PFA-2
Precision Dual-Channel Compact Filter/Amplifier System

Description
The PFA-2 is a compact, rugged, and versatile dual-channel precision filter/amplifier. The low-noise, high common-mode rejection balanced differential input with programmable AC/DC input coupling is ideal for conditioning static or dynamic signal inputs.

Sharp, programmable 6-pole low-pass precision filters support two response characteristics which are optimized for making time-domain or frequency-domain measurements. Gain is distributed as pre- and postfilter gain, allowing for elimination of out-of-band energy such as transducer resonant peaking, which can cause nonlinearities due to clipping of the amplifier. Overload detectors alert the user to pre- and postfilter overload conditions that could otherwise be masked by the filter. The optional 2-pole high-pass filter provides programmable low-frequency roll off to attenuate sources of low-frequency noise.

A high-level command interface is available to control the PFA-2 via a USB 2.0 interface. A spreadsheet-style graphical user interface is supplied to control up to 8 PFA-2 units as a single system. Configurations may be saved to and recalled from the host computer. Settings may be saved to nonvolatile memory for deployment without a host computer. Front panel LED indicators alert the user to overloads.

The PFA-2 is powered by 10 to 30 VDC and is supplied with an external AC-to-DC universal supply.

PFA-2 Features
- Two channels per system
- Balanced differential input
- Programmable AC/DC input coupling
- Prefilter gain: x1 to x128 in binary steps
- Postfilter gain: x1/16 to x16 with 0.025% minimum resolution
- 6.3 nV/√Hz maximum input noise
- 6-pole low-pass filters with programmable flat/pulse characteristics
- Optional 2-pole high-pass filter for band-pass operation
- Cutoff frequencies programmable from 5 Hz to 127.75 kHz
- Input and output overload detection with programmable threshold
- Precise digital calibration of DC offset
- 0.05% overall DC accuracy
- Test input for voltage substitution calibration
- USB 2.0 remote control with field upgradable firmware
- Front panel overload LED indicators
- Spreadsheet-style GUI interface for control of up to 8 PFA-2 units
- Compact stackable chassis design with link kit to lock units together
- Side-by-side rack-mount option

Applications
- Low-pass, band-pass, high-pass filter/amplifier
- IEPE sensor conditioner
- Anti-aliasing filters
- Transient (shock) measurements
- Reconstruction filters

PFA-2 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 Input:
Switch disconnects signal from input connector and injects signal on Test Input BNC at the amplifier input.

Operate:
Normal operating mode
### PFA-2 Details and Specifications

#### Input Characteristics

**Type:** Balanced differential with programmable AC/DC coupling

**Input Connectors**
- **Standard:** Individual Isolated BNC’s at front panel
- **Option 1:** Individual Isolated 2-pin twinaxial BNC at front panel

**Input Impedance:**
- 10 MΩ // 50 pF per side

**Maximum Level:**
- (AC + DC + Common Mode)
  - ±10 Vpk for f ≤200 kHz
  - ±10 Vpk x (200 kHz/f) for f >200 kHz

**Input Protection:**
- 24 V continuous (power on)
- 60 Vpk transient (1 mS pulse, 50% duty cycle)

**Offset Drift:**
- 1 µV/°C, RTI

**Noise:**
- 8 nV/rt. Hz RTI at 10 Hz
- 6.3 nV/rt. Hz RTI, f ≥100 Hz

**AC Coupling Frequency:**
- 0.25 Hz (–3.01 dB)

**CMRR (DC Coupled):**
- 110 dB, DC to 1 kHz, input gain > x16

**CMRR (AC Coupled):**
- 80 dB, 47 Hz to 1 kHz, input gain > x16

**Amplifier Short:** Amplifier inputs may be programmed to ground to measure amplifier noise and DC offset.

**Test Input:** A switch at the channel input allows for injection of an external test signal applied to a front panel BNC connector.

#### Amplifier Characteristics

**Prefilter Gain:**
- x1 to x128 in x2 steps with overload detection (10 Vpk threshold)

**Postfilter Gain:**
- x1/16 to x16

**Postfilter Gain Resolution:**
- 0.025% min for POG ≥ 1
- 0.025%/POG for POG < 1

**Overall DC Accuracy:**
- ±0.05% at any gain setting. Includes filter.

**Temperature Coefficient:**
- ±0.004% / C

**DC Linearity:**
- 0.005% re: full scale output, best-fit straight line

**Frequency Response (Filter Out):**
- DC to 200 kHz: 0 dB ±0.1 dB;
- -3 dB typical at 500 kHz

#### Output Characteristics

**Type:** DC coupled, single-ended output, short circuit protected

**Impedance:**
- 10 Ω

**Max Output:**
- ±10 Vpk, ±25 mA pk

**Offset:**
- < 5 mV after auto adjust at any gain setting

**Offset Drift:**
- 1 µV/°C, RTI + 150 µV/°C RTO, typical

**Noise:**
- 2.8 µV rms RTI + 60 µV rms RTO, 3 Hz to 100 kHz

**Crosstalk:**
- –80 dB, DC to 100 kHz

**Output Overload Detector:**
- Level programmable from 0.1 to 10.2 V in 0.1 V steps

#### Power Requirements

Power is supplied to the PFA-2 from either the external PFA-2-ACPS, included with each system, or a direct power source. The input power supply requirements are 10 VDC to 30 VDC, 25 W maximum. Power is applied at the rear panel Mini DIN connector.

