

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.

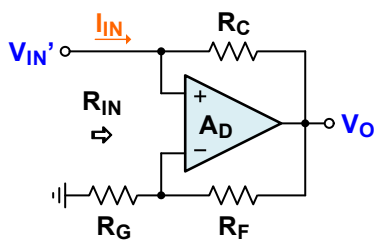


Figure 1. The Circuit Produces a Negative Input Resistance of  $R_{IN} = -R_C \cdot R_G / R_F$

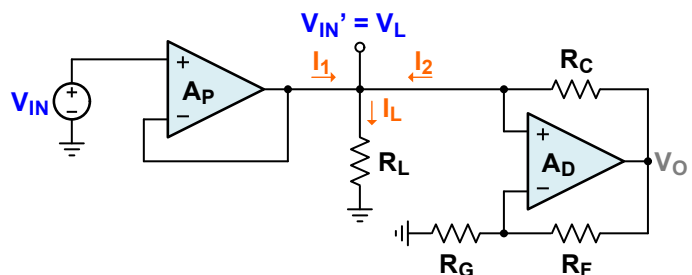


Figure 2. The Circuit Around  $A_D$  cancels the Load for  $A_P$

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

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

Use Equation 2 to express the input current:

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

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

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

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

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

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  $200\Omega$  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  $\pm 5V$ . Figure 4 shows the corresponding DC transfer characteristic for an input voltage and therefore shows the load voltage range of  $V_{IN} = V_L = \pm 2V$ .

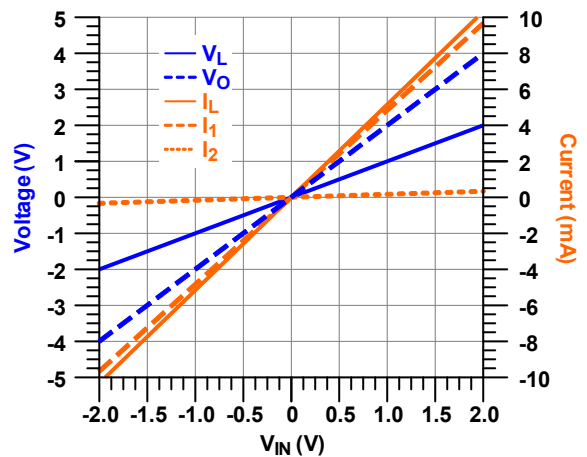
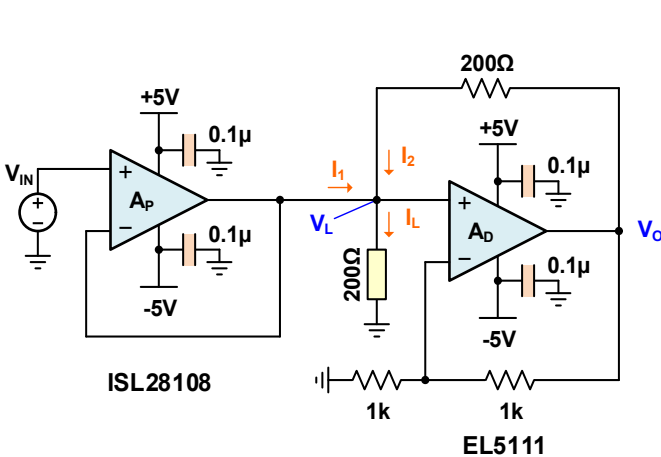


Figure 3. The Circuit Produces a Negative Input Resistance of  $R_{IN} = -R_C \cdot R_G / R_F$

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

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