EE 508

Noise Measurement

Lab 7 Fall 2024

Noise

Noise is often of concern in amplifier and filter structures. In this experiment, emphasis will be placed on observing the noise that is present in an amplifier.

Consider the basic amplifier circuit shown below. Assuming the V_{IN} is ideal and has zero source impedance, there are three contributors to device noise in this circuit. These are the two resistors and the operational amplifier. The contribution to these noise sources all combine and appear at the output along with the amplifier version of V_{IN}. If the magnitude of V_{IN} is large, the noise on the output is often of little concern but if V_{IN} is small, the noise may be comparable in amplitude or even bigger than the output due to the desired excitation.

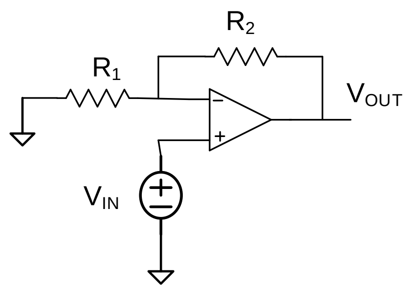

Fig. 1 Basic Amplifier Structure

Noise contributed by the operational amplifier is a major contributor to noise in amplifier and filter circuits and one way to reduce the effects of noise in the operational amplifier is to use operational amplifiers with low noise. There are several different operational amplifiers that are used in various courses in this department. Probably the most popular are the TL082, LM358, LMC 660, LM324, and LM741. There are several different mechanisms that contribute to noise but two of the most significant noise types are thermal noise and 1/f noise. Chopper stabilization and correlated double sampling are often used to reduce the effects of the 1/f noise that is present in the amplifier inputs. Unfortunately the datasheets for these basic amplifiers do not characterize the 1/f noise but most give the thermal noise spectral density.

Part 1 Compare the noise spectral density, as specified in the datasheets, of the 5 specified operational amplifiers at a frequency of 1KHz.

Part 2 Design the basic amplifier of Fig. 1 with a dc gain of 100 (± 10% is close enough) using R_1=1K. Use +/- 15V biases for the op amp. If the input signal is a sinusoidal signal of 200mV p-p at 1KHz, observe the output waveform and the output noise on an oscilloscope using the operational amplifier from the set listed above with the largest noise spectral density. Analytically calculate the signal to noise ratio at the output under two scenarios, one assuming the Op Amp is noiseless and the other assuming the noise due to both the resistors and the Op Amp is present.

Part 3 Measure the input-referred noise spectral density of the operational amplifier (again using the op amp with the most noise) and compare with that given in the datasheet. To facilitate this measurement, consider the following circuit where the Device Under Test (DUT) is the device shown on the left part of Fig. 2. The three amplifier gain stages (actually high-pass filters) are for the purpose of amplifying the noise on the first stage. Assume R_B=100K, R_A=1K. Select the capacitor C so that the amplifiers pass noise above 200 Hz. (If you must use an electrolytic capacitor, it must be biased appropriately). Note the input is set to 0V (shorted out) for this measurement to amplify the noise voltage of the first stage without interference from the input signal. Again, use +/- 15V biases for the amplifier. The coupling capacitors which are used to form the high-pass filter are included to avoid op amp saturation due to the offsets of the op amps and to keep 1/f noise from the Op Amp under test from propagating through the amplifier chain. You may make the assumption that the noise due to the resistors R_1 and R_2 and the Op Amp under test are white noise.

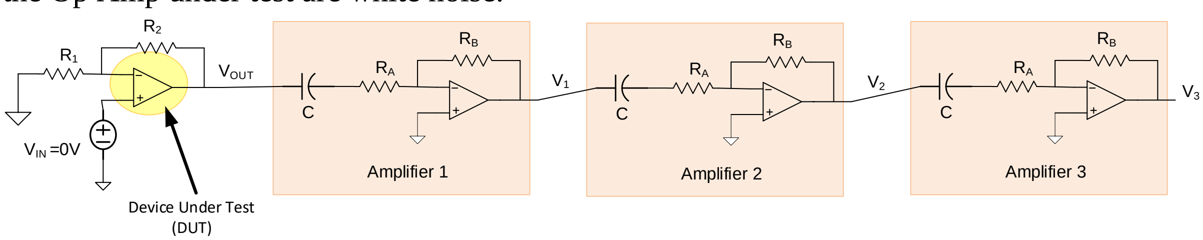

Fig. 2 Test Setup for Measuring Noise of Operational Amplifier

From the output waveform, (V_2 or V_3 as appropriate) obtain an estimate of the noise spectral density of the input amplifier and compare with the value obtained from the datasheet. Since the noise due to R_1 and R_2 can be accurately predicted, the effects of the noise from these resistors needs to be appropriately subtracted when measuring the op amp noise.

When making an assessment of the operational amplifier noise, comment on why the noise contributed by the resistors R_A and R_B and the operational amplifiers in the three gain stages do not significantly compromise the noise measurement of the first stage. The noise you measure will be not the total noise present on the input stage but only the noise over a certain frequency band. Comment on what frequency band of noise is present.

Part 4 Measure the input-referred noise spectral density of the operational amplifier with the lowest noise and compare with the value given in the datasheet. This measurement should be straightforward since the only change that should be needed from the previous measurement is the replacement of the operational amplifier designated as the DUT.