

## SINGLE-SUPPLY OPERATION OF ISOLATION AMPLIFIERS

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For simplicity, many systems are designed to operate from a single external power supply. In battery powered systems such as aircraft and automotive, it's often a requirement. Isolation amplifiers such as the ISO120 and ISO122 can be easily modified for input side single-supply operation with the addition of an INA105 difference amplifier. With ISO amps, it's the isolated input side power supply which most often needs to be single supply. The output side of the ISO amp uses a split  $\pm 15V$  power supply, allowing a full  $\pm 10V$  output swing.

The difference amplifier has advantages as compared to traditional single-supply amplifiers. The inputs of a difference amplifier can swing to both the positive and negative power-supply rails. In fact, in the application shown in Figures 1 and 2, the input range of the circuit extends approximately 2V below ground (the negative power supply rail). This is because the resistors internal to the INA105 divide the input level in half as seen by the op amp.

The technique is illustrated in Figures 1 and 2 using the ISO120 and ISO122. These ISO amps are specified for operation from dual supplies as low as  $\pm 4.5V$  and can be operated with a total single power supply voltage as low as 9V. The circuit shown is designed for operation from a single  $+15V$  power supply. This allows a 0V to  $+5V$  input range.

The most common application is for a single ended input referred to ground as shown. For a differential input, pin 2 can be connected to a second input instead of ground. This provides a 0V to 5V differential input with common-mode to either rail.

To understand how the circuit works, consider the operation of the INA105 difference amplifier. The difference amplifier forces its output (pin 6) relative to its reference (pin 1) to be equal to the differential input (pin 3 – pin 2). The difference amplifier reference pin and the ISO amp common are held at approximately 5.1V by the 10k $\Omega$  resistor and the zener diode. This pseudo ground establishes an arbitrary acceptable operating point for the ISO amp. The difference amplifier then translates its input, relative to true ground, up to the 5.1V pseudo ground. In other words, a 0V to 5V input between pins 3 and 2 of the INA105 is seen as a 0V to 5V signal at the ISO amp input.

Isolated power is often at a premium and both the ISO120/122 and the INA105 operate on relatively low power. Common zener diodes, on the other hand, may require several mA for proper operation. The 1N4689 zener diode specified is a low level type designed for applications requiring low operating currents. It has a sharp breakdown voltage specified at a low 50 $\mu A$ .

