire
- Bridge configuration: 1-arm (2-wire), 1-arm (3-wire), 2-arm or 4-arm (HC14/BC6/BC7/BC8)
- Bridge resistance: 120 Ω , 350 Ω or 1 k Ω (HC14/BC6/BC7/BC8)
- DC shunt cal: instrument or gage (HC10/HC14/BC6/BC7/BC8)
- DC shunt cal resistance and shunt arm: R1 or R2 (HC10/HC14/BC6/BC7/BC8)
- Automatic balance/suppress
- AC/DC input coupling
- Test modes: amp short, 10 V DC CAL, excitation off, test bus (voltage substitution), DC shunt calibration, AC current, excitation monitor
- RTD resistor substitution (HC10)
- Precision DC thermocouple voltage substitution (HC10)
- Output monitor
- Gain: x1/16 to x1024 with 0.05% resolution
- Filter type: pulse or flat
- Cutoff frequency: FX02: 300 Hz, 1 kHz, 3 kHz, 10 kHz, 30 kHz
- Wide-band (190 kHz) or filtered operation

28114 Graphical User Interface Display

All programmable features in addition to:

- On-the-fly excitation monitor
- On-the-fly sensor resistance monitor
- Sensor open or short indication
- Balance/Suppress status
- Transducer sensitivity
- System scaling in engineering units
- Overload status
- Intelligent gain algorithm
- Group control

28114 Details and Specifications

28114 Sensor Configuration

The high degree of modularity of the 28114 allows the card to be easily configured to condition a particular sensor type. Two sensor configuration options are available to support a wide range of transducer conditioning applications.

Bridge/Strain/IEPE Configuration: The HC14 configuration option supports measurements of strain in a ¼, ½ or full bridge configuration or 2-wire/4-wire constant current measurements. Precise low drift (0.2 PPM) completion resistors are included for 120, 350 or 1000 ohm bridges. 255-step bipolar shunt calibration provides programmable shunt cal resistance values ranging from 7.5 kΩ to 1.92 MΩ. Shunt calibration can be applied internally to the 28114 card or remotely at the actual bridge using dedicated shunt calibration connections. Single shunt of R1 or R2 bridge arms is supported.

The HC14 also supplies an 8mA current source for measurements with IEPE transducers. An AC coupling capacitor removes the sensor bias and connects to the amplifier input stage. Sensor Bias and fault conditions are monitored in real time to alert the user to a fault condition.

Bridge/RTD/Thermocouple Configuration: The HC10 Bridge/RTD/Thermocouple Configuration Module supports full-bridge, RTD and thermocouple measurements. A 1mA precision constant current excitation is supplied to the RTD. Current drive and signal sense terminals are available on the input connector to allow a 4-wire Kelvin connection to the RTD. Precision RTD substitution resistors are supplied for calibration purposes.

For thermocouple measurements it is assumed that a third party UTR is used with isothermal block temperature read and processed by external means to compensate the 28114 output for a reference junction and to perform linearization. Precision thermocouple DC input voltage substitution is supported.

For full bridge measurements, programmable single-step bipolar shunt of R1 or R2 is supported. In addition, relay contacts are used to connect the sensor internal cal resistor (if equipped) to + and – excitation.

Sensor Configuration Options: The HC10 and HC14 options are factory configured and support bridge, strain, IEPE, RTD and thermocouple configurations and are recommended for new installations. BC6, BC7 and BC8 options can be installed in the field.

Configuration Module Specifications:

Bridge Configuration*:

1-arm, 1-arm w/ 3 wires, 2-arm or 4-arm, (programmable)

Completion Resistors*:

120 Ω, 350 Ω and 1 kΩ, programmable

Constant Current:

2-wire/4-wire (Kelvin) input, programmable

Resistor Temperature Coefficient**:

±0.2 ppm / °C

Resistor Accuracy**:

±0.02%

HC10 Full-Bridge/RTD/Thermocouple Configuration Module

RTD Substitution Cal

Values: 62.5, 125, 500, 1 k and 2 kΩ, programmable

Accuracy**:

±0.01%, 5ppm/°C

Thermocouple cal via prog. voltage substitution

Range: 1 mV - 100 mV w/ 0.1 mV min resolution of setting

Accuracy: +/-1-10mV: +/- 0.15%; ±10mV-100mV: +/- 0.07%

DC Shunt Calibration (Constant Voltage Excitation Mode Only):

3-Step Bipolar Shunt Cal

DC Shunt Selection:

R1 or R2 bridge arms

Shunt Sensitivity:

±1 mV per volt of programmed excitation

Shunt Resistance:

Selectable:
29.940 kΩ,
87.325 kΩ,
249.5 kΩ

Resistor Accuracy: ±0.2%

Sensor RCAL:

Connects sensor internal cal resistor to + or – excitation via relay contacts.

Notes:

* Not supported on HC10

** These specifications are guaranteed by design, but are not testable to these limits with the 28000 Factory Acceptance Test (FAT) system.

