Since the first analog IC requiring bipolar supplies was developed, people have been trying to operate them from unipolar supplies. Not only do the “headroom” \((V_s - \text{V\text{OUTMAX}})\) requirements come into play, but with a unipolar supply typically come unipolar outputs. To get bipolar output swings from a unipolar supply, drive the load differentially and create a reference signal which can be used a “pseudo ground” for amplifier and input signal reference. This circuit topography requires that your signal be elevated to \(V_s / 2\).

The INA105 is a precision unity gain differential amplifier, and as a low cost monolithic circuit, it offers high reliability and accuracy. With an initial offset voltage of 50µV, gain error of 0.005%, and small signal bandwidth of 1MHz, the INA105 makes an ideal amplifier for creating this pseudo ground. The OPA2541 is a dual power operational amplifier capable of operation from power supplies up to ±40V (or a single, unipolar 80V) at output currents of 5A continuous. With two monolithic power amplifiers in a single package it provides unequaled functional density, and provides the means to deliver differential outputs at high power. By using the INA105 to create the pseudo ground, and the OPA2541 to drive 5A loads differentially, the circuit in Figure 1 can be developed. At 5A output current, the OPA2541 requires a typical headroom of 4.5V, and as configured, output voltage swings of \(2V_s - 18V\) (peak-to-peak) can be achieved. The output swing can be calculated by realizing that when one of the amplifiers reaches its positive output limit \((V_s - \text{V\text{HEADROOM}})\), the other amplifier should reach its negative output limit \((0V + \text{V\text{HEADROOM}})\). This creates a voltage swing.

**FIGURE 1.** Single Supply, Bipolar Output Swing for Floating Signal Source.
of $V_s - 2V_{\text{headroom}}$. This is then multiplied by two, when the input signals reverse polarity so do the output signals which are referenced to the pseudo ground. This causes the peak-to-peak output voltage to be $2V_s - 4V_{\text{headroom}}$. For standard 28V systems, this means that you can see output swings of 38Vp-p at 5A (see Equations for detailed explanation). When only driving 500mA the headroom is typically only 3.2V, and output swings of $2V_s - 12.8V$ are realizable. This means that from the same 28V supply, the peak-to-peak output is 43.2V. By using the maximum rated supply of 80V, a peak-to-peak output of 142V with load currents of 5A can be realized.

Although the OPA2541 is capable of operating with supply voltages up to 80V, the INA105 is limited to an overall power supply voltage of 36V. If higher supply voltages are required, an amplifier such as the OPA445 and a precision resistor network should be utilized for the pseudo ground.

Equations:

- $V_G = \text{Pseudo ground voltage}$
- $V_G = V_s/2$
- $V_{\text{IN}}^- = V_G + V_{\text{IN}}$
- $V_{\text{LOAD}} = \text{Differential voltage across the load}$
- $V_{\text{LOAD}} = V_A - V_B$
- $A_V = 1 + (R_2/R_1)$
- $A_V = R_3/R_1$
- $V_A = V_{\text{IN}}^- \{1 + (R_2/R_1)\} - V_G (R_2/R_3)$
- $V_A = V_{\text{IN}}^- (A_V) - V_G (A_V - 1)$
- $V_A = V_{\text{IN}} (A_V) + V_G$
- $V_B = -V_{\text{IN}}^- (R_2/R_3) + V_G \{1 + (R_4/R_3)\}$
- $V_B = -V_{\text{IN}}^- (A_V) + V_G (A_V + 1)$
- $V_B = V_{\text{IN}} (A_V) + V_G$
- $V_{\text{LOAD}} = V_A - V_B$
- $V_{\text{LOAD}} = \{V_{\text{IN}} (A_V) + V_G\} - \{-V_{\text{IN}} (A_V) + V_G\}$
- $V_{\text{LOAD}} = V_{\text{IN}} (2A_V)$
IMPORTANT NOTICE

Texas Instruments and its subsidiaries (TI) reserve the right to make changes to their products or to discontinue any product or service without notice, and advise customers to obtain the latest version of relevant information to verify, before placing orders, that information being relied on is current and complete. All products are sold subject to the terms and conditions of sale supplied at the time of order acknowledgment, including those pertaining to warranty, patent infringement, and limitation of liability.

TI warrants performance of its semiconductor products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are utilized to the extent TI deems necessary to support this warranty. Specific testing of all parameters of each device is not necessarily performed, except those mandated by government requirements.

Customers are responsible for their applications using TI components.

In order to minimize risks associated with the customer’s applications, adequate design and operating safeguards must be provided by the customer to minimize inherent or procedural hazards.

TI assumes no liability for applications assistance or customer product design. TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right of TI covering or relating to any combination, machine, or process in which such semiconductor products or services might be or are used. TI's publication of information regarding any third party’s products or services does not constitute TI’s approval, warranty or endorsement thereof.

Copyright © 2000, Texas Instruments Incorporated