

27604 QUAD PROGRAMMABLE FILTER/AMPLIFIERS

For the 27000 and 28000 Signal Conditioning Systems



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.

27604 FEATURES

- Broad selection of filter characteristics: 4-, 6- or 8-poles
- Wide range of cutoff frequency selections with filter bypass
- Distributed gain of x1 to x4096 in x2 steps; vernier resolution
- Input and output overload detection available as options
- Hi-Z, Hi-CMRR differential input
- Programmable AC/DC input coupling
- Programmable zero suppression
- Constant current source for piezo-electric transducers
- Single-ended output with optional ground reference
- Optional differential output

27604 INTRODUCTION

The Precision 27604 quad programmable filter/amplifier card allows for up to 64 channels of high-pass or low-pass filters in one 28000-M3 chassis, or 32 channels of bandpass filters. Modular construction provides easy expansion. Systems larger than 64 channels may be accommodated by multiple main-frames controlled from a system controller.

A Flexible Choice of Filter Characteristics

Seventeen standard filter characteristics are available for the Precision 27604: elliptical low-pass, elliptical high-pass, Butterworth low-pass, Bessel low-pass, and the TD Series of constant time-delay low-pass filters. These filters are each available in 4-, 6- and 8-pole configurations.

Standard models offer filter cutoff frequencies that are programmable over a 25500:1 range. In addition, you can define your own programmable cutoffs to custom tailor the Precision 27604 to your filtering application. Available cutoffs span from 0.1 Hz to as high as 127.5 kHz.

INPUT CHARACTERISTICS

Standard:	DC coupled, differential input
Impedance:	10 M Ω // 100 pF 5 M Ω // 200 pF common mode
Level:	± 10 Vpk linear for $f < 127.5$ kHz ± 10 Vpk (127.5 kHz/f) for $f \geq 127.5$ kHz ± 50 Vpk without damage
CM Input Level:	10 V
CMRR:	80 dB, DC to 500 Hz
Bias Current:	< 100 pA
Offset Drift:	15 μ V/ $^{\circ}$ C, typical
Noise:	24 nV/ $\sqrt{\text{Hz}}$ typical at 1 kHz, RTI
Shield:	DIP switch selectable to be floating or grounded (chassis)

Option 1: Single-ended input.
Input low connected to analog channel ground through a 10 Ω resistor. Provides ground reference for devices with floating output circuits. Same specifications as Standard input above.

Option 2: Selectable DC blocking.
Switchable input capacitor provides blocking of up to 50 VDC. Blocking mode, ON or OFF, is manually selected using a DIP switch. Status of the blocking switch is monitored and displayed by the system control. Option 2 is required for AC coupling when AC+DC input levels exceed 10 Vpk.

Impedance: 0.1 μF (50V) & 10 MΩ // 100 pF (LFRO = 0.159 Hz ±10%)
Level: 50 VDC re system analog ground
Drift: Standard drift + 25 μV/°C, typ (Blocking mode set to ON)
CMRR: 80 dB, 40 Hz to 500 Hz

Option 6: Programmable AC/DC coupled input.
Option 6 can be used for AC coupling when total input level (DC plus AC signal) is less than 10 Vpk. AC/DC mode is programmed via the front panel or via remote control.

LFRO: 0.156 Hz ±3%
Level (DC+AC): ±10 Vpk
Noise: 28 nV/√Hz typ at 1 kHz, RTI

Option 8: Fixed input gain, x10
Accuracy: ±0.1% re 0 dB at 1 kHz
Stability: 50 ppm/°C
Noise: 18 nV/√Hz RTI
Max Input: 1 Vpk

Option 9: Selectable IEPE current source with AC coupling. The constant current source is applied to the channel's HI input to power an attached remote IEPE transducer. IEPE mode is set manually using a DIP switch. When IEPE mode is set to ON, the input is AC coupled with input LO connected to ground. When IEPE mode is set to OFF, the input is DC coupled. Status is monitored and displayed by the system control.

