Application Report
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Evaluating the TLV2462 and TLV2772 as Drive Amplifiers for the TLV2544/TLV2548 ADC

Jim Karki *AAP Precision Analog*

ABSTRACT

This report presents a method for comparing the ac performance of the TLV2462 and TLV2772 operational amplifiers to the ac performance of the TLV2544/TLV2548 analog-to-digital converter.

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1 Introduction

The old adage that a chain is only as strong as its weakest link can be used as analogy to the signal chain in an analog system. Once the signal is degraded by weak components, the chain is compromised.

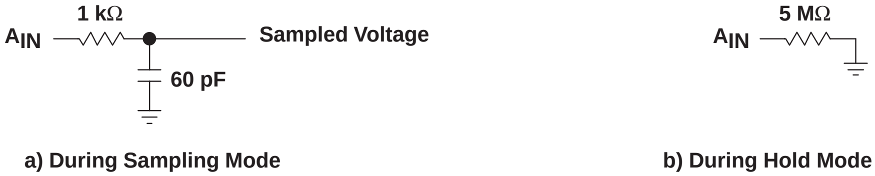
Amplifiers are used to condition the input signal to ADCs (analog-to-digital converters). Normally the functions performed are level shifting, impedance matching, amplification, and the like. The drive amplifier is the link between the input source and the ADC. It must not be weak. It does not make sense to use a very strong ADC with great specs in conjunction with a weak amplifier.

When selecting an amplifier, often times ac performance factors such as bandwidth, slew rate, noise, and distortion drive the decision-making process, with dc errors taking a back seat. One of the difficulties in doing this is that operational amplifiers are not normally specified in the same manner as ADCs.

ENOB (effective number of bits) is a key ac parameter used for ADCs. It is calculated based on SINAD (signal-to-noise + distortion) in dB, where $\text{ENOB} = \frac{\text{SINAD} \pm 1.76}{6.02}$. By measuring the THD+N (total-harmonic-distortion + noise) in dB of the TLV2462 and TLV2772 in different circuit topologies, and then substituting THD+N for SINAD when calculating ENOB, the amplifier's performance is directly comparable to the TLV2544/TLV2548 ADC.

2 Test Circuits

The input to the TLV2544/TLV2548 ADC is modeled as shown in Figure 1. During sampling, the input is active and appears as a series resistor and capacitor to ground—typical values are 1 kΩ and 60 pF. When not sampling, the input is high-impedance.



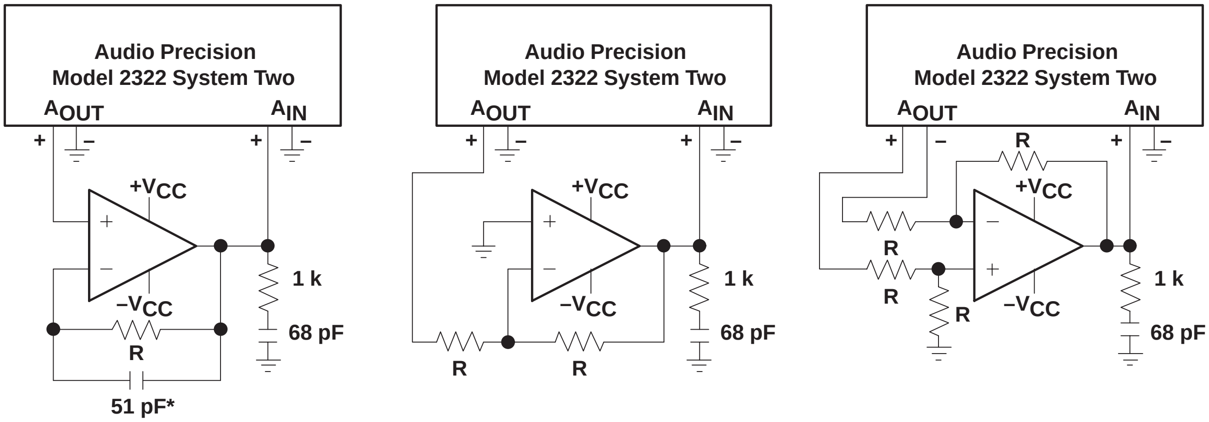
a) During Sampling Mode b) During Hold Mode

Figure 1. Equivalent ADC Input

Figure 2 shows the noninverting, inverting, and differential amplifier circuits tested. A 1-kΩ resistor in series with a 68-pF capacitor is placed on the output of each amplifier to simulate the input of the ADC. The value of resistive components (R) is varied between 1 kΩ, 10 kΩ, and 100 kΩ to show their impact. Note that in the TLV2772 noninverting circuit with 10-kΩ, and 100-kΩ resistor values, a small feedback capacitor is required for stability due to the capacitance of the cabling and measuring instrument. Also R = 0 Ω is tested for the noninverting amplifiers.

