

# 28608B OCTAL PROGRAMMABLE FILTER AMPLIFIER

For the 28000 Signal Conditioning System



## 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 to be used before tests
- Rigorous factory acceptance test for maintenance
- 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 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.

## APPLICATIONS

- Anti-Aliasing Filters with Programmable Amplifiers
- Automatic Test Equipment
- Data Acquisition
- Signal Conditioning
- Production Test Equipment
- Industrial Process Control
- Reconstruction Filters
- Programmable Band-Pass Filters

## SALIENT FEATURES

- Number of Channels: 8 channels per card;  
128 channels per chassis
- Inputs: Balanced differential with programmable AC/DC coupling
- Zero Suppress: Programmable DC voltage is inserted at channel input.
- Pre-Filter Gain: x1 to x512 in x2 steps with input overload detection
- Post-Filter Gain: x0.25 to x16 with 0.05% resolution
- Filters: Choice of 4- or 8-pole low-pass filters or 8-pole band-pass filters.
- Cutoff Frequency: Pulse Mode programmable from 1 Hz to 102.3 kHz;  
Flat Mode programmable from 2 Hz to 204.6 kHz;  
and wideband (500 kHz)
- Outputs: DC coupled, single-ended with ground sense. Two additional buffered outputs per channel supported by optional front panel plug-on output adapters.
- Test Support: Test input and monitor output busses

## 28608B DESCRIPTION

The 28608B octal programmable filter/amplifier card allows for up to 128 channels of programmable precision filtering in one 28016-M3 chassis. Low-pass, high-pass and band-pass configurations are available. The 28608B is ideal for conditioning low-level voltage inputs in front of high-resolution digital data acquisition systems.

A choice of 4 or 8-pole low-pass filters, 4-pole high-pass and 8-pole band-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.

## 28608B DESCRIPTION (Continued)

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.

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 post-filter gain has resolution of better than 0.05% to enable system scaling of the outputs to match the full-scale input of the external recording device. Overload detectors alert the user to over-voltage conditions. Precise, automated digital calibration of gain and DC offset are provided.

Other features of the 28608B include a test input for injection of calibration signals into the channel input and a monitor output that allows for convenient monitoring of any channel output via a single BNC connector on the 28000 chassis.

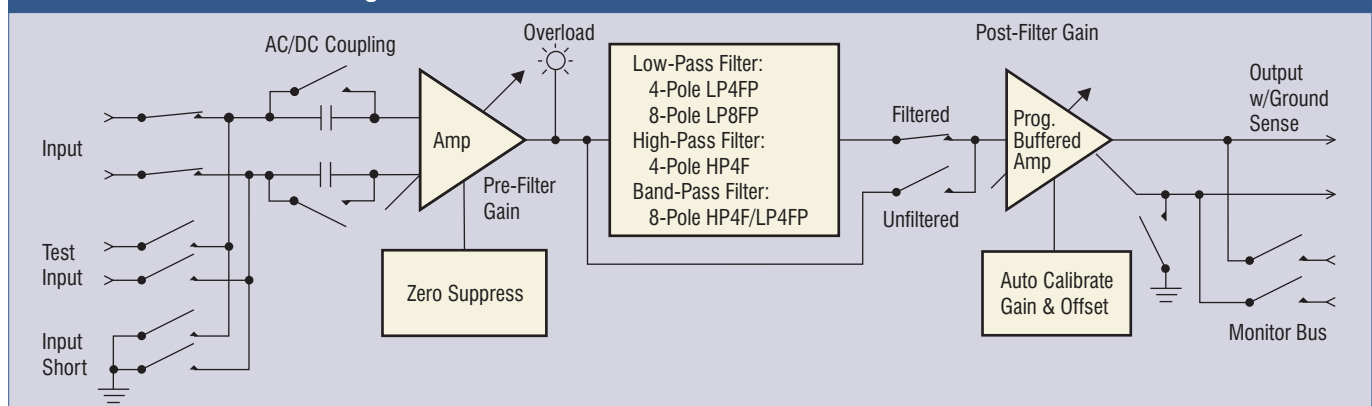
## 28608B AMPLIFIER SPECIFICATIONS

Pre-Filter Gain:	x1 to x512 in x2 steps with overload detection (10.2 Vpk threshold)
Post-Filter Gain:	x0.25 to x16 with 0.05% resolution
DC Accuracy:	0.2% after auto-adjust at any gain setting
Temp. Coef:	±0.008% /°C
DC Linearity:	±0.01% re: Fullscale, relative to best straight line
Freq. Response:	DC to 200 kHz; 0 dB ± 1% –3 dB typical at 500 kHz