**PFA-2-ACPS External Power Supply**

The compact PFA-2-ACPS AC to DC external power supply carries the CE/UL listing marks. One PFA-2-ACPS is supplied with each PFA-2 system.

**Input Voltage, Frequency**
- 100-240 VAC, 47-63 Hz

**Output**
- 12 VDC, 25W

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**PFA-2 Channel Block Diagram**

[Channel Block Diagram Image]

- **Input Overload**
- **Option H**
- **Programmable 2-Pole High-Pass**
- **High-Pass In**
- **High-Pass Out**
- **LP6F or LP6P Programmable 6-Pole**
- **Filter In**
- **Filter Out**
- **Auto Calibrate Offset**
- **Post-Filter Gain**
- **Programmed Buffered Amp**
- **Output**
- **Output Overload**
PFA-2 Details and Specifications

PFA-2 Filter Characteristics

Programmable Flat/Pulse Filter

Type:
Programmable flat/pulse low-pass 6-pole, 6-zero low-pass filter. Programmable for maximally flat pass-band (LP6F) or linear phase (LP6P).

Cutoff Frequencies:
5 Hz to 2.555 kHz in 5 Hz steps
2.75 kHz to 127.75 kHz in 250 Hz steps

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

Wideband Mode:
Filter may be removed from the signal path, resulting in 3-pole Butterworth wideband amplifier frequency response with nominal –3 dB frequency at 500 kHz.

Programmable High-Pass Filter (Option H)

Type:
2-pole Butterworth high-pass filter

Cutoff Frequencies:
1 Hz to 255 Hz in 1 Hz steps
300 Hz to 12.75 kHz in 50 Hz steps
13 kHz to 127.5 kHz in 500 Hz steps

Amplitude Accuracy:
±0.1 dB max, 1.2 Fc to 127.5 kHz
±0.2 dB max, Fc to 1.2 Fc

Amplitude Match:
±0.1 dB max, 1.2 Fc to 127.5 kHz
±0.2 dB max, Fc to 1.2 Fc

Phase Match:
±1° max, 1.2 Fc to 127.5 kHz
±2° max, Fc to 1.2 Fc

Bypass Mode:
High-pass filter is removed from the signal path.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>LP6F 6-Pole Maximally Flat Low-Pass Filter</th>
<th>LP6P 6-Pole 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>
</tr>
<tr>
<td>DC Gain</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>
</tr>
<tr>
<td>Stop-Band Frequency</td>
<td>2.6113 Fc</td>
<td>5.1923 Fc</td>
</tr>
<tr>
<td>Cutoff Frequency Phase</td>
<td>–270.0</td>
<td>–140.3 deg</td>
</tr>
<tr>
<td>Phase Distortion (DC to Fc)</td>
<td>&lt;60 deg</td>
<td>&lt;1.45 deg</td>
</tr>
<tr>
<td>Zero Frequency Group Delay</td>
<td>0.5834/Fc</td>
<td>0.3924/Fc</td>
</tr>
<tr>
<td>Percent Overshoot</td>
<td>15.8%</td>
<td>1.1%</td>
</tr>
<tr>
<td>1% Settling Time</td>
<td>2.80/Fc</td>
<td>0.84/Fc</td>
</tr>
<tr>
<td>0.1 % Settling Time</td>
<td>4.36/Fc</td>
<td>1.02/Fc</td>
</tr>
<tr>
<td>–0.1 dB Frequency</td>
<td>0.766 Fc</td>
<td>0.193 Fc</td>
</tr>
<tr>
<td>–1 dB Frequency</td>
<td>0.9080 Fc</td>
<td>0.5983 Fc</td>
</tr>
<tr>
<td>–2 dB Frequency</td>
<td>0.9624 Fc</td>
<td>0.8293 Fc</td>
</tr>
<tr>
<td>–3.01 dB Frequency</td>
<td>1.0000 Fc</td>
<td>1.0000 Fc</td>
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<tr>
<td>–20 dB Frequency</td>
<td>1.3822 Fc</td>
<td>2.3616 Fc</td>
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<tr>
<td>–40 dB Frequency</td>
<td>1.8546 Fc</td>
<td>3.5115 Fc</td>
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<tr>
<td>–60 dB Frequency</td>
<td>2.3206 Fc</td>
<td>4.5462 Fc</td>
</tr>
<tr>
<td>–80 dB Frequency</td>
<td>2.6113 Fc</td>
<td>5.1923 Fc</td>
</tr>
</tbody>
</table>