HC14 Bridge/Strain/IEPE Bridge/IEPE Configuration Module

DC Shunt Calibration:

255-Step Bipolar Shunt Cal

DC Shunt Selection:

R1 or R2 bridge arms

Shunt Resistance: 7.5 kΩ to 1.92 MΩ

Resistor Accuracy: ±0.1%

IEPE Input Mode:

Level: 8 mA, ±1%

Compliance Voltage:

26 V, Nominal

AC Coupling Frequency w/ IEPE

Selected: 0.32 Hz ±5%

Fault Monitor:

Sensor open/short

IEPE Bias Monitor: Bias voltage continuously monitored and compared to user defined limits

BC6 DC Shunt Calibration

DC Shunt Selection:

R1 or R2 bridge arms

Equivalent Shunt Resistance Settings:

30.75R to 2000R w/ 0.2% minimum resolution where R = 120 Ω, 350 Ω, or 1 kΩ

Shunt Sensitivity:

±0.125 mV/V to ±0.5 mV/V
in ±0.25 μV/V steps
±0.501 mV/V to ±2.0 mV/V
in ±1.00 μV/V steps
±2.004 mV/V to ±8.0 mV/V
in ±4.00 μV/V steps

Shunt Accuracy:

±0.2% for programmed excitation >1 V

BC7 DC Shunt Calibration

DC Shunt Selection:

R1 or R2 bridge arms

Shunt Sensitivity:

±1 mV per volt of programmed excitation

Shunt Resistance:

29.940 kΩ for 120 Ω bridge
87.325 kΩ for 350 Ω bridge
249.5 kΩ for 1 kΩ bridge

Resistor Accuracy:

±0.1%

BC8 Current Sense:

Modes:

2-wire sense or 4-wire sense

Sense Resistor:

250 ohms ±0.1%

28114 Details and Specifications

Bridge Wiring

Input Connector:
26-pin D-shell (2 ea.)

Input Wires:
±EXCITATION (2)
±SENSE (2)
±SIGNAL (2)
SHUNT CAL (3)
¼ Bridge RTN (1) Single Arm Bridge
SHIELD (1)

28114 Excitation Supply

Programmable Constant Voltage Excitation

Maximum Output:
20.475 V, 30 mA (balanced)

Steps:
Programmable from 0 to 20.475
in 5 mV steps

Excitation Sense:
Programmable (instrument or
gage sense)

Accuracy: ±0.03%, ±500 µV

Noise: 100 µVrms, 3 Hz to 200 kHz

Temperature Drift:
±0.0025%/°C of setting or ±50 µV/°C,
whichever is greater

Sense Leakage Current: Less than 10 µA

Calibration:
Automatically calibrated for gain and
offset. Calibration initiated at the GUI
panel.

Excitation Off:
The excitation supply is programmed
to 0 volts.

28114 Constant Current Excitation Supply

Type:
Balanced differential constant current
excitation

Excitation:
0 to 20.475 mA in 5 µA steps

Total Gage Voltage (Volts):
22 – I x 700 minimum

Input Impedance:
100 kΩ nominal per side

CMRR (DC to 1 kHz):
80 dB for 120 Ω gage
70 dB for 350 Ω gage
60 dB for 1 kΩgage

Initial Accuracy:
0.05%, 5 µA

Temperature Drift:
30 nA + 0.0024% of setting per °C

Noise:
65 pA/√Hz at 1 kHz

Bandwidth:
±0.2 dB to 200 kHz (RGAGE <1 kΩ)

HC10 RTD Excitation

The HC10 option provides excitation levels
optimized for RTD measurements.

Type:
Balanced differential constant current
excitation

Level:
0 to 1.02375 mA in 0.25 µA steps

Total Gage Voltage:
22 – I x 14,000 minimum

Input Impedance:
2 MΩ nominal per side

Initial Accuracy: 0.05%, 250 nA

Drift:
1.5 nA + 0.0024% of setting per °C

Noise: 3.5 pA per rt Hz at 1 kHz

Bandwidth: ±0.2 dB to 200 kHz

28114 MUTE Mode

In harsh test environments, a sensor or input
cable can become faulty or intermittent
during a critical test. With high gain signal
conditioning this can be troublesome if large
signal swings on input or output cabling
cross couple to other channels. The 28114
Mute control places the channel in the quiet-
est operational state to minimize system
noise in the event of a failed sensor. The Mute
Mode is also useful to terminate unused
channels in a safe and quiet state.

28114 Transducer Health Monitor

Sensor Excitation Monitor: Transducer
excitation voltage or current is monitored
and reported to the user on-the-fly. Mea-
sured excitation is compared to factory set
tolerance and GUI indicators report if out of
tolerance.

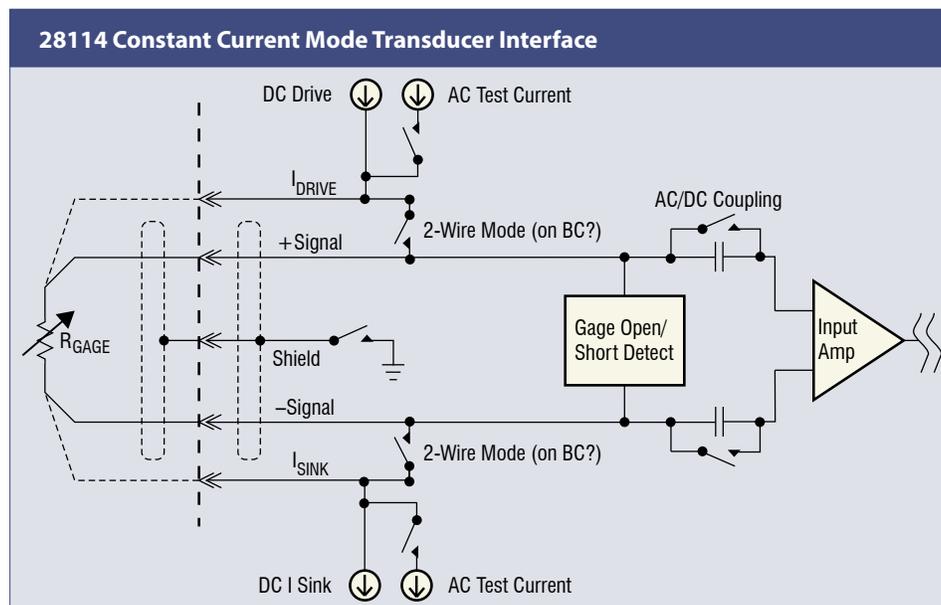
Sensor Resistance Monitor: Transducer
resistance is monitored on-the-fly and
compared to user defined limits. GUI indica-
tors report if sensor resistance is out of user
tolerance.

