Instrumentation amp turns into 600-MHz gain-bandwidth op amp

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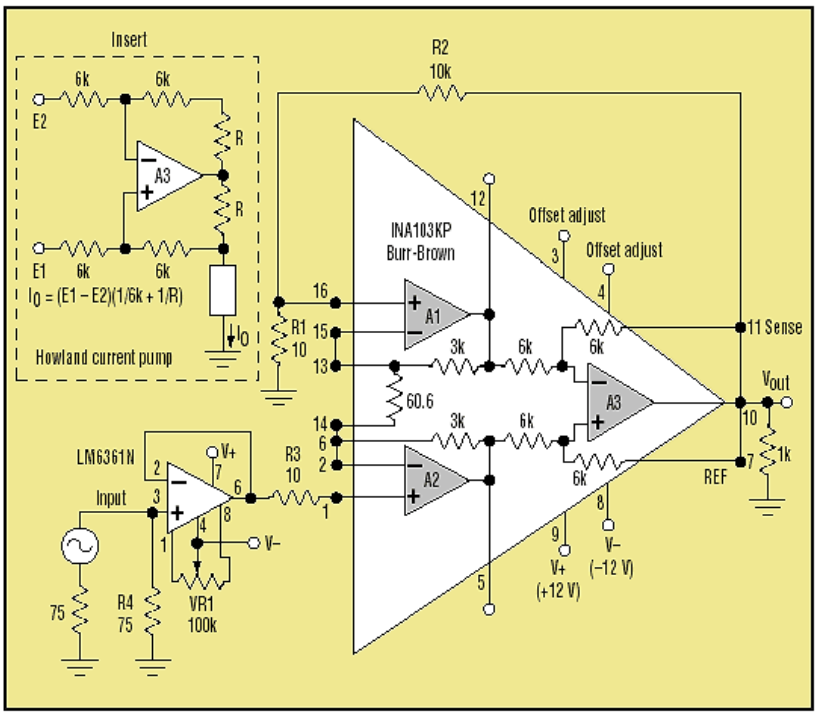
An interesting but brief mention is made in Analog Devices' AN-245 application note (by Scott Wurcer and Walt Jung) that instrumentation amplifiers can be configured as op amps with very high gainbandwidth (GBW) products. In applications that use wide-band transducers, it's necessary to use high-GBW-product amplifiers.

Presented here is an instrumentation amp that's configured as an op amp with a GBW = 600 MHz (gain of 800 and a −3-dB bandwidth of 750 kHz) (see the figure). To achieve such a large GBW, the output stage of the instrumentation amp is configured as a modified Howland-current pump (see the figure, insert), giving it high conductance and large gain. The overall open-loop gain of the composite amplifier is approximately 90 dB at 100 Hz. The inherently high GBW = 100 MHz of the INA103 makes it an ideal candidate for this unusual application of using this device as an op amp. It's difficult to find a low-cost op amp with comparable specifications to this op-amp-configured instrumentation amp with a GBW = 600 MHz.



To attain 600-MHz gain-bandwidth, the output stage of the instrumentation amplifier is configured as a modified Howland-current pump.

In the insert, the current $I_O = (E1 - E2)(1/6\ k\Omega + 1/R)$, but as R tends toward zero, which is the case in the opamp-connected instrumentation amp circuit, the conductance will tend to become very large. This will provide a large voltage gain that's bounded by the CMRR of the output stage. The maximum output voltage swing of the amplifier with a bipolar 12V supply is 16 Vpp (1-kΩ load) at 500 kHz.

The overall gain is equal to $A_V = (R2 + R1)/R1$, and in order to prevent instability due to excessive front-end phase, the gain set by R1 and R2 should be 10 times greater than the front-end gain, which in this case is strapped to 100. The front-end phase makes the op-amp-connected instrumentation amp only viable with large closed-loop gain settings.

Resistor R3 ensures that the source resistances presented to the instrumentation-amp inputs are equal. The dc offset at the output V_{OUT} can be nulled by adjusting RV1. The LM6361N highspeed op amp, which has a GBW = 50 MHz, can be used as a buffer amplifier or to provide additional gain. The LM 6361N should be replaced with a wideband JFET type if the source impedance of the transducer used is high.