Level: 4 mA standard; Consult factory for other options
Accuracy: ±0.6 mA
Compliance: 15 V, using internal IEPE power source

Option 9E: Same as Option 9 with auxiliary power bus to support an external supply

Test Input: Standard: A switch at the input of each channel allows for injection of a test signal. A test signal may be connected either externally at the mainframe rear panel or internally by using the 27000-?-TEST Test Subsystem Module.

Option Z: Zero Suppress.
A programmable DC offset is injected at the channel input stage. Zero suppress is useful for zeroing bridges or suppressing DC voltages at the input.

Level
High Range: -10.24 V to +10.24 V, 5 mV steps
Low Range: -1.28 V to +1.28 V, 625 μV steps
Accuracy
High Range: 1% of setting + 5 mV
Low Range: 1% of setting + 625 μV
DC Drift
High Range: Standard drift + 13.5 μV/°C
Low Range: Standard drift + 2.0 μV/°C

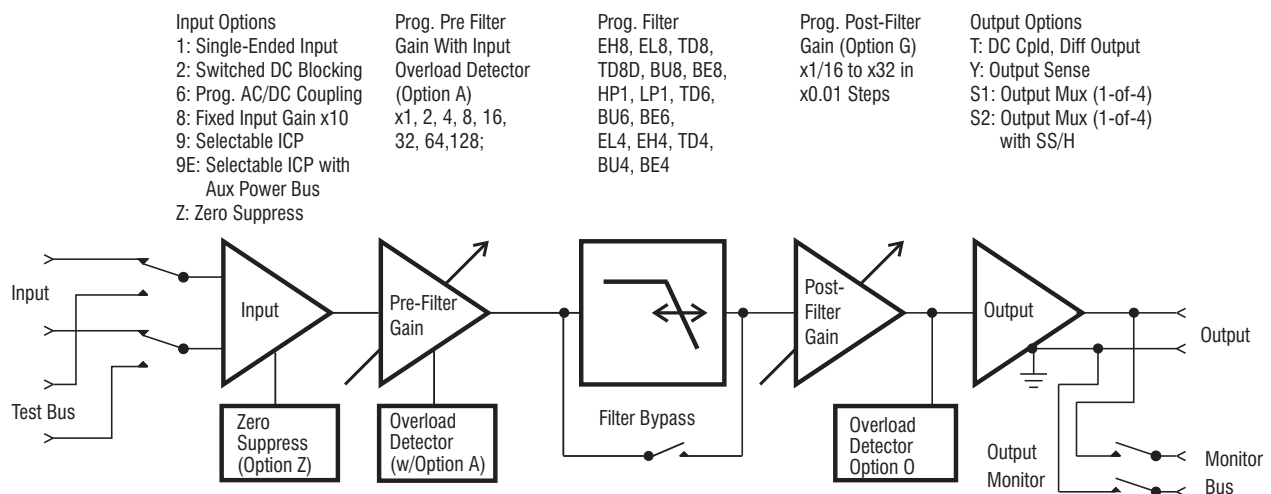


Figure 1 Block Diagram of Typical 27604 Filter Channel

27604 AMPLIFIER CHARACTERISTICS

Option A: Pre-filter gain stage with input overload detector
Gain: 1, 2, 4, 8, 16, 32, 64, and 128
Accuracy: $\pm 0.1\%$ re 0 dB at 1 kHz
Ovld Threshold: ± 10 V

Option G: Post-filter gain with vernier gain multiplier
Gain: x1/16 to x32 in x 0.01 steps.
Accuracy: $\pm 0.1\%$ re 0 dB at 1 kHz

Option O: Post-filter overload detector
Ovld Threshold: Programmable ± 1 V to ± 10 V in 5 mV steps
Accuracy: ± 50 mV $\pm 1\%$