Sensor Open/Short Monitor: Transducer
open or short condition is monitored and
reported to the user via GUI indicators.

Sensor Leakage Monitor: Sensor leak-
age resistance to ground is measured and
recorded.

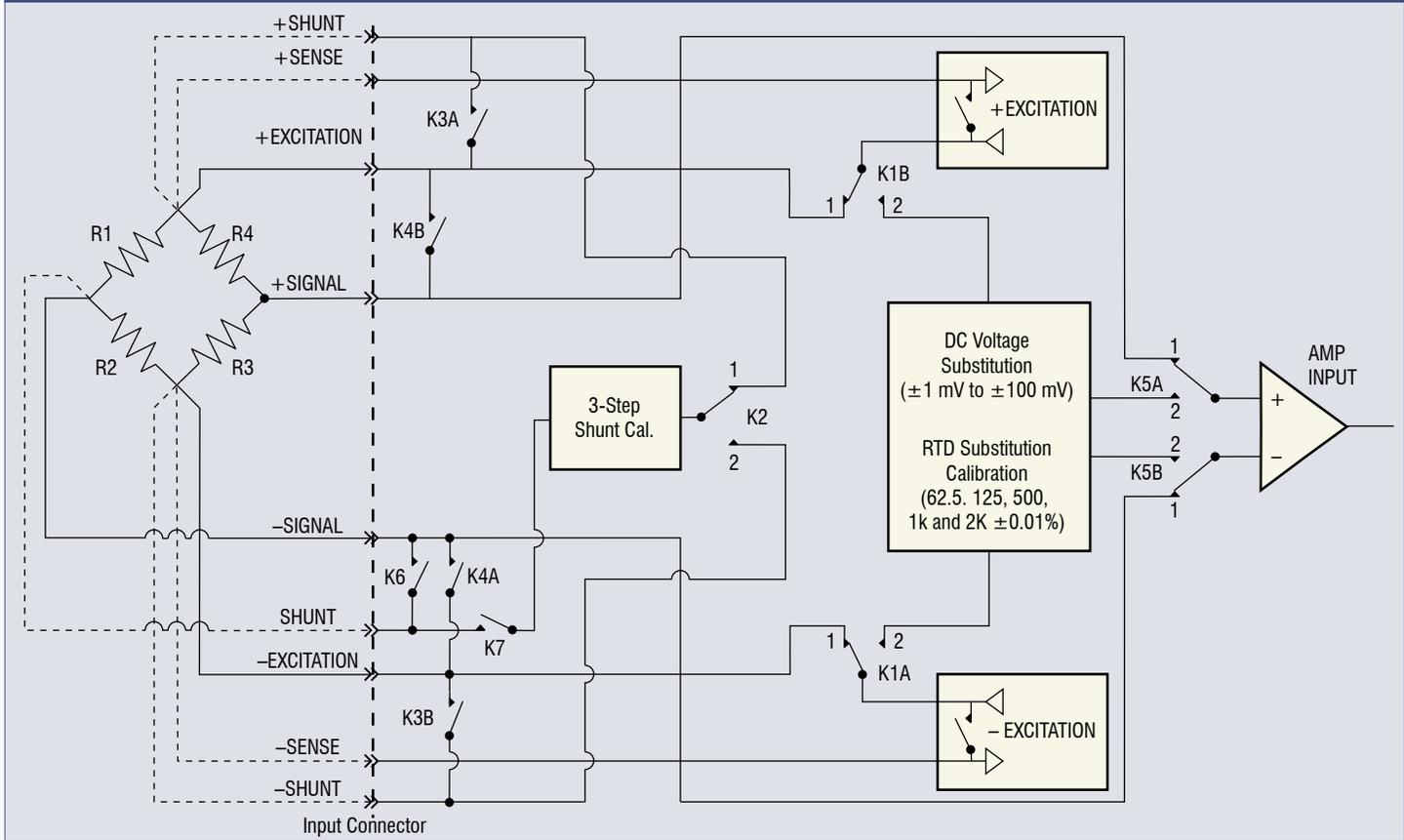
Excitation Current Limit: Current limit
protection is provided by the 28114 excitation
supply. Possible causes of current limit are
an incorrect excitation setting or a shorted
transducer. Current limit indicators are pro-
vided in the GUI.

Excitation Thermal Shutdown: The excita-
tion supply regulator die temperature is
continuously monitored and will shut down
should the temperature reach a level where
damage to the excitation supply may occur.
Thermal shutdown indicators are provided in
the GUI.



