Level Shifting Signals With Differential Amplifiers

The INA105 is a unity gain differential amplifier consisting of a premium grade operational amplifier and an on-chip precision resistor network. The self-contained INA105 makes it ideal for many applications. One such application is precision level shifting.

Figure 1 shows a general case of a unity gain differential amplifier that performs a signal level shift proportional to the voltage V_{SHIFT} appearing on pin 3 of the OPA27. An operational amplifier is used to drive the INA105's "Ref" pin (pin 1) with a low impedance source to preserve true differential operational of the INA105.

A basic understanding of the circuit operation can be gained by considering the INA105 as a three input summing amplifier. The voltage transfer function is then $E_{OUT} = E_2 – E_1 + V_{REF}$. As this relation shows, the output will respond to a difference signal and algebraically add the voltage at the "Ref" input. Therefore, V_{REF} may take on any arbitrary value that will not saturate the INA105 amplifier's output. In the case of the circuit in Figure 1, $V_{REF} = V_{SHIFT}$, yielding an output of $E_O = E_2 – E_1 + V_{SHIFT}$.

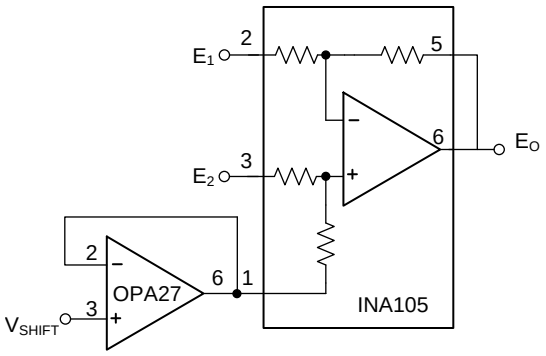

Figure 1. Level Shifting Circuit Using the INA105's V_{REF} Pin

Precision fixed level shifting can be easily accomplished by using a voltage reference source like the REF5010. A REF5010 used with an additional INA105 can be used to provide an accurate, low-drift, +5-V reference to drive the "Ref" pin of the differentially connected INA105 as shown in Figure 2. If, for example, the input signal is a bipolar ±5-V signal, the output will be level shifted to a unipolar 0 to 10-V signal. The same reference circuit also has –5 V available and may thus be used for the opposite conversion from unipolar 0 to 10-V to bipolar ±5-V signals. Due to this circuit cutting the effective voltage reference in half relative to ground, this type circuit configuration allows the creation of non-standard bias voltages such as 1.5 V or 1.65 V, which are half of 3 V and 3.3 V, respectively. Precision level shifting is often used due to the improved accuracy, low noise, and low temperature coefficient compared to a resistor divider. The benefits of a precision voltage reference in level shifting allow for an accurate voltage over temperature and time.

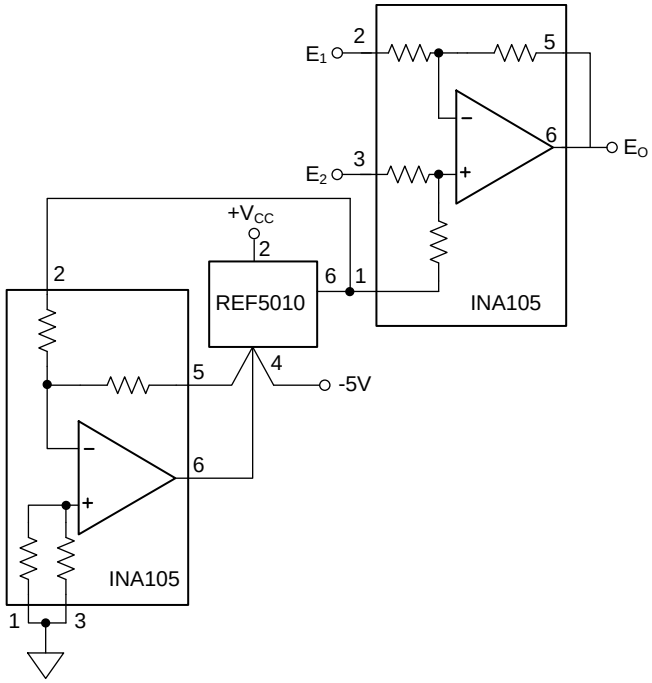

Figure 2. Precision Level Shift Circuit From a Fixed Voltage Reference

The INA105 in conjunction with a precision voltage reference also has the flexibly to create bipolar outputs such as in Figure 3. Figure 3 is an alternative to design to Figure 2 that allows for a the –5-V output. This example uses a REF3450 precision voltage reference that offers a fixed 5-V output but the flexibility is also extended to other precision voltage references.

