

OP-amp biasing for Low Power Small Signal Low Frequency High Gain Amplifiers

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Key Words

Low frequency AC, input offset biasing, low power, adjustable biasing

Executive Summary

When creating low frequency high gain circuits the designer is faced with many challenges. Very few discreet devices are created for low frequency applications. Many of the simple techniques that are used for audio band amplification and above are not useful in the sub-Hertz frequencies. This method does not affect the gain of the original system and maintains low power consumption.

Introduction and Objective

In order to overcome the inherent imperfections of semiconductor manufacturing, novel techniques are required for device operation at the upper limits of their specifications. The slight variation in the turn on voltages for N and P-type devices results in a small voltage at the two input terminals of any op-amp. Also many times in an amplifying system, it is necessary to introduce a DC voltage into the system. Traditionally, these comparatively large and undesirable DC voltages are filtered out with a high pass filter. This note presents an alternative method using variable biasing using an op-amp that is effective with low frequency signals.

Issues

Input-offset voltage:

One challenge is overcoming the input offset voltage in op-amps. This is due to the differences in the physical dimensions of the transistors that act as the two different inputs to the op-amp. This small (micro/milli-volt) DC voltage creates a DC voltage at the output of the op-amp that is amplified the same amount as any other signal.

The low frequency:

Traditionally, this DC offset is overcome by using a blocking capacitor as a high pass filter before and after each stage of amplification. This is a great method for frequencies above 10 Hz. However, it is not practical for frequencies below that because the size of the capacitor would be impractical. Thus, a method for removing all DC (Input offset and input signal) voltage must be used.

The large DC offset and small AC signal:

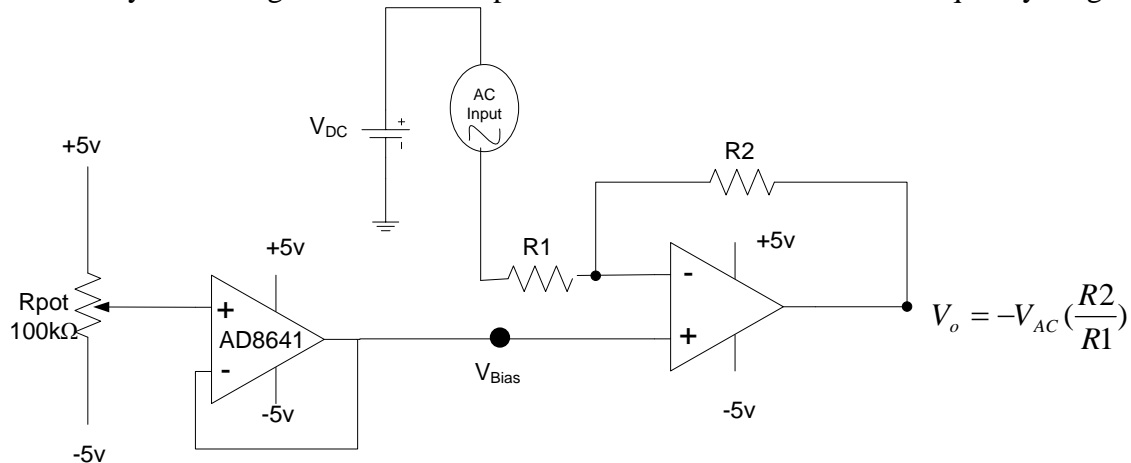
If the input signal to the amplifier is a combination of a small AC signal riding on top of a large DC offset then the maximum gain is determined by the DC signal. This is because, the DC offset will cause the output of the amplifier to be either the positive or negative rail and the AC signal will be lost. This can happen at relatively small gains so care must be taken to bias this DC voltage out when not using a DC blocking capacitor.

Power consumption:

A traditional voltage divider using a potentiometer can be used to create a bias at the input of the op-amp that is opposite the input signal. However, the total series resistance of the voltage divider must be small in order for this voltage to dominate the parallel combinations with the rest of the resistors. This solution creates relatively high power consumption. If the rails are at $\pm 5V$ and the series resistance is 200Ω then this configuration will require 50 mA of current. This is quite high for use in battery powered mobile electronics.

Example

Using a large resistance multi-turn potentiometer and low power op-amp such as an AD8641 from Analog Devices (supply current 250 μ A max.) one can create a low power variable (rail-to-rail) DC voltage source. This can be used with a differential amplifier to bias out any DC voltage and maximize performance over a much lower frequency range.



The total additional power is just:

$$P = 10V * \left(\frac{10V}{100k\Omega} + 250\mu A \right) = 3.5mW$$

Where as before the power consumption was:

$$P = 10V * \left(\frac{10V}{200\Omega} \right) = 500mW$$

This improvement in power consumption is drastic along with being voltage bias agile from rail to rail. All DC offset sources are compensated for in one step. Finally, this method has no reduction in bandwidth so low frequencies are not affected.

Reference:

Wierzba, Gregory M. "ECE 402: Applications of Analog Integrated Circuits" 2008

Mancini, Ron "Op Amps for Everyone" Texas Instruments Design Reference 2002