28114 Details and Specifications

Diagram with HC10 Bridge/RTD/Thermocouple Configuration Module

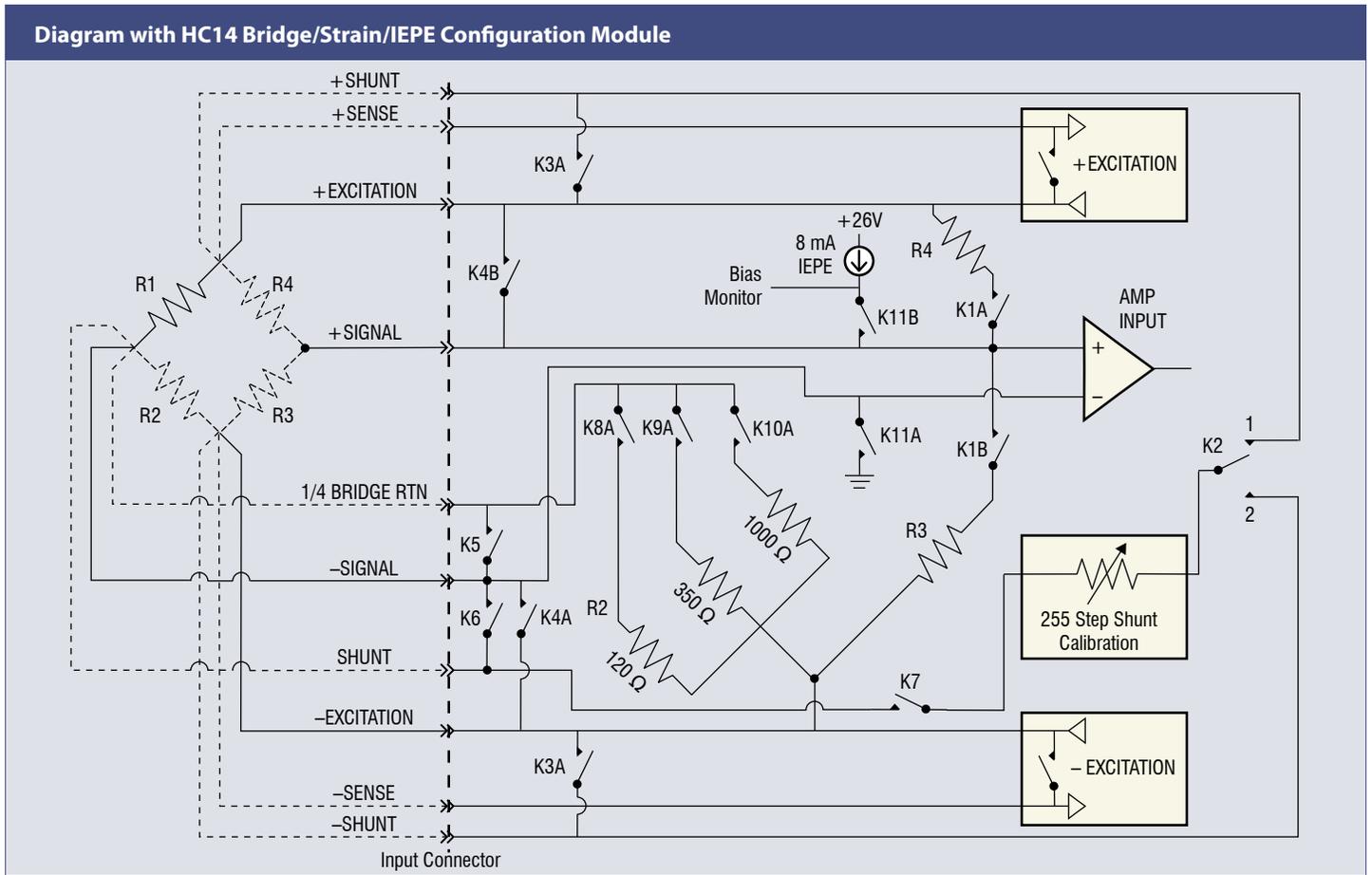


Truth Table

Configuration	K1	K2	K3, K6	K4	K5	K7
Shunt Cal Gage	1		OUT		1	IN
Shunt Cal Instrument	1		IN		1	IN
Shunt R1	1	1			1	IN
Shunt R2	1	2			1	IN
Sensor RCAL	1				1	IN
Constant Current 2-Wire	1			IN	1	
Constant Current 4-Wire	1			OUT	1	
DC Voltage Substitution	2				2	
RTD Substitution	2				2	

28114 with HC10 Bridge Configuration Module

28114 Details and Specifications



Truth Table

Configuration	K1	K2	K3, K6	K4	K5	K7	K8	K9	K10	K11
¼ Bridge, 2-Wire	IN				IN		IN ¹	IN ¹	IN ¹	IN
¼ Bridge, 3-Wire	IN				OUT		IN ¹	IN ¹	IN ¹	IN
½ Bridge	IN						OUT	OUT	OUT	OUT
Full Bridge	OUT						OUT	OUT	OUT	OUT
120 Ohm Completion							IN	OUT	OUT	IN
350 Ohm Completion							OUT	IN	OUT	IN
1000 Ohm Completion							OUT	OUT	IN	IN
Shunt Cal Gage			OUT			IN				
Shunt Cal Instrument			IN			IN				
Shunt R1		1				IN				
Shunt R2		2				IN				
Constant Current 2-Wire				IN						
Constant Current 4-Wire				OUT						
8 mA IEPE Current Source	OUT		OUT	OUT	OUT	OUT				IN

¹ One switch selected at a time.

