The need to glean AC signals from DC in the presence of common-mode noise frequently occurs in signal conditioning applications. AC coupling to an instrumentation amplifier (IA) or difference amplifier can be used to accurately extract the AC signal while rejecting DC and common-mode noise.

Adding capacitors and resistors to AC couple the inputs of an instrumentation amplifier or difference amplifier seems like an obvious approach for AC coupling, but it has problems. The DC restoration circuits shown in this bulletin have the same transfer function but without the foibles.

Common-mode rejection of a difference amplifier depends on extremely precise matching of input source impedance. Adding RC networks to the inputs of either an IA or a difference amplifier can significantly degrade the CMR, especially for AC inputs. Even if the CMR is trimmed, maintaining performance over temperature can be a problem.

The DC restoration circuits shown solve this problem by placing a low-pass network in the feedback to the reference pin of the IA or difference amplifier. The low-pass pole translates into a high-pass function as referred to the input with \( f_{-3dB} = \frac{\text{Gain}}{2\pi R C} \). The Gain term refers to the Gain from the reference pin to the output of the IA or difference amplifier. The selection guide shows this Gain term as the “High-pass multiplier”.

The DC-restored INA117 is shown in Figure 1. With the values shown, the high-pass zero is ≈6.5Hz.

The INA117BM has a CMR of 86dB min. If improved CMR is required for the DC restored INA117, use the circuit shown in Figure 2. Since the trim resistors are small, they will not degrade the stability or drift performance of the INA117.

The INA117 has a common-mode input range and differential offset range of up to ±200V. If a lower common-mode and differential offset range of ±100V is acceptable, the INA106 can be used for lower noise and twice the small signal bandwidth (400kHz vs 200kHz).

![FIGURE 1. AC-Coupled INA117.](image1.png)

![FIGURE 2. AC-Coupled INA117 with CMR Trim.](image2.png)
<table>
<thead>
<tr>
<th>MODEL</th>
<th>GAIN [V/V]</th>
<th>COMMON MODE INPUT RANGE [V]</th>
<th>DIFFERENTIAL OFFSET RANGE [V]</th>
<th>NOISE (RTI) [nV/√Hz]</th>
<th>BANDWIDTH (~3dB) [Hz]</th>
<th>HIGH PASS MULTIPLIER (See Text)</th>
</tr>
</thead>
<tbody>
<tr>
<td>INA117</td>
<td>1</td>
<td>±200</td>
<td>±200</td>
<td>550</td>
<td>200k</td>
<td>19</td>
</tr>
<tr>
<td>INA106(*)</td>
<td>1</td>
<td>±100</td>
<td>±100</td>
<td>300</td>
<td>400k</td>
<td>10</td>
</tr>
<tr>
<td>INA105</td>
<td>1</td>
<td>±20</td>
<td>±10</td>
<td>60</td>
<td>1M</td>
<td>1</td>
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<tr>
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<td>±11</td>
<td>±1</td>
<td>30</td>
<td>500k</td>
<td>1</td>
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<tr>
<td>INA101</td>
<td>2</td>
<td>±7 (1)</td>
<td>±10</td>
<td>1 (2)</td>
<td>6M (3)</td>
<td>1</td>
</tr>
</tbody>
</table>

NOTES (1) Reverse-connected, see figures 3, 4, and 5. (2) Gain is adjustable from 1 to 1000+. Noise and bandwidth depend on Gain setting. INA103 has the lowest noise: 1nV/√Hz, Gain = 1000. INA102 has the highest bandwidth: 6MHz, Gain = 1. INA102 is low power (750µA max), INA110 has FET inputs (I_b = 50pA max). INA101 has lowest drift (25µV/°C max). INA120 has a lower IQ INA101 with internal resistors for Gains of 1, 10, 100, and 1000. (3) Yes! the common-mode input range of standard IAs is only about ±7V with ±10V V_{OUT}; see “Extended Common-Mode Instrument Amps”, Electronic Design, December 22, 1988, pp 67, 68.
FIGURE 5. AC-Coupled ±100V Difference Amp Uses the INA106. Has CMR Trim.

FIGURE 6. General AC-Coupled IA Circuit

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