Audio Precision's model 2322–System Two is used to measure the THD+N of the amplifier circuits. The analog test signal is a sine wave that is swept from 10 Hz to 200 kHz. The measurement bandwidth is 10 Hz to 500 kHz.

It is assumed that it is desired to operate the amplifier from the same 3.3-V or 5-V voltage source used by the ADC. The amplifier is typically biased so that the output is at 1/2 the full-scale voltage of the ADC with zero input. To simplify testing, the amplifiers use supply voltages of ±1.65 V to simulate a 3.3-V system, and ±2.5 V to simulate a 5-V system. The input signal is referenced to ground with peak levels of 0.89 V and 1.78 V. These levels are equivalent to 1 dB down in 2-V and 4-V full-scale systems.



a) Noninverting

b) Inverting

c) Differential

*Capacitor required for TLV2772 with R=10k and 100k

Figure 2. Test Circuits

3 Lab Results

ENOB can be calculated as: $\text{ENOB} = \frac{\text{THD} + \text{N} \pm 1.76}{6.02}$. Figures 3 through 6 show the results of testing the ENOB, with the TLV2544/TLV2548 shown for comparison.

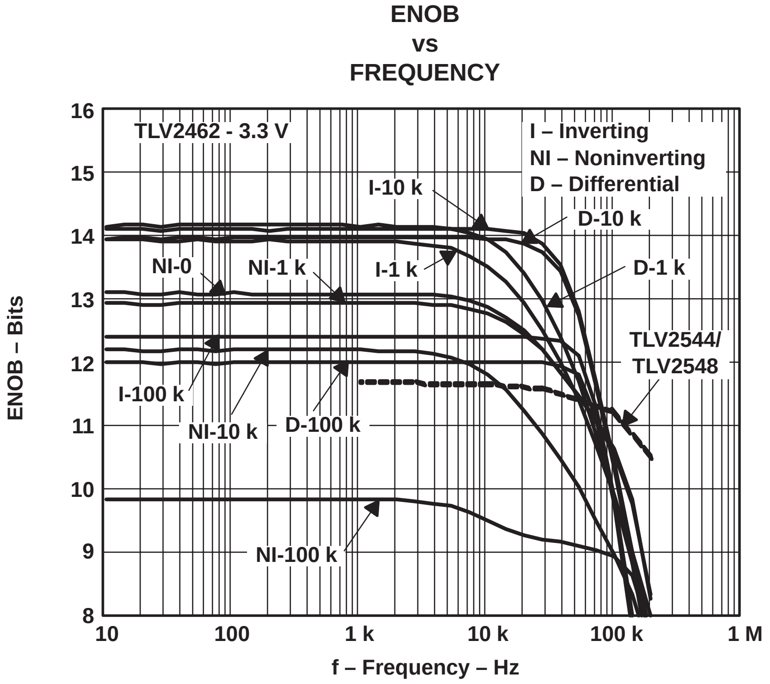


Figure 3. ENOB vs Frequency—TLV2462 at 3.3 V

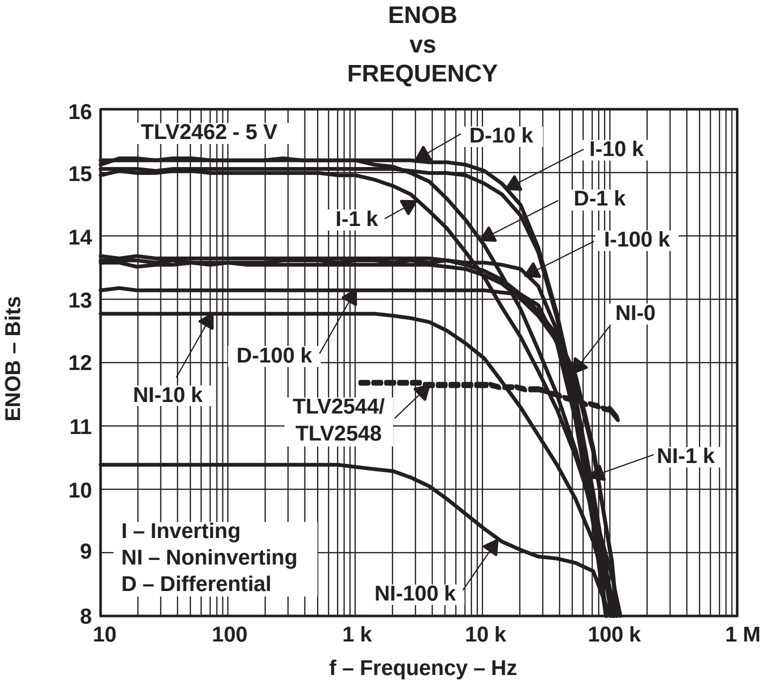


Figure 4. ENOB vs Frequency—TLV2462 at 5 V