28114 Filter Characteristics

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

Flat/Pulse Low-Pass Filters

Our LP4FP 4-pole flat/pulse low-pass filters provide the user with the versatility to address applications in either the time or frequency domain and are available on many 28000 card models.

Flat Mode Low-Pass Filters

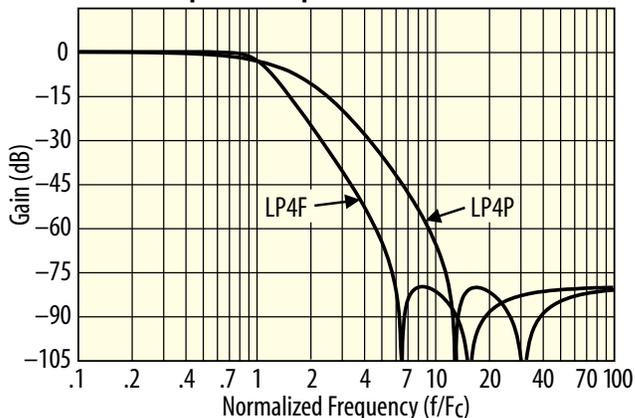
Precision LP4F "flat" mode characteristics are specified to have outstanding passband flatness equivalent to the Butterworth yet deliver very sharp roll-off characteristics.

The LP4F is a good choice as an anti-aliasing filter and for applications such as spectral analysis. The LP4F has zero passband ripple and roll-off superior to the Butterworth.

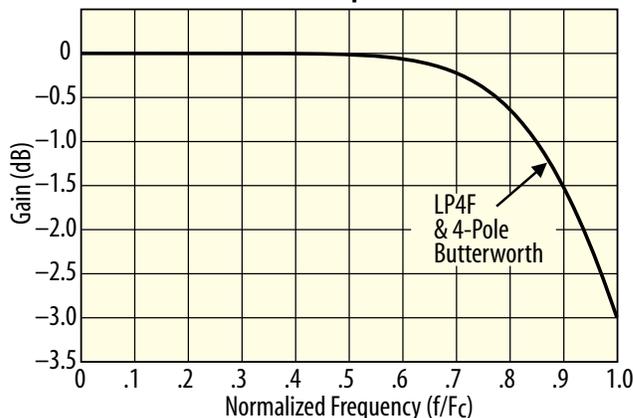
Pulse Mode Low-Pass Filters

For the time domain, program the 28618 low-pass filter to "pulse" mode. These filters have excellent transient response and phase linearity making them ideal filters for time domain applications including transient (shock) measurements and time domain waveform analysis ... all with roll-off characteristics superior to their Bessel filter counterparts.

