Operating the Differential Line Receiver EL5172 from a Single 5V Supply

This application note explains the correct method for DC biasing this high-speed amplifier and provides circuit examples of reference voltage buffers that generate a 2.5V DC bias for maximum output dynamic range.

Contents

1. Introduction

The EL5172 is a high-speed difference amplifier that can operate from either a dual ±5V supply, or a single 5V supply. The device comprises two identical operational amplifiers with their open-loop gains of A1 = A2 = A.

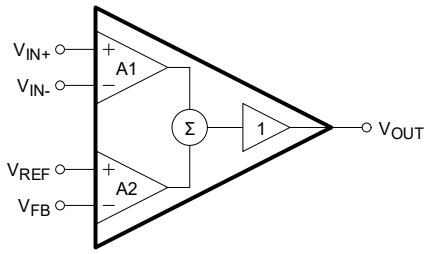

Figure 1. EL5172 Inner Structure

A1 provides the difference between the two input voltages, V_{IN+} and V_{IN-}, amplified by the open-loop gain, and A2 generates the difference between the reference voltage, V_{REF}, and the feedback voltage, V_{FB}, amplified by the open-loop gain. The outputs of both op-amps add to a combined output voltage:

(EQ. 1) $$V_{OUT} = (V_{IN+} - V_{IN-})A_1 + (V_{REF} - V_{FB})A_2$$

Similar to a standard op-amp, achieving a symmetrical output dynamic range requires the signal sources (V_{IN+} and V_{IN-}) and the gain resistor, R_G, to be referenced to V_{REF} (Figure 2); therefore, making the feedback voltage:

(EQ. 2) $$V_{FB} = V_{REF}(1-\beta) + V_{OUT}\beta \quad \text{with } 1-\beta = \frac{R_F}{R_F + R_G} \quad \text{and } \beta = \frac{R_G}{R_F + R_G}$$

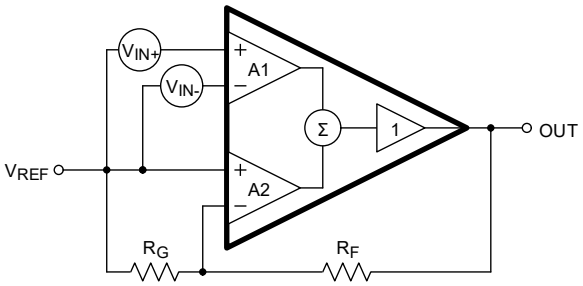

Figure 2. Biasing for Output Symmetry

Replacing V_{FB} in Equation 1 with Equation 2 makes V_{OUT}:

(EQ. 3) $$V_{OUT} = (V_{IN+} - V_{IN-}) \times \frac{A_1}{1 + A_2\beta} + V_{REF} \times \beta \times \frac{A_2}{1 + A_2\beta}$$

Because both op-amps are matched ($A_1 = A_2$) and the loop-gain is much larger than unity ($A\beta \gg 1$), Equation 3 is simplified to:

(EQ. 4) $$V_{OUT} = (V_{IN+} - V_{IN-}) \times \left(1 + \frac{R_F}{R_G}\right) + V_{REF}$$

To maximize the output dynamic range, V_{REF} is connected to the mid-supply potential, which means that for a dual supply system, V_{REF} = GND (Figure 3), and for a single-supply system, $V_{REF} = V_S/2$ (Figure 4).

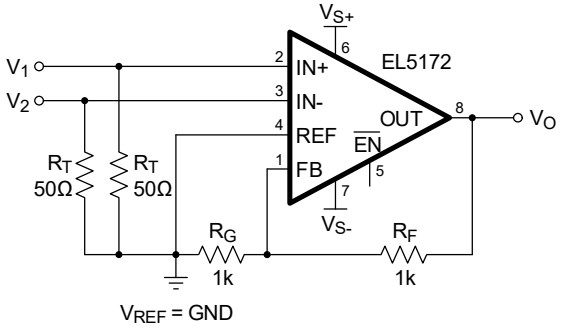

Figure 3. Dual Supply Operation with Gain = 2

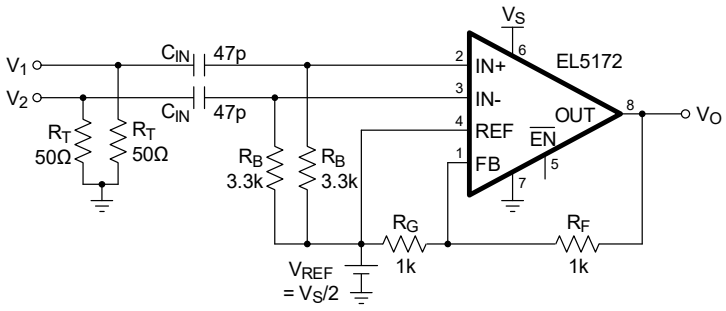

Figure 4. Single Supply Operation with Gain = 2

However, in the single-supply circuit (Figure 4), the ground referenced input signals must be level-shifted to $V_S/2$, requiring AC-coupling using input capacitors and bias resistors connected to V_{REF}.