## 28608B INPUT CHARACTERISTICS

Type:	Balanced Differential w/ programmable AC/DC input coupling
Input Impedance:	10 MΩ //100pF per side
Max Level:	(AC + DC + Common Mode) ±10 Vpk for f ≤ 200 kHz ±10 Vpk x (200 kHz/f) for f > 200 kHz
Input Protection:	35 V
Offset Drift:	1 μV/°C, typical
Noise:	7 nV/√Hz at 1 kHz and pre-filter gain > 64, typical
AC Coupling Freq:	0.25 Hz (–3.01 dB)
CMRR (DC Cpld.):	100 dB, DC to 440 Hz and input gain > x16
CMRR (AC Cpld.):	80 dB, 10 Hz to 440 Hz, input gain > x16
<b>Input Short:</b>	All amplifier inputs may be programmed to ground to measure amplifier noise and DC offset.
<b>Test Input:</b>	A switch at the channel input allows for injection of external test signal via an external 28000 chassis front panel BNC connector.
<b>Zero Suppress:</b>	Precision programmable DC offset is injected at the channel input stage to suppress the DC operating voltage. Manual or automatic suppression modes are supported.
Range:	–160 mV to +160 mV in 78 μV steps –1.28 V to +1.28 V in 625 μV steps –10.24 V to +10.24 V in 5 mV steps
Accuracy:	±0.25% of setting ±5 mV

## 28608B Channel Block Diagram



## 28608B FILTER 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:** 4-pole, 4-zero high-pass filter. Maximally flat pass-band.

**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).

### 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:  $\pm 0.1$  dB max, DC to  $0.8 F_c$   
 $\pm 0.2$  dB max,  $0.8 F_c$  to  $F_c$   
Amplitude Match:  $\pm 0.1$  dB max, DC to  $0.8 F_c$   
 $\pm 0.2$  dB max,  $0.8 F_c$  to  $F_c$   
Phase Match:  $\pm 1^\circ$  max, DC to  $0.8 F_c$   
 $\pm 2^\circ$  max,  $0.8 F_c$  to  $F_c$

### HP4F:

Amplitude Accuracy:  $\pm 0.1$  dB max,  $1.2 F_c$  to 204.6 kHz  
 $\pm 0.2$  dB max,  $F_c$  to  $1.2 F_c$   
Amplitude Match:  $\pm 0.1$  dB max,  $1.2 F_c$  to 204.6 kHz  
 $\pm 0.2$  dB max,  $F_c$  to  $1.2 F_c$   
Phase Match:  $\pm 1^\circ$  max,  $1.2 F_c$  to 204.6 kHz  
 $\pm 2^\circ$  max,  $F_c$  to  $1.2 F_c$

Bypass: Bypasses filter but not amplifier stages. Each filter may be independently bypassed for the HP4F/LP4FP band-pass filter.

