Operational Amplifiers

Load Cancellation Enables Precision Op-Amps to Drive Heavy Loads

Abstract

The application note reviews how the load cancellation enables a precision op-amp to drive heavy loads without affecting its performance accuracy.

Load Cancellation Enables Precision Op-Amps to Drive Heavy Load

Precision op-amps are characterized by having a high open-loop gain, low offset voltage and current, low input voltage and current noise, and low distortion. However, these op-amps often lack the capability of a high output current drive and have a problem driving low-impedance loads.

With the help of a second op-amp that has a high drive capability but less DC precision, canceling the load enables the precision amp to control the current drive of its more powerful counterpart while maintaining a high precision performance.

One example of a load cancellation solution is to have the power driver generate a negative input resistance that matches the precision op-amp output load so that $R_{IN} = -R_L$. If connecting R_{IN} in parallel to R_L, the combined load resistance at the precision op-amp output becomes theoretically infinite.

Figure 1 shows a circuit that generates a negative input resistance of $R_{IN} = -R_C \cdot R_G / R_F$, where R_C is a compensation resistance.

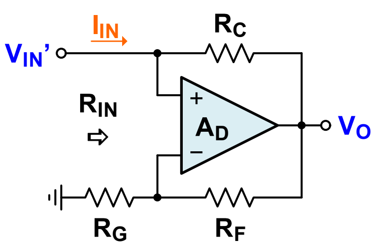

Figure 1. The Circuit Produces a Negative Input Resistance of $R_{IN} = -R_C{\cdot}R_G/R_F$

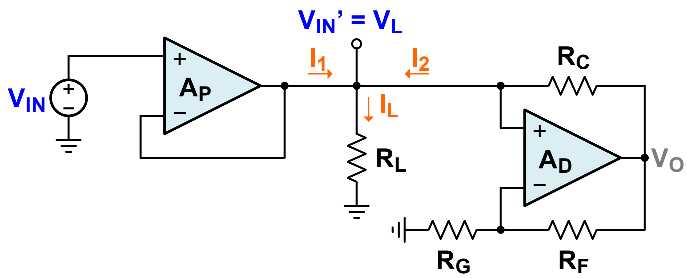

Figure 2. The Circuit Around A_D cancels the Load for A_P

Equation 1 the input resistance of the circuit in Figure 1:

(EQ. 1) $$R_{IN} = \frac{V_{IN}}{I_{IN}}$$

Use Equation 2 to express the input current:

(EQ. 2) $$I_{IN} = \frac{V_{IN} - V_O}{R_C}$$

Use Equation 3 to express the op-amp output voltage:

(EQ. 3) $$V_O = V_{IN}\left(1 + \frac{R_F}{R_G}\right)$$

Insert Equation 2 and 3 and solve for the input resistance (V_{IN}/I_{IN}) for the following result:

(EQ. 4) $$R_{IN} = \frac{V_{IN}}{I_{IN}} = -R_C \bullet \frac{R_G}{R_F}$$

Figure 2 shows the theoretical concept of load cancellation, where a precision op-amp (A_P) is configured as a unity-gain buffer; and, a wideband op-amp with high current drive capability (A_D) operates as a non-inverting amplifier with a gain of two.

Because $R_F = R_G$, the negative input resistance of the circuit around A_D equals the compensation resistor, R_C: $R_{IN} = -R_C$. By making $R_C = R_L$, the output of the precision op-amp sees an open circuit.

As a result, the precision buffer (A_P) drives the positive input of the wideband amplifier (A_D) that drives the load.

Note: Gain error, output-current limits, and resistor mismatches limit the minimum load resistance that can be driven, but driving a 200Ω load is easy.

- This load is about 50-times lower than the precision amplifier can otherwise handle without suffering some loss of performance.
- Also, to the first order, A_P accuracy is not affected by the A_D gain error, offset voltage, and offset current.
- And A_D does not have significant positive feedback, because its non-inverting input is driven by the low output impedance of A_P.

Figure 3 shows the practical load cancellation circuit with the 40V precision op-amp, ISL28108, and the 60MHz wideband op-amp, EL5111. Both amplifiers operate from a bipolar supply of ±5V. Figure 4 shows the corresponding DC transfer characteristic for an input voltage and therefore shows the load voltage range of $V_{IN} = V_L = \pm 2V$.

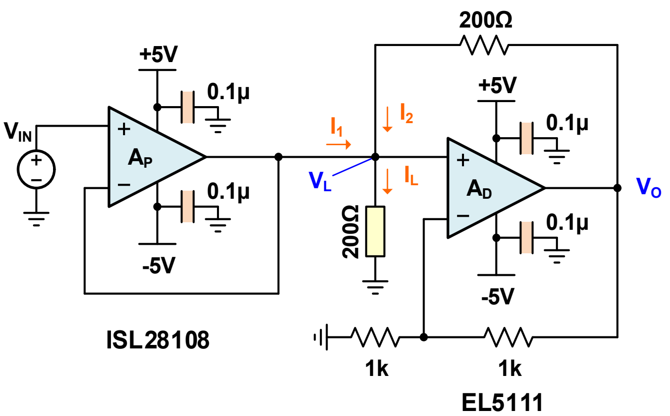

Figure 3. The Circuit Produces a Negative Input Resistance of $R_{IN} = -R_C \cdot R_G / R_F$

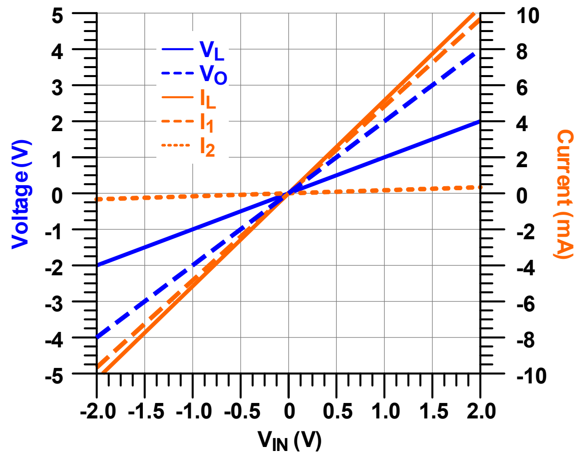

Figure 4. The Circuit Around A_D cancels the Load for A_P

These figures show that load cancellation enables a precision op-amp to drive heavy loads without affecting its performance accuracy.

Revision History

Rev.	Date	Description
1.00	Jul.9.20	Initial release

IMPORTANT NOTICE AND DISCLAIMER

Corporate Headquarters

TOYOSU FORESIA, 3-2-24 Toyosu,
Koto-ku, Tokyo 135-0061, Japan
www.renesas.com

Contact Information

For further information on a product, technology, the most up-to-date version of a document, or your nearest sales office, please visit:
www.renesas.com/contact/