Parameter 2-Pole Butterworth High-Pass Filter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>2-Pole Butterworth High-Pass Filter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cutoff Amplitude</td>
<td>–3.01 dB</td>
</tr>
<tr>
<td>High Frequency Gain</td>
<td>0.00 dB</td>
</tr>
<tr>
<td>Pass-Band Ripple</td>
<td>0.00 dB</td>
</tr>
<tr>
<td>Low Frequency Roll off</td>
<td>–40 dB/Decade</td>
</tr>
<tr>
<td>Cutoff Frequency Phase</td>
<td>90 deg</td>
</tr>
<tr>
<td>–0.1 dB Frequency</td>
<td>2.559 Fc</td>
</tr>
<tr>
<td>–0.25 dB Frequency</td>
<td>2.026 Fc</td>
</tr>
<tr>
<td>–1 dB Frequency</td>
<td>1.402 Fc</td>
</tr>
<tr>
<td>–2 dB Frequency</td>
<td>1.143 Fc</td>
</tr>
<tr>
<td>–3.01 dB Frequency</td>
<td>1.000 Fc</td>
</tr>
<tr>
<td>–20 dB Frequency</td>
<td>0.316 Fc</td>
</tr>
<tr>
<td>–40 dB Frequency</td>
<td>0.100 Fc</td>
</tr>
<tr>
<td>–60 dB Frequency</td>
<td>0.0316 Fc</td>
</tr>
<tr>
<td>–80 dB Frequency</td>
<td>0.0100 Fc</td>
</tr>
</tbody>
</table>
**PFA-2 Specifications and Accessories**

**Flat/Pulse Low-Pass Filters**
The PFA-2 has a flexible high-performance 6-pole low-pass filter characteristic that can be optimized for time- or frequency-domain measurements.

![LP6F and LP6P Amplitude Response](image)

The LP6F and LP6P 6-pole low-pass filters have the versatility to address applications in either the time domain or the frequency domain. Simply program the filter characteristic to match your measurement requirements.

**Flat Mode Low-Pass Filters**
The LP6F FLAT mode characteristic has a pass-band amplitude response nearly identical to the 6-pole Butterworth yet with much sharper roll-off characteristics. This makes the LP6F a good choice for spectral analysis or for anti-aliasing applications.

![LP6F vs. 6-Pole Butterworth Amplitude Response](image)

Like the Butterworth low-pass filter, the LP6F has a nonlinear phase response with 60 degrees of phase distortion at the cutoff frequency. The nonlinear phase characteristics of the LP6F result in an input-to-output time delay that is not constant versus frequency. Filters with linear phase, such as the LP6P, have constant delay for all frequencies in the pass-band.

**Pulse Mode Low-Pass Filters**
For the time domain, the LP6P PULSE mode low-pass filter has excellent transient response and phase linearity required for time-domain applications such as transient (shock) measurements and time-domain waveform analysis.

When compared to a 6-pole Bessel filter, the LP6P has similar pass-band characteristics yet has a much sharper transition slope from pass-band to stop-band.

![LP6P vs. 6-Pole Bessel Amplitude Response](image)

**Anti-Aliasing Applications**
When used for anti-aliasing applications, the LP6F provides more usable bandwidth for a given sampling frequency.

In exchange for linear phase and excellent transient response, the LP6F is less selective and thus requires a higher sampling frequency than the LP6F.

The chart below provides a comparison of attenuation of aliases versus sampling frequency for the LP6F, 6-pole Bessel (BE6), LP6P, and 6-pole Butterworth (BU6). It is clear that much lower sampling frequencies are required for the PFA-2 LP6P and LP6F than for traditional filter characteristics.

<table>
<thead>
<tr>
<th>Frequency (Fc)</th>
<th>LP6F Attenuation @ Fc</th>
<th>BE6 Attenuation @ Fc</th>
<th>BU6 Attenuation @ Fc</th>
<th>LP6P Attenuation @ Fc</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>3.4 Fc</td>
<td>3.4 Fc</td>
<td>2.5 Fc</td>
<td>2.4 Fc</td>
</tr>
<tr>
<td>40</td>
<td>4.6 Fc</td>
<td>4.5 Fc</td>
<td>3.2 Fc</td>
<td>2.9 Fc</td>
</tr>
<tr>
<td>60</td>
<td>6.4 Fc</td>
<td>5.5 Fc</td>
<td>4.2 Fc</td>
<td>3.3 Fc</td>
</tr>
<tr>
<td>80</td>
<td>9.0 Fc</td>
<td>6.2 Fc</td>
<td>5.6 Fc</td>
<td>3.6 Fc</td>
</tr>
</tbody>
</table>

**Ordering Information**
- **Option H**: 2-Pole High-Pass Filter
- **Option 1**: Twinaxial Input Connectors
- **PFA-2 Dual-Channel Filter/Amplifier**