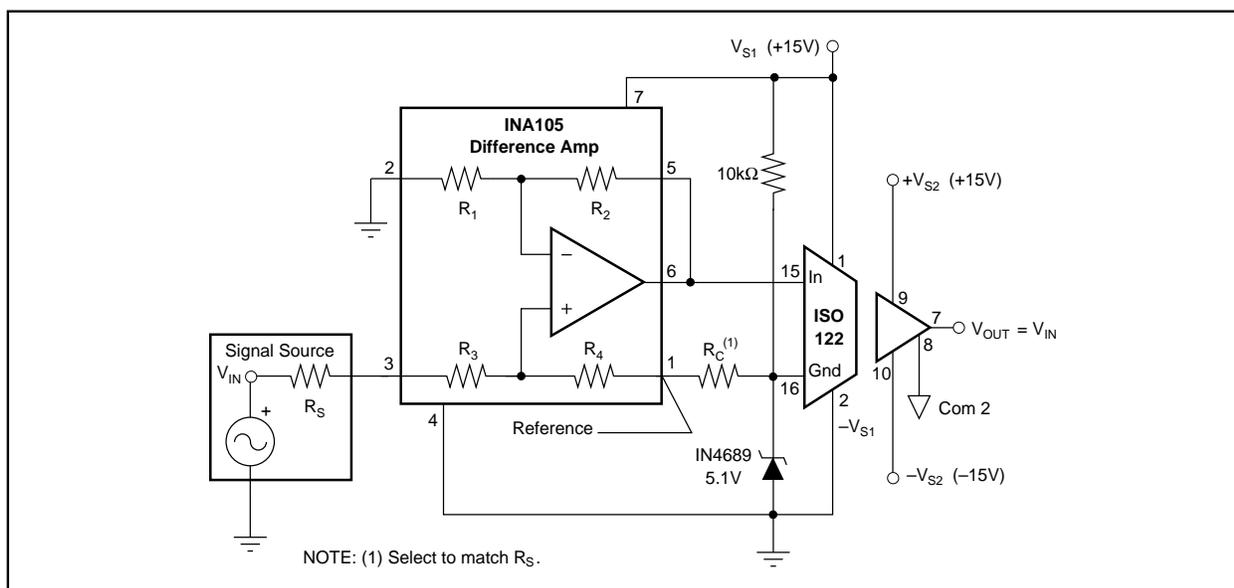


FIGURE 1. Single Supply Operation of the ISO122 Isolation Amplifier.

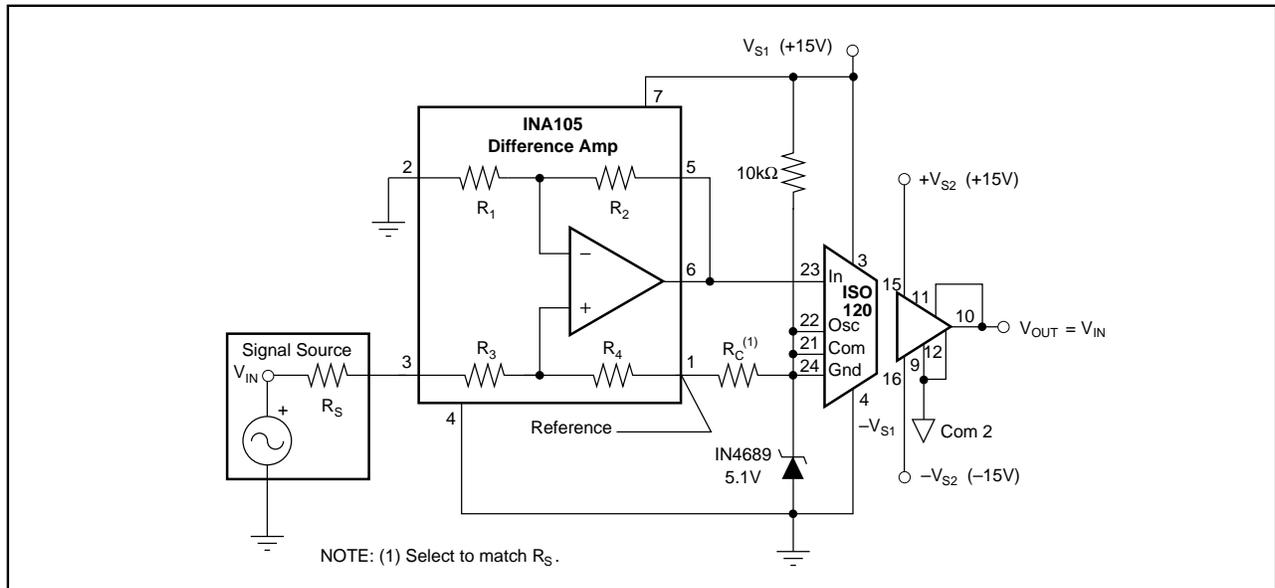


FIGURE 2. Single Supply Operation of the ISO120 Isolation Amplifier.

The accuracy of the INA105 difference amplifier relies on careful resistor ratio matching ( $R_3/R_4 = R_1/R_2$ ). Any source impedance of the signal ( $R_s$ ) adds to the difference resistor ( $R_3$ ). For low source impedances, the error is acceptable. For better accuracy at higher source impedances, a compensating resistor ( $R_c$ ) can be added to restore the ratio matching. The resistors in the INA105 are  $25k\Omega$ . For 0.1% gain accuracy, no compensating resistor is required with source impedances up to  $25\Omega$ . For source impedances up to  $2.5k\Omega$ , use a compensating resistor which matches  $R_s$  within 1%. If the source impedance is not known exactly, a trim pot can be used to adjust gain accuracy.

For operation with source impedances greater than  $2.5k\Omega$ , a unity-gain-connected single-supply op amp can be added to buffer the input as shown in Figure 3. Although the input

range of the OPA1013 single-supply op amp includes the negative rail, its output can not quite swing all the way to the rail. The negative swing limit of this circuit is therefore  $\approx 100mV$ —still adequate in many applications.