Other Overall Amplifier Specifications

DC Gain Stability: 50 PPM/ $^{\circ}$ C
Freq Response: ± 0.1 dB DC to 127.5 kHz

OUTPUT CHARACTERISTICS

Type: DC-coupled, single-ended output
Impedance: $50 \Omega // 100$ pF
Max Output: ± 10 Vpk, ± 5 mApk
Drift: $\pm (\text{Input Drift}) * (A * G) \pm (20 \mu\text{V}/^{\circ}\text{C}) * G * n \pm 15 \mu\text{V}/^{\circ}\text{C}$, where
A = pre-gain setting,
G = post-gain setting and
n = number of filter poles
Noise: 200 μVrms into 1 MHz BW at a gain of x1
Total Harmonic Distortion: Better than -80 dB re: fullscale
Intermodulation Distortion: Better than -80 dB re: fullscale
Crosstalk: -80 dB

Auto-Offset (Std): Standard. Offsets are automatically adjusted for each gain setting. User can initiate the offset correction routine via front panel or remote control. Offset correction data is non-volatile and remains effective if the card is relocated to a different card slot or chassis.

Offset: ± 1 mV $\pm 500 \mu\text{V}$ x post gain setting

Output Monitor: Standard. A switch at the output of each channel allows for connection to the output monitor bus. The output monitor bus is available via a BNC connector at the mainframe rear panel. The monitor function is used by the auto-offset circuitry and by the Test Subsystem Module (27000-?-TEST).

OUTPUT CHARACTERISTICS (Continued)

Option S1: Output multiplexer (1-of-4) for use with Data Acquisition Systems.
Number of Channels: 4, one for each filter/amp output
Number of Outputs: 1 pair per filter/amp card
Control Signals: 2 address lines

Option S2: Output multiplexer (1 of 4) with simultaneous sample and hold for use with Data Acquisition Systems.
Number of Channels: 4, one for each filter/amp output
Number of Outputs: 1 pair per filter/amp card
Control Signals: 2 address lines, 1 track and hold line
Acquisition Time: 750 nS typical, 1 μS max
Aperture Jitter: 200 pS
Droop Rate: 1 $\mu\text{V}/\mu\text{S}$
Non-Linearity: 0.003% typ, 0.005% max

Option T: DC coupled differential output
Impedance: $50 \Omega // 100$ pF
Maximum Output: ± 10 Vpk, ± 5 mA pk
Noise: 250 μVrms into 1 MHz BW at a gain of x1

Option Y: Output Sense. Used for driving grounded single ended loads. Senses ground at the load on the output stage and refers the output to this ground. 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: $50 \Omega // 100$ pF, Hi Output
 $1 \text{ k}\Omega // 0.1 \mu\text{F}$, Sense Input (Lo Output)
Jumper selectable to $10 \Omega // 0.1 \mu\text{F}$

Ground Error Rejection: 40 dB, DC to 120 Hz

27604 FILTER CHARACTERISTICS

8-Pole Filters

- EL8: 8-pole, 8-zero Elliptic low-pass filter.
EH8: 8-pole, 8-zero Elliptic high-pass filter. Cascading an EH8 with an EL8 results in a symmetrical band-pass filter on a log frequency scale.
TD8: 8-pole, 6/8-zero constant time delay (linear phase) low-pass filter. Both the TD8A and TD8B characteristics are provided. Selecting between the TD8A and TD8B is accomplished via front panel or computer control.
TD8D: 8-pole, 8-zero constant time delay (linear phase) low-pass filter.
BU8: 8-pole Butterworth low-pass characteristic.
BE8: 8-pole Bessel low-pass characteristic.

6-Pole Filters

- LP1: 6-pole, 6-zero Elliptic low-pass filter.
HP1: 6-pole, 6-zero Elliptic high-pass filter. Cascading an HP1 with an LP1 results in a symmetrical band-pass filter on a log frequency scale.
TD6: 6-pole, 4/6-zero constant time delay (linear phase) low-pass filter. Both the TD6A and TD6B characteristics are provided. Selecting between TD6A and TD6B is accomplished via front panel or computer control.
BU6: 6-pole Butterworth low-pass characteristic.
BE6: 6-pole Bessel low-pass characteristic.