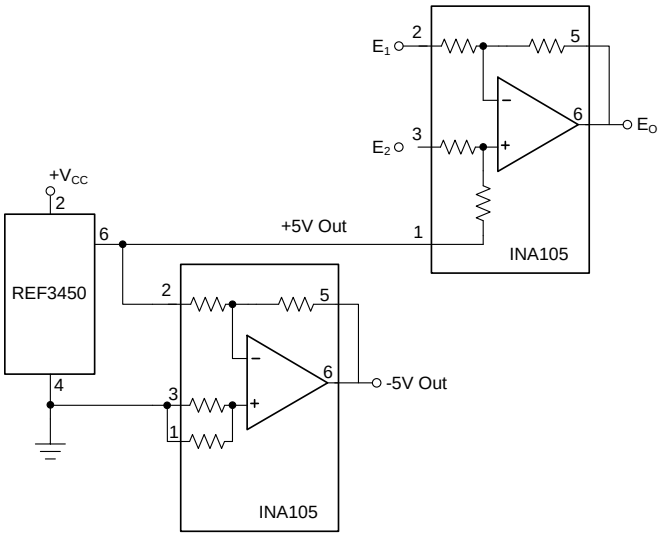

Figure 3. Precision Level Shift Circuit With Bipolar Options

For precision level shifting in low voltage applications, the INA213 is an alternative to the INA105. The INA213 operates from a single 2.7-V to 26-V power supply that makes it suitable for lower voltage systems with single supplies. This type of application the REF2030 a suitable precision voltage reference companion device to the INA213 for level shifting as the REF2030 is a dual output precision voltage reference that can both source V_{CC} and the V_{BIAS} (½ V_{CC}) level shifting voltage for a signal chain and level shifting applications.

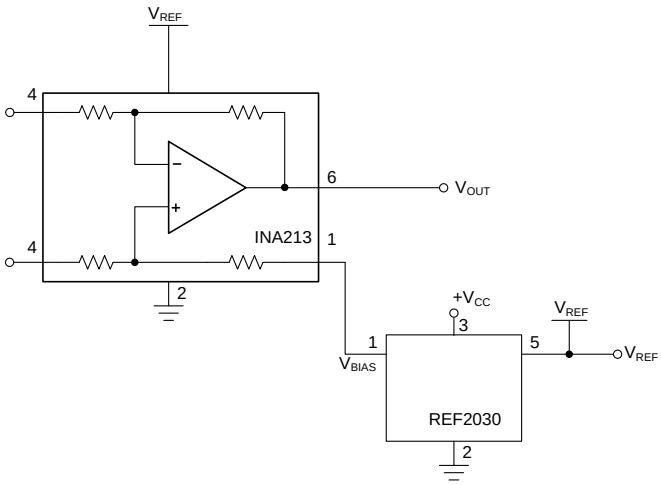

Figure 4. Precision Level Shift Circuit With REF2030

Table 1. Device Information

DEVICE	OPTIMIZED PARAMETERS
INA105	Precision Unity Gain Differential Amplifier
REF5010	10-V, Low-Noise, Very Low Drift, Precision Voltage Reference
REF3450	5-V, Low-Drift, Low-Power, Small-Footprint Series Voltage Reference
OPA27	Ultra-Low Noise Precision Operational Amplifiers
INA213	26-V, Bidirectional, Zero-Drift, High Accuracy, Low-/High-Side, Voltage Out Current Shunt Monitor
REF2030	3-V and 1.5-V, Low-Drift, Low-Power, Dual-Output Vref and Vref/2 Voltage Reference

Table 2. Alternate Device Information

DEVICE	OPTIMIZED PARAMETERS
REF3425	2.5-V, Low-Drift, Low-Power, Small-Footprint Series Voltage Reference
REF5050	5-V, Low-Noise, Very Low Drift, Precision Voltage Reference
ATL431	2.5-V, Low-Iq Adjustable Precision Shunt Regulator

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