Bypass BW: 500 kHz, typical

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
Pass-Band Ripple	0.00 dB	0.00 dB	0.00 dB	0.00 dB	0.00 dB
Stop-Band Frequency	$5.9465 F_c$	$11.863 F_c$	$1.7479 F_c$	$3.4688 F_c$	$0.1682 F_c$
Cutoff Frequency Phase	-180.0 deg	-101.5 deg	-360 deg	-161.9 deg	180 deg
Phase Distortion (DC to $F_c$ )	< 31.8 deg	< 3.7 deg	< 102 deg	< 0.05 deg	-
Zero Frequency Group Delay	$0.4117/F_c$	$0.2920/F_c$	$0.7197/F_c$	$0.4496/F_c$	-
Percent Overshoot	11.1%	0.5%	18.9%	1.1%	-
1% Settling Time	$1.65/F_c$	$0.66/F_c$	$4.03/F_c$	$1.25/F_c$	$1.86/F_c$
0.1% Settling Time	$2.72/F_c$	$0.77/F_c$	$7.02/F_c$	$2.25/F_c$	$2.92/F_c$
-0.1 dB Frequency	$0.635 F_c$	$0.182 F_c$	$0.8538 F_c$	$0.1800 F_c$	$1.5753 F_c$
-1 dB Frequency	$0.8487 F_c$	$0.5741 F_c$	$0.9437 F_c$	$0.5685 F_c$	$1.1783 F_c$
-2 dB Frequency	$0.9370 F_c$	$0.8129 F_c$	$0.9772 F_c$	$0.8087 F_c$	$1.0672 F_c$
-3.01 dB Frequency	$1.0000 F_c$	$1.0000 F_c$	$1.0000 F_c$	$1.0000 F_c$	$1.0000 F_c$
-20 dB Frequency	$1.7412 F_c$	$3.0248 F_c$	$1.2149 F_c$	$2.2342 F_c$	$0.5743 F_c$
-40 dB Frequency	$2.9555 F_c$	$5.6932 F_c$	$1.4443 F_c$	$2.7556 F_c$	$0.3384 F_c$
-60 dB Frequency	$4.5986 F_c$	$9.0980 F_c$	$1.6391 F_c$	$3.2016 F_c$	$0.2175 F_c$
-80 dB Frequency	$5.9465 F_c$	$11.8629 F_c$	$1.7479 F_c$	$3.4688 F_c$	$0.1682 F_c$

## 28608B OUTPUT CHARACTERISTICS

Type:	DC coupled, single-ended output with ground sense
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 $\Omega$ // 100 pF
Low Output (Sense Input):	100 $\Omega$ // 100pF or ground via manual card switch.
Output Shield:	Selectable ground or open via manual card switch.
Max Output:	$\pm 10$ Vpk, $\pm 10$ mA pk
Offset:	<5 mV after auto-adjust at any gain setting
Offset Drift:	1 $\mu$ V/ $^{\circ}$ C, RTI + 150 $\mu$ V/ $^{\circ}$ C RTO
Noise:	2.8 $\mu$ V rms RTI + 60 $\mu$ V rms RTO 3 Hz to 100 kHz
Crosstalk:	-90 dB, DC to 100 kHz
<b>Output Monitor:</b>	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.

## 28608B GENERAL CHARACTERISTICS

28608B 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 and output connectors are integral to the 28608B card. Cutouts on the 28000 frames allow for the input connector to pass through the backplane to directly mate with the input/output cables. One 26-pin high density D connector is utilized for the 8 inputs and one 26-socket high density D connector is used for the 8 outputs. Three wires per input or output are provided in order to accommodate twisted/shielded cables. Connectors have high quality machined gold plated pins/sockets.

## ORDERING INFORMATION

28608B-<LP4FP|LP8FP|HP4F|HP4F/LP4FP>

Filter Specification

4-pole low-pass (LP4FP)

8-pole low-pass (LP8FP)

4-pole high-pass (HP4F)

8-pole band-pass (HP4F/LP4FP)

## 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-IN-26D-MTL:

High-Density 26-pin D-shell mating input connector with machined crimp pins and metal backshell with strain relief.

#### CONN-IN-26D-SC-MTL:

High-Density 26-pin D-shell mating input connector with machined solder cup pins and metal backshell with strain relief.

#### CONN-OUT-26D-MTL:

High-Density 26-pin D-shell mating output connector with machined crimp pins and metal backshell with strain relief.

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

High-Density 26-pin D-shell mating output connector with machined solder cup pins and metal backshell with strain relief.

### Output Adapter

Measurement systems sometimes require multiple outputs per signal conditioning channel. These outputs may be routed to control systems, tape backup systems, auxiliary data acquisition systems, scope bays and other destinations.

28608B cards are fitted with front panel connectors that accept the 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 two additional fully buffered outputs per channel on two high-density 26-pin D shell connectors.

#### BUFF-8CH/(2)HD26D:

Dual output buffer for 8-channel cards: Two sets of eight outputs on two high-density 26-pin D connectors.