4-Pole Filters

- EL4: 4-pole, 4-zero Elliptic low-pass filter.
EH4: 4-pole, 4-zero Elliptic high-pass filter. Cascading an EH4 with an EL4 results in a symmetrical band-pass filter on a log frequency scale.
TD4: 4-pole, 4-zero constant time delay (linear phase) low-pass filter.
BU4: 4-pole Butterworth low-pass characteristic.
BE4: 4-pole Bessel low-pass characteristic.

CUTOFF FREQUENCY SETTINGS

Standard 2-Range Models

A Range	5 Hz to 1.275 kHz in 5 Hz steps	(Low)
	1.5 kHz to 127.5 kHz in 500 Hz steps	(High)
C Range	1 Hz to 255 Hz in 1 Hz steps	(Low)
	300 Hz to 25.5 kHz in 100 Hz steps	(High)
E Range	1 Hz to 255 Hz in 1 Hz steps	(Low)
	260 Hz to 2.55 kHz in 10 Hz steps	(High)

Standard F8??? Single 255:1 Ranges (no setup required)

F8001 Range	1 Hz to 255 Hz in 1 Hz steps
F8010 Range	10 Hz to 2.55 kHz in 10 Hz steps
F8100 Range	100 Hz to 25.5 kHz in 100 Hz steps
F8500 Range	500 Hz to 127.5 kHz in 500 Hz steps

Fixed Frequency Models

???	??? denotes a fixed cutoff frequency in the range between 1 Hz and 127.5 kHz.
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27604 FILTER SPECIFICATIONS

Cutoff Amplitude: -0.044 dB for LP8, HP8
 -0.1 dB for EL8, EH8
 -3.01 dB for TD8B, BU8, BE8,
 LP1, HP1, TD6B, BU6, BE6,
 EL4, EH4, TD4, BU4, BE4
 -10.06 dB for TD8A
 - 9.61 dB for TD6A

BU4, BE4, EL4, EH4, TD4, BU6, BE6, TD6, BU8, BE8, TD8, TD8D:

Ampl. Accuracy (DC to $F_{-3.01\text{ dB}}$; $F_{-3.01\text{ dB}}$ to 127.5 kHz for EH4):
 $\pm 0.1\text{ dB}$
 Amplitude Match (DC to $F_{-3.01\text{ dB}}$; $F_{-3.01\text{ dB}}$ to 127.5 kHz for EH4):
 $F_c \leq 20\text{ kHz}$: 0.05 dB max, 0.005 dB typ
 $20\text{ kHz} < F_c \leq 127.5\text{ kHz}$: 0.1 dB max,
 0.01 dB typ
 Phase Match (DC to $F_{-3.01\text{ dB}}$; $F_{-3.01\text{ dB}}$ to 127.5 kHz for EH4):
 $F_c \leq 20\text{ kHz}$: 0.5° max, 0.05° typ
 $20\text{ kHz} < F_c \leq 127.5\text{ kHz}$: 1° max, 0.1° typ

LP1, HP1, EL8, EH8:

Ampl. Accuracy (DC to $0.8 F_c$; $1.2 F_c$ to 127.5 kHz for HP1, EH8):
 filter char. $\pm 0.15\text{ dB}$
 Amplitude Match (DC to $0.8 F_c$; $1.2 F_c$ to 127.5 kHz for HP1, EH8):
 0.1 dB max, 0.01 dB typ
 Phase Match (DC to $0.8 F_c$; $1.2 F_c$ to 127.5 kHz for HP1, EH8):
 1 deg max, 0.1 deg typ
 -3.01 dB Frequency Amplitude Accuracy:
 $\pm 0.25\text{ dB}$

FILTER SPECIFICATIONS (Continued)

Filter Bypass (Std): Bypasses the filter but not the amplifier stages. Specifications when the filter is bypassed:
 -3.01 dB Bandwidth: 250 kHz, typ
 High Freq. Rolloff: 18 dB/octave
 Freq. Response: $\pm 0.05\text{ dB}$, DC to 127.5 kHz