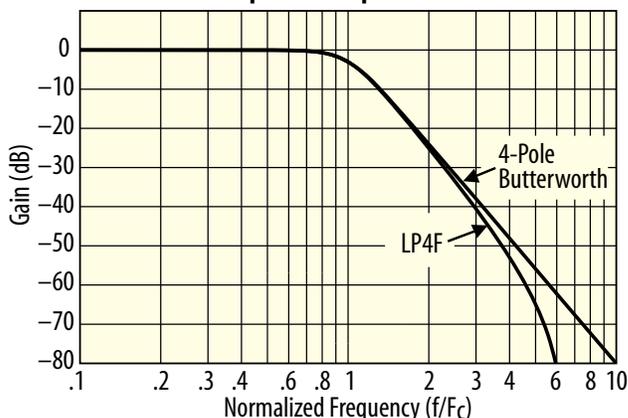
LP4F and LP4P Amplitude Response



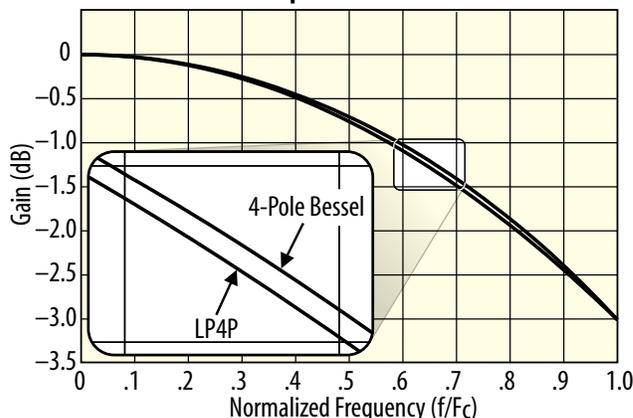
LP4F vs Butterworth Passband Response



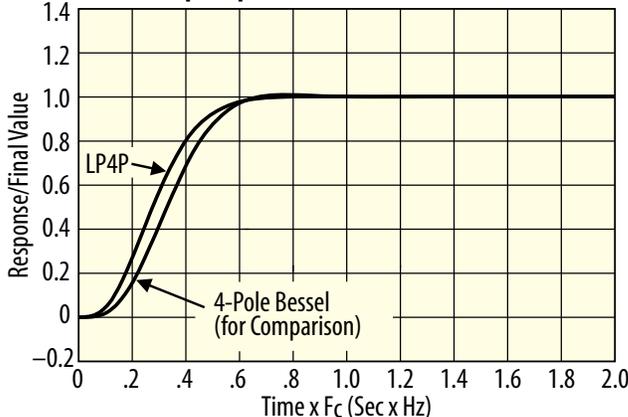
LP4F vs Butterworth Amplitude Response



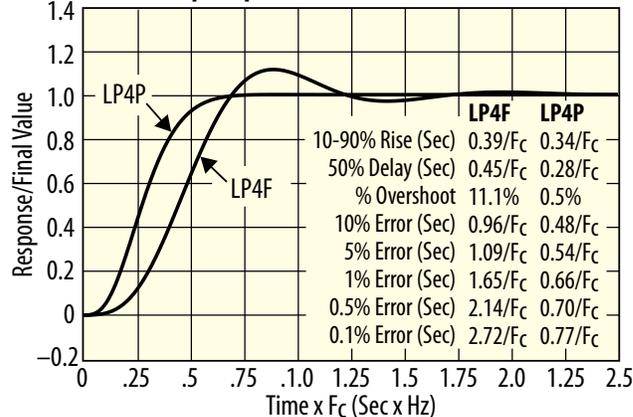
LP4P vs Bessel Passband Response



LP4P vs Bessel Step Response



LP4F and LP4P Step Response



28114 Details and Specifications

28114 Filter Type Characteristics

Filter Type:

LP4FP: 4-pole, 4-zero low-pass filter.
 Programmable for maximally flat pass-band (LP4F) or linear phase with optimized pulse response (LP4P).

Cutoff Frequencies:

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

Amplitude Accuracy:

±0.1 dB max, DC to 0.8 Fc
 ±0.2 dB max, 0.8 Fc to Fc

Amplitude Match:

±0.1 dB max, DC to 0.8 Fc
 ±0.2 dB max, 0.8 Fc to Fc

Phase Match:

±1° max, DC to 0.8 Fc
 ±2° max, 0.8 Fc to Fc

Filter Bypass:

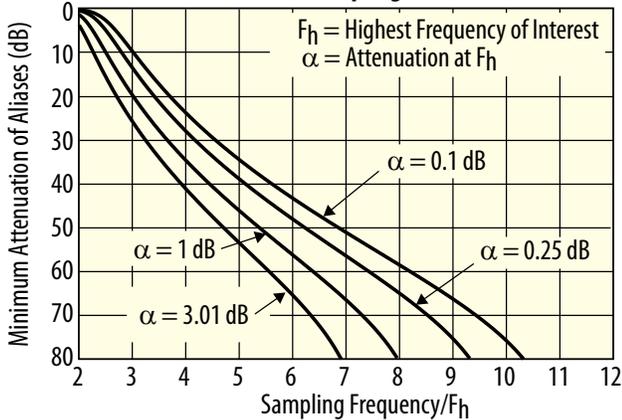
Bypasses filter but not amplifier stages.
 Bypass Bandwidth: 190 kHz, typical

Custom Filters:

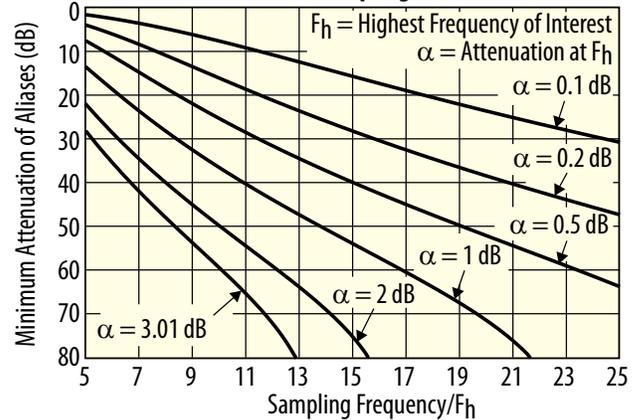
Other filter characteristics and cutoff frequencies are available. Please consult with factory for more information.

Specification	LP4F Maximally Flat Low-Pass Filter	LP4P Constant Time Delay Low-Pass Filter
Cutoff Frequency Amplitude	-3.01 dB	-3.01 dB
DC Gain	0.00 dB	0.00 dB
Pass-Band Ripple	0.00 dB	0.00 dB
Stop-Band Frequency	5.9465 Fc	11.863 Fc
Cutoff Frequency Phase	-180.0 deg	-101.5 deg
Phase Distortion (DC to Fc)	< 31.8 deg	< 3.7 deg
Zero Frequency Group Delay	0.4117/Fc	0.2920/Fc
Percent Overshoot	11.1%	0.5%
1% Settling Time	1.65/Fc	0.66/Fc
0.1% Settling Time	2.72/Fc	0.77/Fc
-0.1 dB Frequency	0.6348 Fc	0.1816 Fc
-1 dB Frequency	0.8487 Fc	0.5742 Fc
-2 dB Frequency	0.9370 Fc	0.8129 Fc
-3.01 dB Frequency	1.0000 Fc	1.0000 Fc
-20 dB Frequency	1.7412 Fc	3.0248 Fc
-40 dB Frequency	2.9555 Fc	5.6932 Fc
-60 dB Frequency	4.5986 Fc	9.0980 Fc
-80 dB Frequency	5.9465 Fc	11.8629 Fc

LP4F Attenuation of Aliases vs Sampling Rate



LP4P Attenuation of Aliases vs Sampling Rate



28114 Details and Specifications

28114 Input Characteristics

Type:

Balanced differential w/ programmable AC/DC input coupling

Input Impedance:

10 M Ω //100 pF per side

Max Level:

(AC + DC + Common Mode):

± 10 Vpk for $f < \text{or} = 200$ kHz

± 10 Vpk x (200 kHz/f) for $f > 200$ kHz

Input Protection (Power On):

25 V continuous (power on)

60 Vpk transient (1 ms pulse, 50% duty cycle)

Offset Drift:

3.5 $\mu\text{V}/^\circ\text{C}$, typical

Noise:

4 nV per rt. Hz at 1 kHz and pre-filter gain

>64, typical

AC Coupling Frequency:

0.25 Hz (-3.01 dB)

CMRR (DC Coupled):

86 dB, DC to 440 Hz and input gain >x8

CMRR (AC Coupled.):

80 dB, 10 Hz to 440 Hz and input gain >x8

Auto Bridge Balance Mode:

The bridge is automatically balanced utilizing voltage insertion at the input amplifier when bridge balance mode is selected. The inserted voltage is derived from and thus tracks the excitation supply. A successive approximation A/D converter mechanization is used for rapid bridge balance.