Note: C_{IN} and R_B form high-pass filters whose cutoff is at $f_c = 1/(2\pi R_B C_{IN})$. To minimize phase and gain errors, set f_c at least one decade below the minimum signal frequency: $f_c \le f_{S\text{-}min}$. The circuit example in Figure 4 assumes a minimum input frequency of 10MHz; therefore, the high-pass cutoff is set to 1MHz.

2. Generating a Stable Reference Voltage

In single supply applications, the reference voltage must be derived from the supply voltage. While there are various options for doing this, all must provide a low-impedance output to ensure a stable reference.

The ratio-metric approach uses a voltage divider that ensures V_{REF} tracks with the supply voltage. The problem is that to establish a stable reference, the current through the divider should be at least ten times that of the current loading the divider. Considering the low-impedance 1kΩ values of R_F and R_G, the divider resistance has to be in the lower hundreds of ohms, which is usually not acceptable because of the high current consumption caused by the reference circuit.

Another ratio-metric option is to use a high-impedance voltage divider whose output is buffered by a voltage follower (Figure 5). However, this solution is sensitive to power supply ripples and requires an additional filter capacitor at the input to provide ripple rejection.

The cleanest and most stable solution is an integrated voltage reference IC, such as the ISL21090-25. Although not ratio-metric, this device provides a low-noise output voltage with sufficient current sink and source capability and high supply-ripple rejection or PSRR (Figure 6).

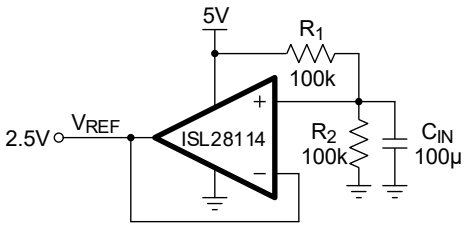

Figure 5. V_{REF} Buffer with Op-Amp

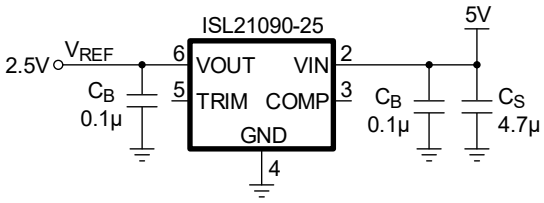

Figure 6. 2.5V Bandgap Reference IC

Figure 7 shows the final circuit of the high-speed difference amplifier EL5172 operating from a single 5V supply.

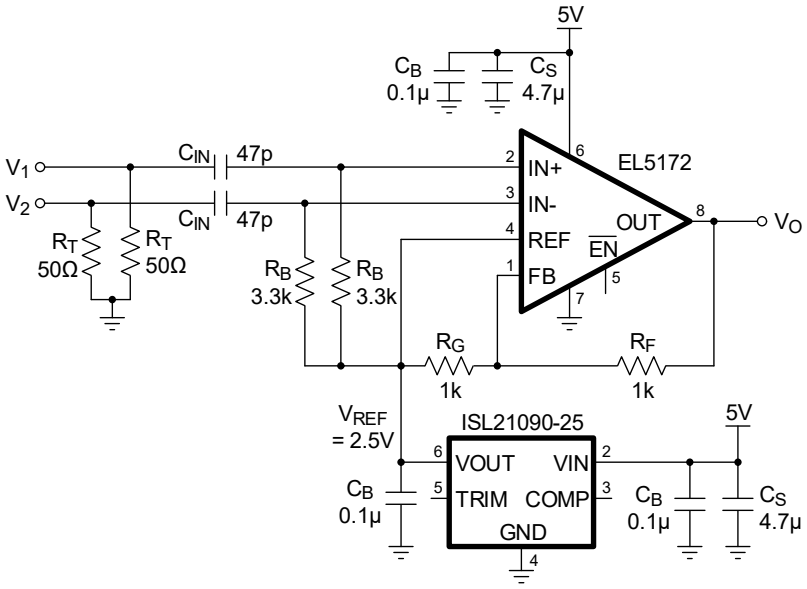

Figure 7. High-Speed Difference Amplifier EL5172 Operating from a Single 5V Supply

3. Revision History

Revision	Date	Description
1.00	Jul 19, 2022	Initial release.

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