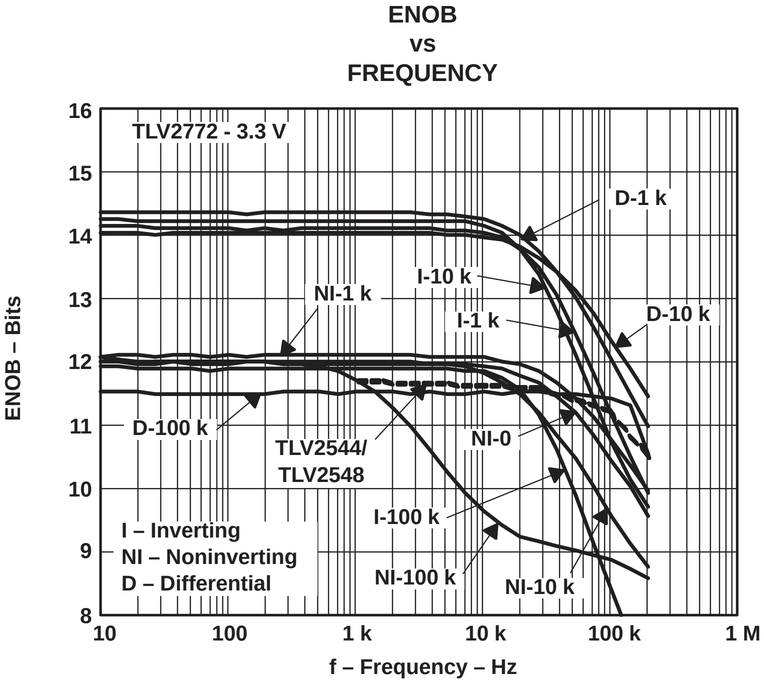


Figure 5. ENOB vs Frequency—TLV2772 at 3.3 V

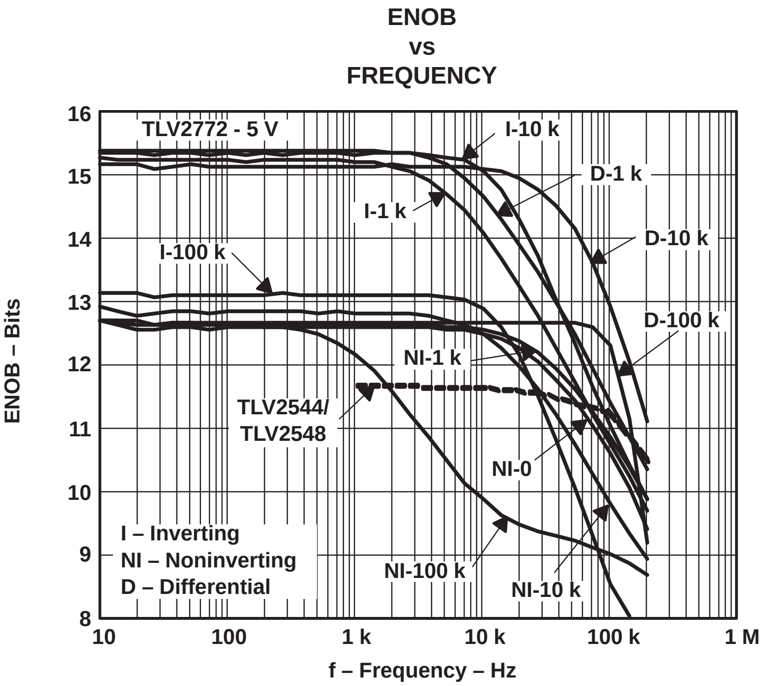


Figure 6. ENOB vs Frequency—TLV2772 at 5 V

4 Conclusion

The data shows that the TLV2462 and TLV2772 inverting and differential-amplifier topologies with resistive elements of R =10 kΩ result in the strongest amplifier performance.

This result may appear surprising at first since the noise gain of the inverting amplifier is twice that of the noninverting amplifier. The larger values of THD+N measured in the noninverting mode stem from the fact that the input bias point is made to move through most of its common-mode voltage range, resulting in larger distortion products with noise being less dominant. The input-bias point of the differential amplifier is also made to change, but only 1/4 as much. In the inverting topology, the input remains biased midway between the power supply rails. This optimizes distortion performance.

Actually, noise is what limits the performance of the noninverting and differential amplifiers. Since noise is proportional to the square-root of the bandwidth, two more bits are added to the ENOB when the bandwidth is limited to 20 kHz.

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