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National Semiconductor

LINEAR BRIEF 1

instrumentation amplifier

LB-1

INSTRUMENTATION AMPLIFIER

The differential input single-ended output instrumentation amplifier is one of the most versatile signal processing amplifiers available. It is used for precision amplification of differential dc or ac signals while rejecting large values of common mode noise. By using integrated circuits, a high level of performance is obtained at minimum cost.

Figure 1 shows a basic instrumentation amplifier which provides a 10 volt output for 100 mV input, while rejecting greater than ±11V of common mode noise. To obtain good input characteristics, two voltage followers buffer the input signal. The LM102 is specifically designed for voltage follower usage and has 10,000 MΩ input impedance with 3 nA input currents. This high of an input impedance provides two benefits: it allows the instrumentation amplifier to be used with high source resistances and still have low error; and it allows the source resistances to be unbalanced by over 10,000 ohms with no degradation in common mode rejection. The followers drive a balanced differential amplifier, as shown in Figure 1, which provides gain and rejects the common mode voltage. The gain is set by the ratio of R_4 to R_2 and R_5 to R_3. With the values shown, the gain for differential signals is 100.

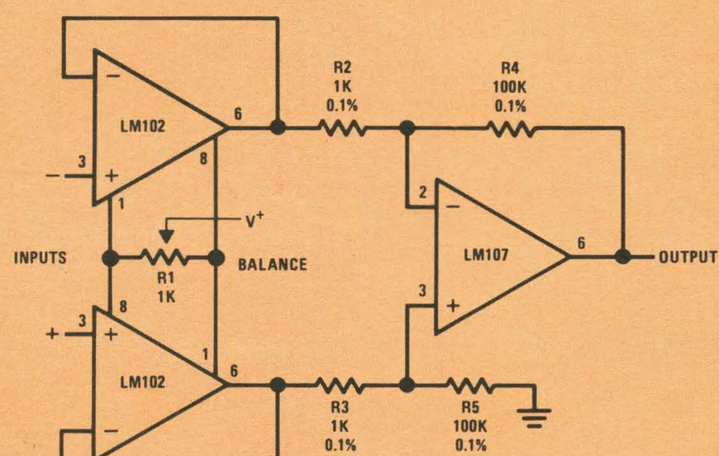

FIGURE 1. Differential-Input Instrumentation Amplifier

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Figure 2 shows an instrumentation amplifier where the gain is linearly adjustable from 1 to 300 with a single resistor. An LM101A, connected as a fast inverter, is used as an attenuator in the feedback loop. By using an active attenuator, a very low impedance is always presented to the feedback resistors, and common mode rejection is unaffected by gain changes. The LM101A, used as shown, has a greater bandwidth than the LM107, and may be used in a feedback network without instability. The gain is linearly dependent on R_6 and is equal to $10^{-4} R_6$.

To obtain good common mode rejection ratios, it is necessary that the ratio of R_4 to R_2 match the ratio of R_5 to R_3. For example, if the resistors in circuit shown in Figure 1 had a total mismatch of 0.1%, the common mode rejection would be 60 dB times the closed loop gain, or 100 dB. The circuit shown in Figure 2 would have constant common mode rejection of 60 dB, independent of gain. In either circuit, it is possible to trim any one of the resistors to obtain common mode rejection ratios in excess of 100 dB.

For optimum performance, several items should be considered during construction. R_1 is used for zeroing the output. It should be a high resolution, mechanically stable potentiometer to avoid a zero shift from occurring with mechanical disturbances. Since there are several ICs operating in close proximity, the power supplies should be bypassed with .01 μF disc capacitors to insure stability. The resistors should be of the same type to have the same temperature coefficient.

A few applications for a differential instrumentation amplifier are: differential voltage measurements, bridge outputs, strain gauge outputs, or low level voltage measurement.

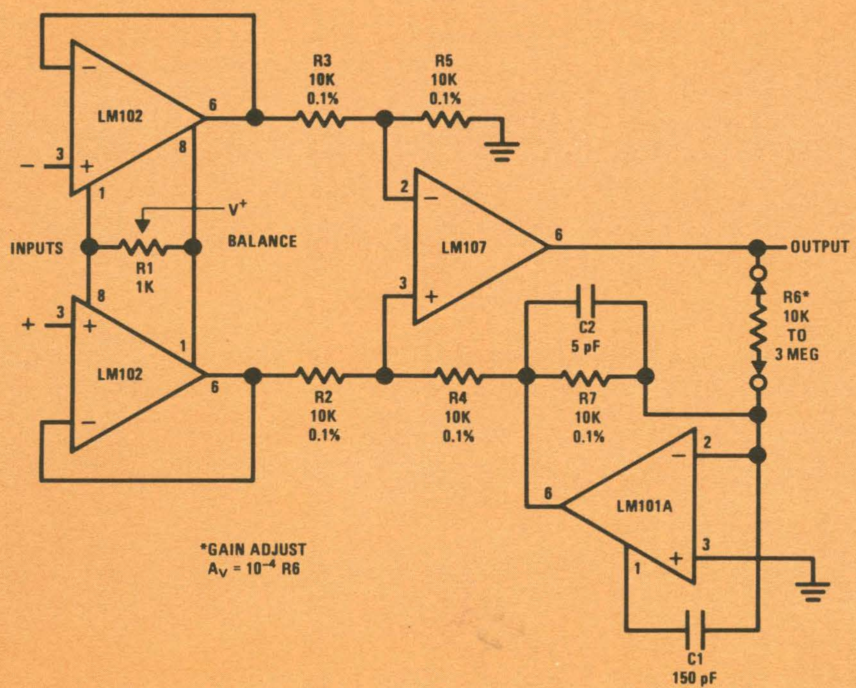

FIGURE 2. Variable Gain, Differential-Input Instrumentation Amplifier

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