For an instrumentation amplifier (IA) front end, the other half of the OPA1013 can be connected to the inverting input of the INA105 (pin 2) as shown in Figure 4.

For a true single-supply ISO amp with high impedance differential inputs, the circuit shown in Figure 5 can be used. In this circuit, the inputs—and therefore the outputs—of the OPA1013s are level-shifted up a  $V_{BE}$  with a matched pair of PNP input transistors. The transistors are biased as emitter followers by a pair of  $100\mu A$  current sources contained in the REF200 dual current source.

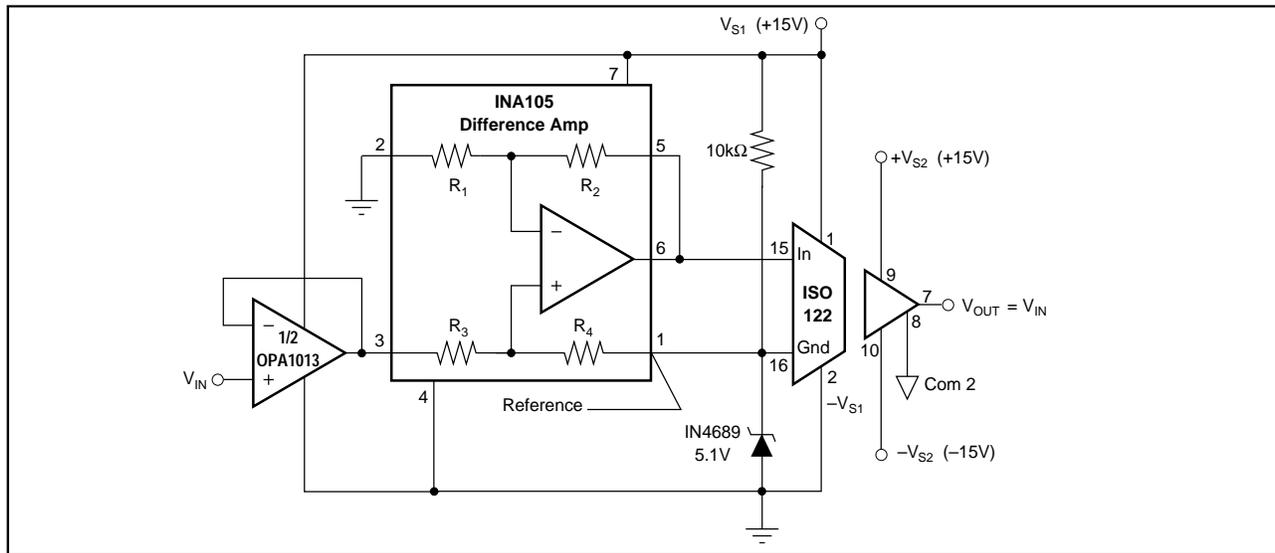


FIGURE 3. Single Supply (almost—see text), High Input Impedance Isolation Amplifier.

The circuits shown in this bulletin were designed for 0V to 5V operation from a single +15V power supply. With reduced range, operation from a lower voltage is feasible. For higher input range the circuit can be operated from a higher supply voltage. Table 1 shows the ranges obtainable for selected power supplies.

$V_s$ (V)	INPUT RANGE FIGURES 1, 2 (V) <sup>(1)</sup>	INPUT RANGE FIGURES 3, 4 (V) <sup>(1)</sup>	INPUT RANGE FIGURE 5 (V) <sup>(1)</sup>
20+	-2 to +10	0.1 to +10	-0.3 to +10
15	-2 to +5	0.1 to +5	-0.3 to +5
12	-2 to +2	0.1 to +2	-0.3 to +2

Note: (1) Since the amplifier is unity gain, the input range is also the output range. The output can go to -2V since the output section of the ISO amp operates from dual supplies.

TABLE 1. Single-Supply ISO Amp Input Range vs Power Supply.