Other Specifications

Stop-Band Amplitude Response

Conformance: f = frequency in the stop-band or where there is greater than 80 dB attenuation for monotonic filters.
 for $f \leq 100\text{ kHz}$, minimum stop-band attenuation $\pm 3\text{ dB}$
 for $100\text{ kHz} < f < 1\text{ MHz}$, $\pm 5\text{ dB}$

High-pass Filter Small

Signal Bandwidth: 250 kHz

4-Pole Filter Selection Guide					
	EL4	EH4	TD4	BU4	BE4
Filter Type	LP	HP	LP	LP	LP
Function	Cauer	Cauer	Bessel w/Z	Butterworth	Bessel
Number of Poles, Zeroes	4p, 4z	4p, 4z	4p, 4z	4p	4p
Pass-band Ripple (dB p-p)	0.1	0.1	n/a	n/a	n/a
-0.1 dB Frequency	$0.827 F_c$	$1.209 F_c$	$0.189 F_c$	$0.625 F_c$	$0.189 F_c$
-3.01 dB Frequency	F_c	F_c	F_c	F_c	F_c
-20 dB Frequency	$1.492 F_c$	$0.670 F_c$	$2.524 F_c$	$1.776 F_c$	$2.542 F_c$
-40 dB Frequency	$2.398 F_c$	$0.417 F_c$	$4.483 F_c$	$3.162 F_c$	$4.724 F_c$
-60 dB Frequency	$3.666 F_c$	$0.273 F_c$	$7.049 F_c$	$5.623 F_c$	$8.482 F_c$
-80 dB Frequency	$4.719 F_c$	$0.212 F_c$	$9.144 F_c$	$10.00 F_c$	$15.13 F_c$
Stop-band Frequency	$4.719 F_c$	$0.212 F_c$	$9.144 F_c$	n/a	n/a
Stop-band Attenuation (dB)	80	80	80	n/a	n/a
Phase at F_c ($^\circ$)	-220.35	220.35	-107.16	-180.00	-120.82
Phase Distortion at F_c ($^\circ$)	53.26	n/a	0.25	30.49	0.28
Overshoot (%)	13.8	n/a	0.80	11.4	1.03
1% Settling Time (sec)	$2.73/F_c$	$2.59/F_c$	$0.63/F_c$	$1.66/F_c$	$0.64/F_c$
0.1% Settling Time (sec)	$4.36/F_c$	$4.07/F_c$	$1.15/F_c$	$2.73/F_c$	$1.00/F_c$

6-Pole Filter Selection Guide						
	LP1	HP1	TD6A	TD6B	BU6	BE6
Filter Type	LP	HP	LP	LP	LP	LP
Function	Cauer	Cauer	Bessel w/Z	Bessel w/Z	Butterworth	Bessel
Number of Poles, Zeroes	6p, 6z	6p, 6z	6p, 4z	6p, 6z	6p	6p
Pass-band Ripple (dB p-p)	0.1	0.1	n/a	0.2	n/a	n/a
-0.1 dB Frequency	0.925 F _c	1.081 F _c	0.109 F _c	0.582 F _c	0.731 F _c	0.186 F _c
-3.01 dB Frequency	F _c	F _c	0.589 F _c	F _c	F _c	F _c
-20 dB Frequency	1.190 F _c	0.840 F _c	1.388 F _c	1.882 F _c	1.467 F _c	2.350 F _c
-40 dB Frequency	1.474 F _c	0.678 F _c	2.113 F _c	3.093 F _c	2.154 F _c	3.640 F _c
-60 dB Frequency	1.776 F _c	0.563 F _c	3.017 F _c	4.428 F _c	3.162 F _c	5.416 F _c
-80 dB Frequency	1.970 F _c	0.508 F _c	4.064 F _c	n/a	4.642 F _c	7.990 F _c
Stop-band Frequency	1.970 F _c	0.508 F _c	n/a	4.893 F _c	n/a	n/a
Stop-band Attenuation (dB)	80	80	n/a	70	n/a	n/a
Phase at F _c (°)	-358.50	358.50	-255.32	-255.32	-270.00	-154.37
Phase Distortion at F _c (°)	111.3	n/a	2.11	2.11	48.6	0.00
Overshoot (%)	19.2	n/a	0.60	5.04	14.4	0.64
1% Settling Time (sec)	4.64/F _c	5.21/F _c	1.21/F _c	1.46/F _c	2.36/F _c	0.74/F _c
0.1% Settling Time (sec)	8.45/F _c	9.14/F _c	1.94/F _c	2.21/F _c	3.89/F _c	1.16/F _c