64 mV/V Mode Auto-Balance Range:

0 mV/V to ± 64 mV/V in ± 1.95 mV/V steps

512 mV/V Mode Auto-Balance Range (Gain limited to x128):

0 mV/V to ± 512 mV/V in ± 15.625 mV/V steps

Accuracy:

$\pm 0.1\%$ of setting $\pm 0.1\%$ of F.S. range

Stability:

± 25 ppm / $^\circ\text{C}$ of setting

Drift (RTI):

± 1 μV / $^\circ\text{C}$ for 64 mV/V range;

± 8 μV / $^\circ\text{C}$ for 512 mV/V range

Auto Balance Time:

Less than 15 seconds per system of 64 channels.

Auto Suppress Mode:

A programmable DC offset derived from a precision 10 V reference is injected at the channel input stage to suppress the gage DC operating voltage. Manual or automatic suppression modes are supported.

1.28 V Suppress Ranges:

0 mV to ± 1.28 V in ± 39 μV steps

10.24 V Suppress Ranges

(Gain limited to x128):

0 V to ± 10.24 V in ± 312.5 μV steps

Accuracy:

$\pm 0.1\%$ of setting $\pm 0.1\%$ of F.S. range

Stability:

± 25 ppm / $^\circ\text{C}$ of setting

Drift (RTI):

± 1 μV / $^\circ\text{C}$ for 1.28 V range

± 8 μV / $^\circ\text{C}$ for 10.24 V range

Auto Suppress Time:

Less than 15 seconds per system of 64 channels.

28114 Amplifier Characteristics

Pre-Filter Gain:

x1 to x64 in x2 steps with overload detection (10.2 Vpk threshold)

Post-Filter Gain:

x1/16 to x16 in binary steps with vernier adjustment

Overall Gain:

x1/16 to x1024

Gain Setability:

0.05% steps for POG $\geq 1\text{X}$

0.05%/POG for POG $< 1\text{X}$

DC Gain Accuracy:

0.02% typical, 0.2% maximum for POG $\geq 1\text{X}$

0.2%/POG maximum for POG $< 1\text{X}$

Frequency Response:

DC to 100 kHz, 0 dB ± 0.1 dB

-3 dB typical at 190 kHz

Temperature Coefficient:

$\pm 0.005\%$ / $^\circ\text{C}$ max

DC Linearity:

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

28114 Test Modes

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 external 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.

Shunt Cal: Applies shunt to bridge.

Excitation Monitor (Constant Voltage Mode Only): The amplifier input is switched from the bridge to the excitation supply to monitor the excitation voltage at the amplifier output. Excitation monitor gain is x0.5.

Excitation Off: The excitation supply is programmed to zero volts or zero mA.

AC Current (Constant Current Mode Only):

An AC current is injected into the current loop to evaluate end-to-end system frequency response. The AC current is generated from a voltage waveform on the test bus.

28114 Output Characteristics

Type:

DC coupled, single-ended output with ground sense (Option Y)

Output Ground Sense:

Used for driving grounded single-ended loads. Output is referred to ground at the load. Output sense also reduces ground loop interference by providing a high impedance connection between the ground at the load and the output stage ground.

Impedance:

Hi Output: 10 Ω // 100 pF

Low Output (Sense Input):

100 Ω // 100 pF or ground via manual card switch.

Max Output:

± 10 Vpk, ± 20 mA pk

Offset:

<5 mV after auto-adjust at any gain setting

Offset Drift:

3.5 μ V/ $^{\circ}$ C, RTI + 150 μ V / $^{\circ}$ C RTO

Noise:

6 μ V rms RTI + 100 μ V rms RTO,
3 Hz to 100 kHz

Crosstalk:

-90 dB, DC to 100 kHz

Output Monitor:

A switch at the output of each channel allows for multiplexed connection to the 28000 chassis output monitor bus BNC connector for viewing the channel output with an external device.

28114 General Characteristics

28114 Card Size:

6.63 x 17.5 x 0.75 inches

Card Weight:

1.4 lb. net

Temperature:

0 $^{\circ}$ C to 40 $^{\circ}$ C (operating);

-20 $^{\circ}$ C to 70 $^{\circ}$ C (storage)