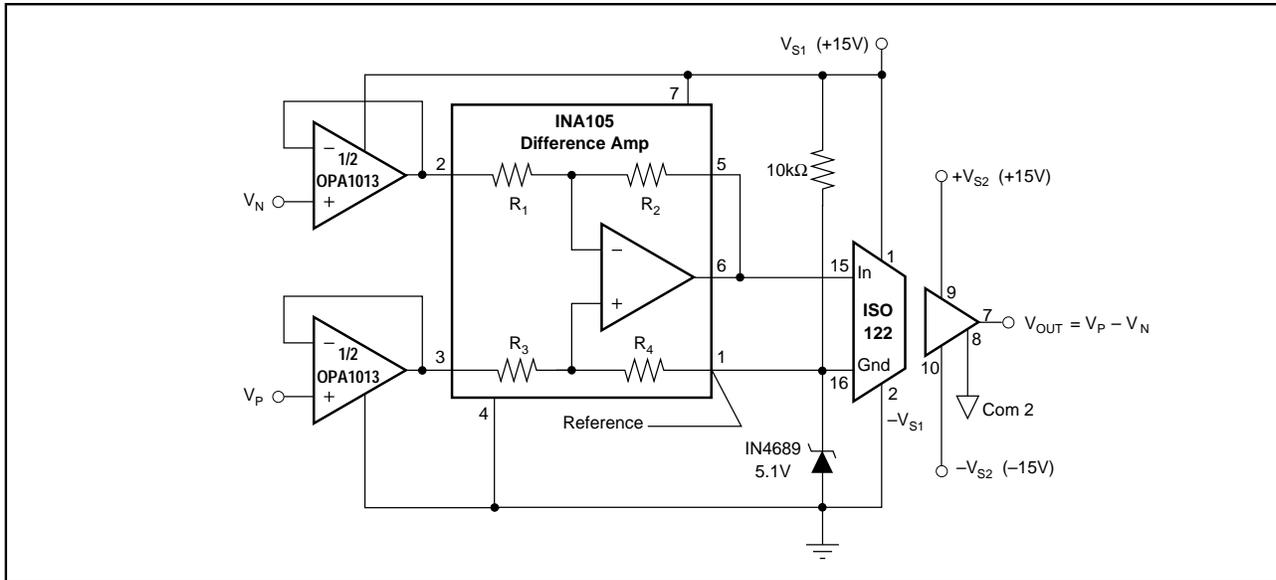


FIGURE 4. Single Supply (almost—see text), Isolation Amplifier with High-Impedance Differential Inputs..