8-Pole Filter Selection Guide							
	EL8	EH8	TD8		TD8D	BU8	BE8
			TD8A	TD8B			
Filter Type	LP	HP	LP	LP	LP	LP	LP
Function	Cauer	Cauer	Bessel w/Z	Bessel w/Z	Bessel w/Z	Butterworth	Bessel
Number of Poles, Zeroes	8p, 8z	8p, 8z	8p, 6z	8p, 8z	8p, 8z	8p	8p
Pass-band Ripple (dB p-p)	0.1	0.1	n/a	0.2	0.005	n/a	n/a
-0.1 dB Frequency	F _c	F _c	0.104 F _c	0.569 F _c	1.093 F _c	0.791 F _c	0.185 F _c
-3.01 dB Frequency	1.099 F _c	0.910 F _c	0.565 F _c	F _c	1.274 F _c	F _c	F _c
-20 dB Frequency	1.266 F _c	0.790 F _c	1.345 F _c	1.694 F _c	1.629 F _c	1.333 F _c	2.347 F _c
-40 dB Frequency	1.441 F _c	0.694 F _c	1.867 F _c	2.340 F _c	2.113 F _c	1.778 F _c	3.337 F _c
-60 dB Frequency	1.618 F _c	0.618 F _c	2.396 F _c	2.951 F _c	2.624 F _c	2.371 F _c	4.522 F _c
-80 dB Frequency	1.750 F _c	0.571 F _c	2.915 F _c	3.332 F _c	2.975 F _c	3.162 F _c	6.069 F _c
Stop-band Frequency	1.788 F _c	0.559 F _c	n/a	3.332 F _c	3.000 F _c	n/a	n/a
Stop-band Attn. (dB)	90.75	90.75	n/a	80.28	82.57	n/a	n/a
Phase at F _c (°)	-359.20	359.20	-301.88	-301.88	-400.50	-360.00	-182.16
Phase Distortion at F _c (°)	84.9	n/a	0.23	0.23	0.5	66.2	0.00
Overshoot (%)	19.8	n/a	0.19	5.56	10.2	16.7	0.34
1% Settling Time (sec)	5.15/F _c	6.03/F _c	1.34/F _c	1.54/F _c	3.15/F _c	3.45/F _c	0.79/F _c
0.1% Settling Time (sec)	7.97/F _c	9.35/F _c	1.86/F _c	2.23/F _c	5.15/F _c	5.08/F _c	1.14/F _c

GENERAL CHARACTERISTICS

27604 Card Size: 5.68 x 13.15 x 0.75 inches
 Card Weight: 1.87 lbs net, 3.3 lbs shipping
 Temperature: 0°C to 40°C (operating)
 -20°C to 70°C (storage)

ORDERING INFORMATION

27604-?-XXX-? (Notes: †, * = Select only 1)
 L Options: 1,2†,6,8,9†,9E†,A,G,O,S1*,S2*,T*,Y*,Z
 Filter Type: EH8, EL8, TD8, TD8D, BU8, BE8,
 LP1, HP1, TD6, BU6, BE6,
 EL4, EH4, TD4, BU4, BE4
 Freq. Indicator: A,, C, ...etc. See Page 4.