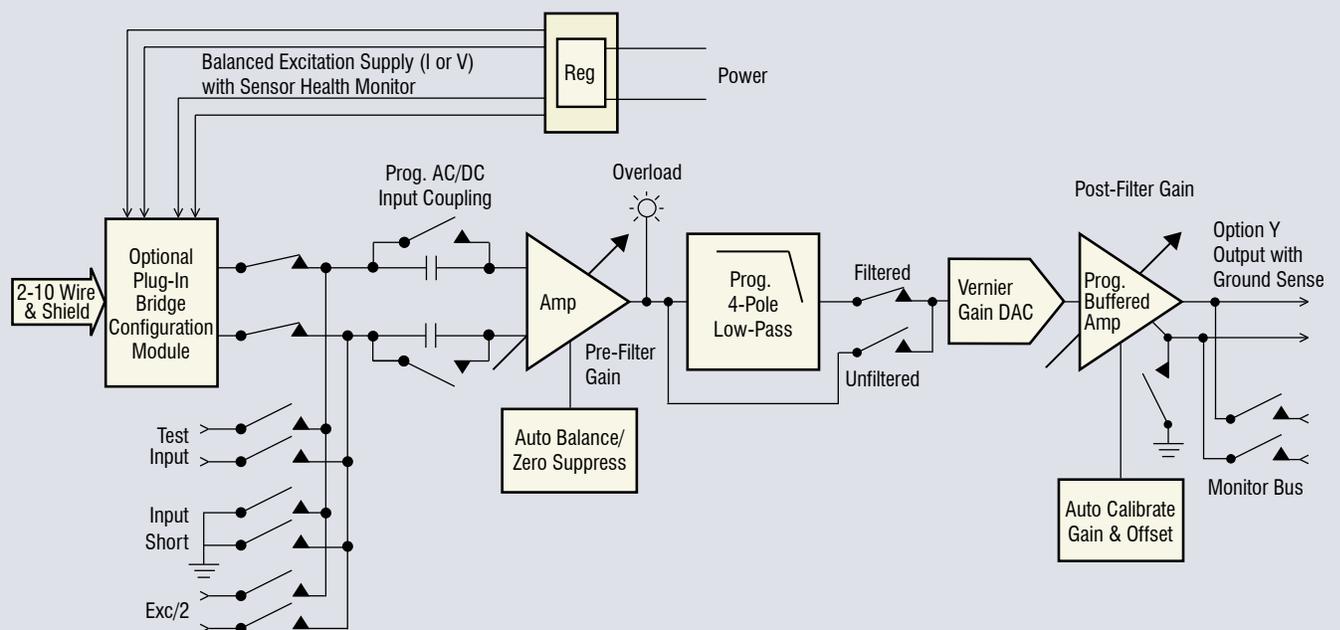
Connectors:

The input connectors are integral to the 28114 card. Cutouts on the 28000 frames allow the input connector to pass through the backplane and to directly mate with the input cables.

Two 26-pin high-density D connectors are utilized for the 4 inputs (2 inputs per connector). Connectors have high quality machined gold plated pins/sockets.

28114 outputs are available on 50-pin D connectors that are integral to the 28000 System chassis. Three wires per output are provided to accommodate twisted/shielded cables.

28114 Channel Block Diagram



Accessories

Mating Connectors

Precision Filters mating connectors accommodate up to 22-AWG wire and are supplied with high quality metal backshells with strain relief and gold plated screw machined contacts for high reliability connections and long service life.

CONN-IN-26D: High-Density 26-pin D-shell mating output connector.

CONN-IN-26D-SC: High-Density 26-pin D-shell mating output connector with machined solder cup pins.

CONN-OUT-26D: High-Density 26-pin D-shell mating output connector with machined crimp pins.

CONN-OUT-26D-SC: High-Density 26-pin D-shell mating output connector with machined solder cup pins.

CONN-I/O-50D-A: 50-pin D-shell mating connector with machined crimp pins.

CONN-I/O-50D-SC-A: 50-pin D-shell mating connector with machined solder cup pins.

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.

28114 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. The adapters provide one or two additional fully buffered outputs per channel or RMS to DC functionality.

28000-RMS/DC4: Quad RMS-to-DC Converter Module

BUFF-4BNC/15D: Quad Output Buffer with single output per channel on four BNC Connectors or one 15-Pin D Connector

BUFF-4CH/(2)15D: Quad Output Buffer with dual outputs per channel on two 15-Pin D Connectors

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



Exceptional desktop performance.

Ideal for conditioning low-level voltage inputs in front of high-resolution digital data acquisition systems. Fully programmable 8-channel and 16-channel configurations are available, both offering a choice of either 4 or 8-pole low-pass filters with programmable gain.

High Density Programmable Switch Systems

Computer controlled analog signal switching replaces tedious manual patch panels.



Precision 4164 64x64 Switch Matrix System

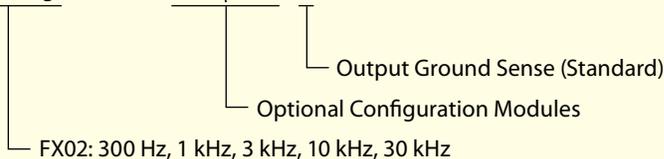


Precision 464kC Switch Matrix System

Precision switch systems are reliable solid-state switch matrix systems, providing computer-controlled connection between input and output signals. Configure the 464kC with up to 256 inputs and 256 outputs, all in a single mainframe, or choose the compact 4164 system with 64 inputs and 64 outputs. Save time and reduce errors on test system setup. Download switch configurations from the host computer over the network. Built-in self-test with fault diagnostics.

Ordering Information

28114-<Filter Range>-LP4FP-<HC10|HC14>-Y



BC6, BC7, BC8, HC10, HC14 Optional Programmable Configuration Modules:

Only one BC or HC module may be supported per 28114 card.

BC6, BC7 and BC8 are separately ordered plug-on modules that are automatically identified and controlled by the system. One module supports all four channels on the card.

HC10 and HC14 are factory installed configuration modules and are specified as an option for the 28114 card.