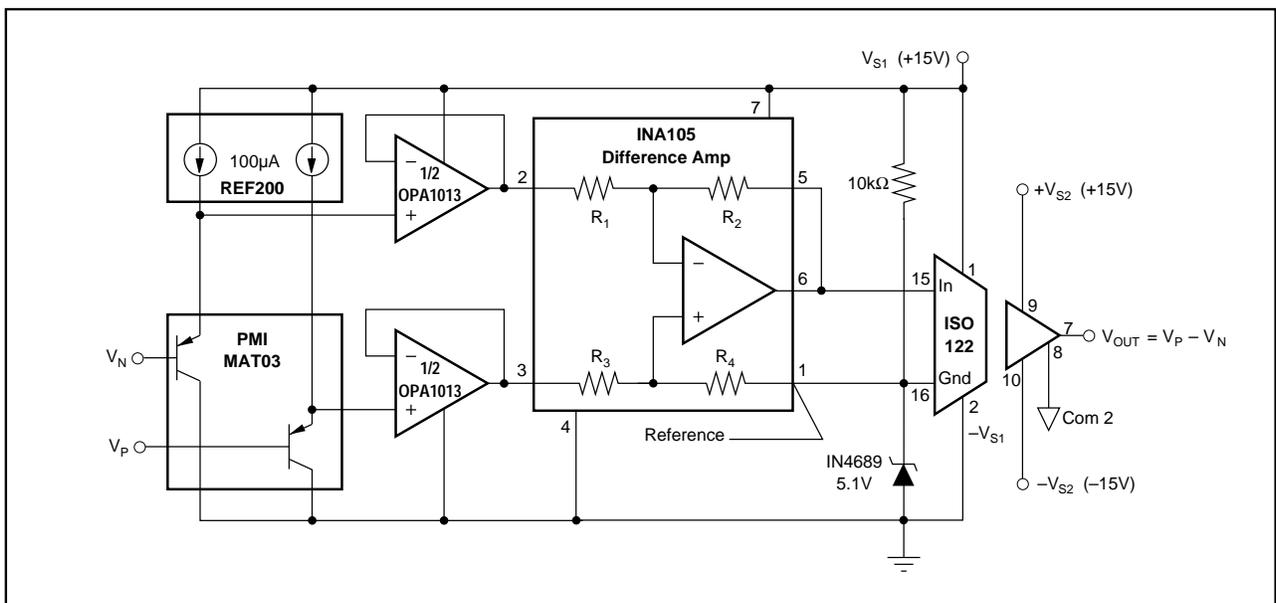


FIGURE 5. Single Supply Isolation Amplifier with High-Impedance Differential Inputs.

For a single-supply ISO amp with higher common-mode-voltage differential inputs, an INA117 high common-mode voltage difference amplifier can be substituted for the INA105 difference amplifier as shown in Figure 6. With a +15V

power supply, the input common mode range is approximately +125V, -50V. With a +12V supply, the input common mode range is approximately  $\pm 50V$ . Differential input range remains as shown in Table I for Figures 1 and 2.

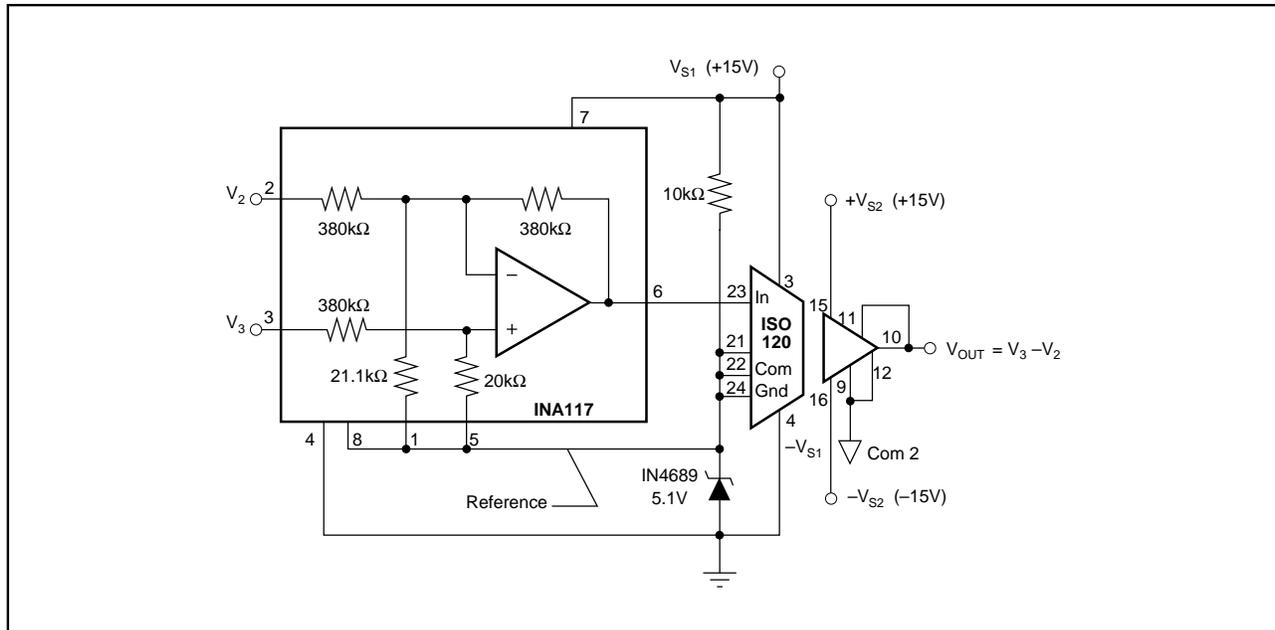


FIGURE 6. Single Supply Isolation Amplifier with High Common-Mode Range Differential Inputs.

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